CITY OF CALGARY

DESIGN GUIDELINES FOR BRIDGES AND TRANSPORTATION STRUCTURES

2024

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Prepared by Bridges and Geotechnics, Public Spaces Delivery, City of Calgary

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ACRONYMS AND ABBREVIATIONS

ASTM	ASTM International
CIP	cast-in-place
CN	Canadian National Railway
CPKC	Canadian Pacific Kansas City
CSA	CSA Group
CPTED	Crime Prevention Through Environmental Design
FLS	fatigue limit state
FRP	fibre reinforced polymers
HPC	high performance concrete
Hz	hertz
IFC	Issued for Construction
kN/m	kilonewtons per metre
LL	live load
LRT DGM	The City of Calgary LRT Design Guidelines Manual
lx	lux
MCAA	Municipal Consent and Access Agreement
m	metre
mm	millimetre
MPa	megapascals
mrand	milliradians
MSE	Mechanically Stabilized Earth
PTFE	Polytetrafluoroethylene
PVC	polyvinyl chloride
QA	quality assurance
QC	quality control
QMP	Quality Management Plan
SECs	severe environmental conditions
SLS	serviceability limit state
TAC	Transportation Association of Canada
ULS	ultimate limit state
USB	Universal Serial Bus

1. INTRODUCTION

1.1 Purpose

The Design Guidelines for Bridges and Transportation Structures (the Guidelines) sets forth The City of Calgary (The City) design criteria that govern design of new bridges and structures, as well as evaluation and rehabilitation of existing structures. The Guidelines apply to the following structure types including, but not limited to, the following:

i. Vehicular bridges
ii. Pedestrian, cyclist, and multi-use bridges
iii. Large culverts and tunnels (>2.5m in diameter)
iv. Retaining walls (>1m in height)
v. Highway accessory supports
vi. Noise barriers
vii. Tree trenches

This document reflects the current City policies governing planning, design, construction, and rehabilitation of structures owned and managed by The City.

This document provides basic design considerations; and any unique applications, issues, or departure from the Guidelines shall be referred to The City of Calgary, Public Spaces Delivery, Bridges and Geotechnics, for review and acceptance through a Design Exception at the early stages of design or construction as applicable.

Additional guidance for LRT bridge and transportation structure design shall be as provided in The City of Calgary LRT Design Guidelines Manual (DGM).

This document supersedes City of Calgary Design Guidelines for Bridges and Structures, 2020.

1.2 Modifications and Revisions

Revisions to Guidelines

Revisions to the Guidelines occur periodically upon changes of reference codes; modifications to the policies governing structures management; and as a result of most current best practices and new materials, products, and systems available.

Comments and suggestions to improve the Guidelines are welcome and should be referred to: bridge-design@calgary.ca

The City of Calgary, Public Spaces Delivery, Bridges and Geotechnics Division, will conduct necessary research, review, or analysis of the proposed modifications and if the proposed modifications are deemed appropriate, implementation of the revision will follow.

Revisions to Standard Technical Specifications

The Standard Specifications included in Appendix C of this document shall not be altered when used as part of Procurement Documents.

Modifications to the Standard Technical Specifications for specific projects may be made through Supplemental Technical Specifications. Such modifications shall be made only upon prior review and Approval by authorized City personnel.

1.3 Consultant Terms of Reference

Consultants shall refer to project-specific requirements pertaining to planning, design, construction review, and project closure.

1.4 Definitions

The following are the administrative definitions that shall be used in conjunction with the Guidelines as well as with codes and standards referenced herein:

i. **Approved or Approval** means acceptance, in writing, by The City.

ii. **CHBDC** means the CAN/CSA S6 - Canadian Highway Bridge Design Code, and the CAN/CSA S6.1 – Commentary on CSA S6, Canadian Highway Bridge Design Code, latest editions.

iii. **CSA S7:23** means the Pedestrian, cycling, and multiuse bridge design guidelines, latest edition.

iv. **Design Life** means a period of time specified by the Owner (The City) during which a structure is intended to remain in service while satisfying all specified requirements of the design standard (CHBDC unless noted otherwise). Design Life represents the period of time on which statistical derivation of transient loads is based. Design Life refers to the entire structure and non-replaceable components.

v. **Durability** means the capability of a structure or any component to satisfy, with planned maintenance, the design performance requirements over the specified period of time under the influence of the environmental actions, or as a result of the self-aging process.

vi. **Engineer of Record (EOR)** means an engineer licensed in the Province of Alberta who, through a contract with The City, is responsible for design and verification of construction compliance in accordance with the Agreement; the terms Engineer and EOR are used interchangeably for the purpose of these Guidelines.

vii. **Guidelines** means this document, the City of Calgary Design Guideline for Bridges and Structures, and it's included Appendices.

viii. **Owner** means The City or its representatives.

ix. **Reviewed or Review** means planning, design, or construction work is accepted by The City without detailed checking of calculations and application of engineering principles.

x. **Service Life** means the specified period of time during which a structure or any of its components meet or exceed the design performance requirements of the Design Standard without unforeseen major repairs being necessary.

xi. **Standard Technical Specifications** means the written specifications developed by the City of Calgary and set out The City's requirements and standards for materials, systems, workmanship and services necessary for the proper design and construction of transportation bridges and structures. The Standard Technical Specifications are included in Appendix C of these Guidelines

xii. **Supplementary Technical Specifications** means the written specifications that are prepared by the Consultant for inclusion in the Procurement Documents. The Supplementary Technical Specifications may include some or all of the Standard Technical Specifications.

xiii. **The City** means The City of Calgary.

2. QUALITY AND STANDARDS

2.1 General

New design and evaluations of existing bridges and transportation structures shall be performed by a Professional Engineer experienced in bridge design, employed by a firm prequalified by The City.

The design shall be independently checked by an experienced bridge engineer or structural engineer, as applicable to the scope of the design.

Design requirements assigned to construction contractors or suppliers shall be clearly outlined in the Procurement Documents.

2.2 Codes and Standards

All codes and standards shall be the latest edition at the time of design, unless noted otherwise.

Permanent and Existing Structures

Permanent and existing structures shall be designed in accordance with the CHBDC, except as noted otherwise in these Guidelines.

Section 14 of the CHBDC shall be used for load limit restrictions of the existing bridges and for assessment of serviceability or fatigue life of the existing bridge elements. It shall not be used for justification of a design that does not meet the requirements of other clauses of the CHBDC.

Use of loads and strength formulas from other codes in conjunction with the CHBDC requires an investigation, Approved by The City, into compatibility and safety levels with appropriate calibration of load and resistance factors.

Temporary Structures

Temporary structures shall be designed in accordance with the CHBDC, except for falsework and formwork, which shall be designed to CSA S269.1, Falsework and formwork. Temporary access scaffolding shall be designed per CSA S269.2, Access scaffolding for construction purposes; and CSA Z797, Code of practice for access scaffold.

Falsework and temporary scaffolding shall be designed and independently checked by a Professional Engineer licensed in the Province of Alberta.

Staging and construction design loads and load combinations shall be described on the Drawings and accounted for. Any exclusions (for example, construction-specific loads) shall be clearly noted on the Drawings.

Plus 15 and Plus 30 Elevated Walkways

Design of Plus 15 and Plus 30 elevated walkways, connecting two buildings, shall conform to The City of Calgary Design Guidelines for Plus 15 Structures (2019 edition) and the Alberta Building Code, unless specified otherwise.

2.3 Quality Assurance

Consultants shall submit a Quality Management Plan (QMP), specific to the scope of the project. The QMP shall include all stages of design and construction.

The QMP shall be updated as necessary to reflect specific quality checks throughout the duration of the project.

Compliance with the QMP shall be reported to The City on a regular basis throughout all stages of design and construction.

Non-compliance with the QMP shall be reported to The City and shall include, as a minimum:

i. Non-compliance issue
ii. Reason for non-compliance
iii. Rectification of the issue

2.4 Permits and Regulatory Approvals

Permit and Regulatory Approvals

Below is a list of potential legislation and permits that a project may be required to follow / obtain. Consult the City of Calgary's latest version of Stormwater Management and Design Manual Chapter 2: Authorizations and Processes for other authorizations and permits that may be required. As processes are continually changing it is the consultant's responsibility to research and identify relevant legislation, agreements, and permits that may be applicable. This list is not exhaustive.

Legislation potentially requiring permits/approvals:

Governing Legislation	Jurisdiction	Agency	FNC Trigger
Canadian Navigable Waters Act	Federal	Transport Canada	TC will send questions to the proponent to clarify impacts on navigation for First Nations
Fisheries Act	Federal	Fisheries and Oceans Canada	Yes, FN right to fish
Species at Risk Act and Recovery Strategy for Bank Swallow	Federal	Environment and Climate Change Canada	No
Historical Resources Act	Provincial	Culture and the Status of Women	Yes, if the area is identified having potential for indigenous traditional

			use
Public Lands Act	Provincial	Alberta Environment and Protected Areas Alberta Energy Regulatory (oil and gas related)	Yes, if the area is identified as culturally significant (i.e. former residential school site) or where treaty rights on public land will be significantly impacted (i.e. the bed and shore of a river and impacts to fish)
Wildlife Act	Provincial	Alberta Environment and Protected Areas	Potentially if doing a fish salvage, trapping of wildlife
Environmental Enhancement and Protection Act	Provincial	Alberta Environment and Protected Areas	Yes, if an application is required for associated stormwater infrastructure
Water Act	Provincial	Alberta Environment and Protected Areas	Yes

Legislation that does not require permits/approvals:

Governing Legislation	**Jurisdiction**	**Agency**	**FNC Trigger**
Migratory Bird Convention Act	Federal	Environment and Climate Change Canada	No
Canadian Environmental Protection Act (CEPA)	Federal		Potentially

City of Calgary Permits:

Governing Legislation	**Jurisdiction**	**Agency**	**FNC Trigger**
Development Permit	Municipal	City of Calgary *Land Use Bylaw 1P2007*	No
Hoarding Permit	Municipal	City of Calgary	No
Excavation Permit	Municipal	City of Calgary *Streets bylaw 20M88*	No
Utility Alignment Permit	Municipal	Appropriate utility provider	No
Overweight and Load Ban permit	Municipal	City of Calgary	No
Calgary Transit Work Permits	Municipal	City of Calgary	No
Drainage Permits (Stormwater, Wastewater)	Municipal	City of Calgary	No
Pathways ePermit	Municipal	City of Calgary	No
Parks Greenspace rental	Municipal	City of Calgary	No

City of Calgary approvals (when required) before construction:

Document	City of Calgary Approver
Tree Protection Plan	Urban Forestry
Habitat Restoration Plan	Urban Conservation
Biophysical Impact Assessment	Parks/Environment
Preliminary Natural Site Assessment	Parks/Environment
ECO Plan	Parks/Environment

3. GENERAL DESIGN CRITERIA

3.1 Design Life and Service Life

Unless Approved otherwise, the Design Life of new bridge structures shall be 75 years, as stipulated in the CHBDC.

Design Life of noise barriers and overhead sign support structures shall be a minimum of 50 years.

Service Life of bridges, retaining walls, river crossings, , and tunnels shall be 100 years, with the following exceptions:

i. Bridge size culverts shall be designed for a Service Life of 75 years.

ii. Steel culvert lining systems may be designed for a Service Life of 50 years if design provisions are made for future replacement of the lining.

Service Life of replaceable components shall be assessed based on manufacturer data, anticipated deterioration, and life-cycle maintenance.

Hydraulic design shall be in accordance with applicable regulatory authority and TAC Guide to Bridge Hydraulics.

3.2 Sustainability

Bridges and transportation structures shall be planned, designed, and constructed with consideration of principles of economic, social, and environmental sustainability considerations. Consultants are encouraged to use the following reference: Transportation Association of Canada (TAC) Sustainability Considerations for Bridges Guide.

Safety

Safety of the structures shall be assured through:

i. Application of design methodology based on Limit States in accordance with the CHBDC

ii. Choice of multiple load-path structural systems (unless Approved otherwise)

iii. Assurance of clear and continuous flow of forces and detailing

iv. Choice of materials that enhance durability and facilitate maintainability of the structures

Function

Functional requirements for a structure shall be established or Reviewed and Approved by The City. The design may proceed upon Approval of the functional criteria. Functional requirements include:

i. Purpose
ii. Use
iii. Location
iv. Environmental and socio-economic impacts
v. Any other applicable terms of reference

Provisions for, or impact on ALL users (that is, motorists, cyclists, pedestrians, wheelchair) shall be considered in the project functional definition.

Efficiency and Economy

The efficient structural design shall result in minimum use of structural materials as controlled by safety.

The design shall result in an economic structure. The economy of the design shall be based on minimum cost controlled by safety, serviceability, and lifetime maintenance.

Unless Approved otherwise, life-cycle costs shall be used along with initial construction costs in the cost analysis of alternative structure types.

Aesthetic Design

Aesthetic considerations, appropriate to function and location, shall be included in the design of bridges and structures.

Most City structures will be constructed in urban surroundings, and the visual impact of the structures on the environment shall be considered in the design.

The proportion and configuration of the bridge elements shall be compatible with the context of the space and the immediate environment. In the selection of the bridge type and its components, the following elements shall be considered:

i. Good visibility achieved through provision of large, under-span openings and avoidance of vertical lines of piers and walls close to the driving lanes.
ii. Visual continuity of the bridge form with topography of the environment.
iii. Superstructure geometry: an overall pleasing bridge line achieved through balanced span-to-depth proportion, smooth horizontal and vertical alignment, and camber or vertical crest curve of the bridge spans.
iv. Substructure geometry: shape and location of piers, and placement, height, and shape of abutments.
v. Clarity of function expressed by form.

vi. Harmony of all elements of the bridge expressed by compatibility, contrast, and rhythm of shapes, weight, and materials used.

Proper design of details is essential to producing aesthetic design of structures. The following elements shall be considered:

i. Use high-quality surface finishes.

ii. Use consistent and compatible shape and colour for all structure components.

iii. Carefully detail joints; in particular, expansion joints shall be designed to prevent the uncontrolled flow of water over concrete surfaces and to prevent staining.

iv. Control surface water runoff from the structures.

v. Use hidden pier caps, diaphragms, and screen walls.

vi. Carefully plan signage, lighting, and landscaping to complement the appearance of the structure and avoid clutter.

vii. Conceal construction joints in exposed concrete surfaces by reveals or other architectural details.

viii. Avoid smooth surfaces that may encourage graffiti.

Aesthetic design shall be submitted for Approval prior to proceeding to the detailed design phase.

Environmental Considerations

Bridges and structures shall be planned, designed, and constructed in accordance with the environmental requirements established for the project site. The design shall include assessment of possible environmental impacts and measures proposed to mitigate or minimize adverse impacts.

The environmental exposure conditions shall be evaluated for specific structures, their location, and micro-climatic exposure conditions.

The design shall consider balancing impacts of the project footprint, with elements of landscaping and methods of conservation of the natural environment.

Use of environmentally sustainable materials and methods of construction are encouraged. Materials and products shall be specified through conscientious choices of the sustainability characteristics, including:

i. Durability, thus enhancement of bridges and structures' Service Life

ii. Minimum use of natural, non-renewable resources

iii. Use of recyclable and recycled materials

iv. Minimum wastage of space, materials, and energy

v. Energy-efficient processes and products

vi. Innovative materials, systems, and solutions promoting sustainability

Where stipulated in the project scope, structure design shall incorporate features that minimize generation and propagation of noise.

Refer to Section 4.0, Bridge Geometry, for minimum slopes and grades, and Sections 6.8 and 6.9, Bridge Deck Drainage and Deck Drains, for drainage design requirements. Sustainable drainage solutions, such as bio-swales, are encouraged.

3.3 Special Considerations for Pedestrians, Cyclists, and Reduced Mobility Users

The design, evaluation, and rehabilitation of active transportation bridges shall be in accordance with CSA S7 Pedestrian, Cycling and Multiuse Bridge Design Guideline.

Planning Considerations

Planning and conceptual design of multiuse bridges and active transportation routes across vehicular bridges shall consider functional requirements, such as safety, good visibility, universal accessibility, and connectivity with adjacent pathways and public transportation facilities.

Design Requirements for Pedestrian Underpasses

Narrow and long pedestrian underpasses shall be avoided unless warranted for a specific location and Approved.

Should a pedestrian underpass be warranted, consideration shall be given to the following requirements:

- i. Visibility and security of users shall be protected through the use of Crime Prevention Through Environmental Design (CPTED) guidelines.
- ii. Length of the underpass shall be minimized, while the width and vertical clearance shall be maximized.
- iii. Adequate lighting shall be provided throughout the entire structural entry and exit areas, as per Clause 3.3.5.
- iv. Effective drainage shall be achieved through adequate cross-falls and slopes.
- v. The structure shall be durable, easy to maintain, and not encourage graffiti.
- vi. Aesthetics shall be adequate to the context.
- vii. Adequate wayfinding and clearances signage shall be provided.
- viii. Non-slip walking surface, such as asphalt or concrete, shall be provided.

Bridge Approaches

Considerations shall be given to provision of safe access and exit areas for active transportation structures, including:

- i. Good visibility at entrance and exit approaches, as well as across the structure
- ii. Safe connection to pathway and walkway systems
- iii. Directional railings
- iv. Grab rails if applicable
- v. Fence, signage or other means of directing pedestrian and cyclist traffic

vi. Approaches to pedestrian structures shall be fully accessible.

Lighting

Lighting design shall generally conform to The City of Calgary Design Guidelines for Street Lighting and the American National Standards Institute (ANSI) and Illuminating Engineering Society (IES) standard, ANSI/IES RP-8-18, American National Standard Practice for Design and Maintenance of Roadway and Parking Facility Lighting, latest edition.

Lighting for active transportation bridges located at LRT stations shall follow The City's LRT Design Guidelines.

Street lighting and pathway lighting shall be used for the illumination of pedestrian overpasses. In areas of transit-oriented design, a minimum average horizontal illumination value of 50 lux and average vertical of 20 lux is required for stairs, ramps and walkways, or as specified by the City's LRT Design Guidelines.

Minimal or no lighting may be appropriate for active transportation bridges located within parks or other natural areas, subject to Approval, following consideration of CPTED and safety evaluations, traffic volumes, and the use of the park.

Light standards shall not be located on pedestrian overpasses, except for river crossings or where Approved otherwise.

Should light standards be required on active transportation bridge structures, their locations shall be considered at piers and abutments only.

Fatigue impacts of lights standards shall be evaluated, and the design shall be submitted to The City for Review.

Table 3.3 lists the recommended minimum lighting design criteria for pedestrian tunnels and underpasses.

Table 3.3 – Recommended Minimum Lighting Design Criteria for Pedestrian Tunnels and Underpasses

Time	E_{avg}(lx/fc)	Ev_{min}(lx/fc)	E_{avg}/ E_{min}
Day	100/10	50/5	3
Night	40/4	20/2	3

Notes:
lx/fc = lux per footcandle(s)

3.4 Special Consideration for Rehabilitation of Bridges and Transportation Structures

Functional Improvements

Functional improvements for a bridge shall be considered and submitted for Review and Approval by The City during the rehabilitation preliminary design phase.

Consideration shall be made regarding the following:

- Connectivity to an existing pathway network or missing link
- Alignment to the City's 5A Network or other Council approved policies
- Alignment to City's requirements for a multi-use pathway (MUP)
- Required upgrades to the adjoining sidewalks/pathways
- Adequacy of existing bridge barriers and railings to current codes and standards, including height for cyclists
- Review of bridge width and traffic lane configuration, and options for optimizing bridge cross section for prioritizing active modes and accessibility and reduced mobility users
- Any recommended environmental and climate adaptation upgrades

Collecting pedestrian, cyclist and vehicle count data should be considered to confirm the existing demand and to support any changes to the bridge's level of service. The site context and amenities such as schools, regional pathways, parks, retail, and transit stops that would support a pedestrian facility enhancement shall be reviewed.

For bridges that require widening of the structure:

- Determine the maximum width the bridge can be widened utilizing existing structural capacity and the resulting MUP width from this analysis.
- To meet the standard or recommended MUP width, determine any requirements for structural strengthening.

Constructability of a widening options:

- Determine if the bridge can be widened while also accommodating vehicle traffic.

Lighting

The existing lighting levels for pedestrian and vehicular areas should be determined through lighting studies on site during the preliminary design phase, and compared to the current standards as specified in Section 3.3.5

Consideration for lighting improvements should be recommended as part of the preliminary design phase.

Functional improvements shall also include environmental and socio- economic impacts and any other applicable considerations defined in the terms of reference.

4. BRIDGE GEOMETRY

4.1 Vertical Clearances

Vehicular Bridges

Vertical clearance over roadways shall be minimum 5.4 metres (m) (posted), plus 0.1 m to account for construction tolerance, long-term deformations, and future paving.

Vertical clearance over the federal railways shall be minimum 7.16 m (or 23 feet, 6 inches) above the base of the rail.

Vertical clearance over LRT tracks shall be a minimum 6.0 m above the top of rail.

Active Transportation Bridges, Underpass, and Sidewalks

Vertical clearance over roadways shall be minimum 5.7 m (posted), plus 0.1 m to account for construction tolerance, long-term deformations, and future paving.

Vertical clearance over pedestrian pathways and bikeways shall be minimum 3 m, unless Approved otherwise. This will be measured from the pathways and bikeways to the underside of the structure, plus 0.1m to account for construction tolerance, long-term deformations, and future paving.

Vertical clearance over pedestrian pathways and bikeways located in tunnels and underpasses shall be minimum 3.6 m, plus 0.1 m to account for construction tolerance, long-term deformations, and future paving, unless otherwise Approved.

4.2 Horizontal Clearances

Vehicular Bridges

Horizontal clearances shall include considerations for any future widening plans of the roadway below (where applicable).

Horizontal clearances shall include substructure protection by traffic barriers designed in accordance with the CHBDC, unless the clear zone requirements are met.

Active Transportation Bridges, Underpass, and Sidewalks

Minimum clear widths are outlined in **Table 4.2.**

Table 4.2 – Minimum Clear Widths *

Land Crossings	
A. Pathways and sidewalks integrated with interchange bridge structures:	
Part of regional pathway system	3.0 m
Part of pathway system	2.5 m
Part of sidewalk system	2.0 m
B. Stand-alone structures:	
Stand-alone pathway underpasses	3.0 m
Stand-alone pathway overpasses	3.0 m
River Crossings	
A. Pathways and sidewalks integrated with vehicular bridge structures:	
Part of pathway system	3.0 m
Part of sidewalk system	2.5 m
B. Stand-alone bridges	4.2 m

Notes:

Some locations may require a wider structure, based on site-specific analysis (including land use, expected user volumes)

*Unless otherwise approved

4.3 Grades and Slopes

Vehicular Bridges

Vehicular bridges shall have a minimum grade of 1%, unless otherwise Approved.

Roadway cross-falls shall be 2%, except on super-elevated road alignments, where special assessment of safety and drainage may be required.

Construction of bridges on spiral horizontal alignments shall be avoided unless Approved.

Safety and drainage analyses shall be required to justify exceptions.

Active Transportation Bridges, Underpasses, and Sidewalks

Longitudinal grade on bridge spans shall be minimum 1% and maximum 5%.

Approach ramps shall be designed with 9-m-long segments sloping up to 1/12 (8.33%) and intermittent landings 1.5-m-long with 1% longitudinal slope (to facilitate drainage).

Active transportation bridge decks shall be designed for positive drainage with min. 1% crowns or cross-falls. 1% longitudinal grade min. shall be provided on landings.

Sidewalks integrated with vehicular bridges and active transportation bridge decks shall be provided with a min. 1% cross-fall, sloping towards the roadway and a minimum 1% longitudinal grade, unless otherwise Approved.

4.4 Approach Slabs

Vehicular Bridges

Vehicular bridges shall be provided with reinforced concrete approach slabs anchored to the abutments.

The approach slab shall extend to the lateral limits of the roadway but shall not be integral with the curbs or barriers or wingwalls to allow differential settlement to occur, unless otherwise Approved.

Longitudinally, the approach slab shall not extend into the intersecting roadway.

Active Transportation Bridges, Underpasses, and Sidewalks

Active Transportation bridge approach slabs, if used, shall be anchored to the abutments and shall have a surface finish and slopes consistent with these on the structure.

4.5 Horizontal Layout

Vehicular Bridges

Vehicular bridge layout shall be based on the roadway geometry and shall include allowance for bridge inspection and maintenance (that is, access for maintenance equipment).

Active Transportation Bridges, Underpass, and Sidewalks

Tight switch-back alignment of ramps shall be avoided. Switch-back landings shall be round-shaped and shall allow for unobstructed sight lines for both downward and upward traffic. Cargo lengths bicycles shall at a min. be able to navigate turns at min. 10km/hr. Additionally, maintenance equipment shall be able to navigate turns and allowance for turn-around locations for maintenance vehicles shall be provided in the project.

Spiral ramps, if Approved, shall have a minimum radius of 25 m and shall conform to vertical clearance requirements.

Landings at entry and exit areas shall facilitate the anticipated traffic to and from the bridge and shall safely direct the traffic to the connecting pathways.

Wayfinding features, landscaping, public art, and viewing features are encouraged within the approaches of pedestrian crossing facilities.

4.6 Other Requirements

Accessibility

Design of access ramps for active transportation bridges shall take into consideration The City of Calgary Access Design Standards.

The geometric design may be constrained by the land availability. In that case, an Approval of an alternative accessibility feature is required.

Access via stairs only requires Approval.

Grab Rails and Railing

Pedestrian railings shall be 1,050 millimetres (mm) high. Bicycle or mixed-use bridge railings shall be 1,400 mm high.

Pedestrian railings shall be constructed such that the maximum clear distance between solid elements (that is, vertical pickets or posts) of the railing shall not exceed 100 mm within a height of 1,050 mm.

Pickets shall not be required between the top pedestrian rail and horizontal bicycle rail.

In some locations, railings higher than 1,400 mm may be required. Refer to project-specific requirements.

Grab rail at the height of 865 mm to 965 mm (from wearing surface to top of rail) shall be required on all sloped ramps and the intermittent landings. Grab rail section diameter shall be between 30 and 43 mm.

Grab rails are required on pedestrian bridges with approach ramps, unless otherwise Approved. Exceptions may be considered for bridges with less than 5% longitudinal grade, upon Approval.

Design of railings shall discourage climbing and shall be subject to review by The City. Posts and pickets shall be vertical.

Light Rail Transit

For bridges located over LRT tracks, railings shall be grounded per The City of Calgary Transit LRT Design Guidelines

For bridges located over LRT tracks, protective shrouds shall be required over the catenary wires. Refer to the LRT Design Guidelines for details.

Additional design requirements may be provided by Calgary Transit for specific project elements.

Tall street structures, such as cable-stay towers or up-stand arches, shall be grounded.

Clear Zones and Crash Walls

Structural elements located within the LRT, Canadian Pacific Kansas City (CPKC) or Canadian National Railway (CN) clear zones shall be protected by a suitably designed crash wall.

Bridge supports located within clear zones shall be protected in accordance with the CHBDC.

4.7 Finishes, Curb, and Joints

Pedestrian wearing surfaces shall be broom finished or shall have an Approved non-slip finish.

Pedestrian overpass and bridge sidewalk curbs shall be minimum 75 mm high unless otherwise Approved.

Concrete bridge barriers located between roadway and sidewalk shall be furnished with control joints spaced such that their locations coincide with sidewalk-to-roadway drainage openings.

Pedestrian deck expansion joint cover plates shall be coated with PPG Protective & Marine Coatings SFT 675 (grey) non-slip coating or Approved equivalent.

4.8 Camber and Deflections

Bridges shall be built to match the profile grade after permanent dead load has been applied.

Steel girders typically shall be cambered for 100% of dead load effects. Self-weight, superimposed dead loads, and final roadway grade line shall be considered. Data shall be presented on a camber diagram on the Drawings that show overall camber, as well as net camber values for individual fabrication segments.

For precast girders, camber and deflection diagram(s), including effects of prestressing, post-tensioning, and stages of construction, shall be shown on the Drawings. Camber shall be designed to include the effects of creep and shrinkage. The design height of haunches shall be shown on camber diagrams. Verification and adjustment of the height and reinforcing of haunches shall be made at all applicable stages of construction.

For cast-in-place (CIP) concrete superstructures, elevations for setting of forms, camber, and deflection shall be shown on the Drawings.

Deflections on Pedestrian Bridges

The following maximum limits of live load (LL) deflections shall apply:

i.	Pedestrian Load	Span/500
ii.	Maintenance Vehicle Load	Span/500
iii.	Cantilever due to Pedestrian LL	Cantilever Length/300
iv.	Horizontal Deflection due to Wind	Span/500

These limits shall not replace other serviceability design criteria, provided in the CHBDC and the Commentary, which may result in more stringent deflection limits.

5. LOADS AND LOAD EFFECTS

5.1 General

Bridge and structure design shall be based on the limit states philosophy, with equal emphasis being given to ultimate limit states (ULS), serviceability limit states (SLS) and fatigue limit state (FLS), in accordance with the CHBDC and CSA S7 as applicable.

Service Life design shall provide an adequate plan for supporting the assumptions of the Limit States design.

5.2 Live Load

The design live load for new bridge structures shall be a CL-800 truck load increased by dynamic load allowance or CL-800 lane load. The uniformly distributed portion of the CL-800 lane load shall be 9 kilonewtons per metre (kN/m) and shall have a width of 3.0 m.

Overload trucks shall not be used for new bridge design.

The design live load for bridge rehabilitation shall be CL-625 truck load or CL-625 lane load.

Existing bridges shall be evaluated using Load Evaluation Trucks CL1-800, CL2-800, and CLS-800 and specific overload trucks provided by The City.

5.3 Pedestrian Load

Pedestrian load shall be included in the design for all designated occupancy areas, such as sidewalks and pathways on bridges, or pedestrian bridges and ramps, in accordance with the CSA S7.

Pedestrian dynamic loading is an important consideration for pedestrian bridges. The most dynamically susceptible bridges would be those having vertical natural frequencies of 1.7-2.4 hertz (Hz) and horizontal frequencies less than 1.3 Hz. Careful dynamic analysis and design of dynamic response control system may be required.

5.4 Maintenance Vehicle Load

Maintenance Vehicle Load shall be considered, along with snow load on a bridge where the geometry of the facility warrants entry of small snow removal vehicles.

Maintenance Vehicle Loads for sidewalks on bridges shall be included at the ULS only.

Maintenance Vehicle Loads for active transportation bridges shall be considered at both the ULS and SLS.

5.5 Multiple Use Structure Loads

For live loads and load factors on bridges that carry LRT in addition to vehicular traffic, refer to The City of Calgary Transit LRT Design Guidelines.

5.6 Vehicle Collision Load

Bridge piers located within 10 m from the edge of the road pavement shall be designed for a collision load, regardless of the presence of guardrail, unless otherwise Approved. The magnitude and application of the equivalent horizontal static force shall be in accordance with the CHBDC.

LRT underpasses shall be designed for a collision load as specified in The City of Calgary Transit LRT Design Guidelines; however, in no case shall the total factored load effect of the collision load and the relevant load combination be less than that specified herein.

5.7 Construction Loads

Construction dead load shall include weight of materials, formwork, falsework, stationary lifting devices, and equipment.

Construction live load shall include weight of workers, equipment, and other elements subject to movement during construction at the construction stage considered.

Concurrent loads due to wind, ice, stream flow, and temperature change shall be considered at a 10-year return period, as applicable.

The magnitude and type of construction loads included on the design shall be clearly described on the Drawings.

5.8 Seismic Loads

Seismic analysis and design shall be based on requirements pertinent to Seismic Performance Zone 1 in the CHBDC.

5.9 Methods of Analysis

A simplified method of analysis may be used for short- and medium-span bridges conforming to the conditions stated in the CHBDC.

Regardless of the method of analysis, load distribution factors used for girder design shall be shown on the Drawings.

All relevant structural responses, including time-related deformations, shall be analyzed. Refined methods of analysis shall be selected based on the criteria outlined in the CHBDC.

5.10 Diaphragms

Intermediate diaphragms are required in bridges with steel or concrete girders and concrete deck systems, unless otherwise Approved. Concrete diaphragms are required over piers supporting concrete superstructures.

5.11 Construction and Temporary Load Conditions

During design, evaluation of the structure for the following temporary construction load conditions shall be performed:

i. Prior to superstructure installation, where applicable

ii. During all stages of superstructure installation and deck casting

The assumed magnitude of construction loads, methodology, and sequence shall be included in the Drawings Notes. Any deviation from these assumptions made by the contractor shall be submitted to the designer for review and approval.

The EOR shall review the proposed changes if applicable.

6. DURABILITY

6.1 General

Consideration shall be given in all aspects of design to minimizing the deterioration of the structure components and systems, and to ensuring the anticipated performance during their Service Life.

Structural design and detailing shall focus on minimizing the impacts of such environmental factors as temperature variations, snow, ice, salt, rain, wind, and solar radiation. The relevant site investigation shall include testing of soils, groundwater, local runoff water, and atmospheric pollution levels and, where applicable, drainage system discharge, to detect corrosive substances.

Durability shall be ensured by selection of the proper structural systems, adequate design for strength and serviceability, choice of materials, as well as adequate detailing and quality assurance (QA) and quality control (QC) during design, fabrication, and construction.

Mixing different types of concrete mixes within one structural element shall not be allowed unless the structural elements are separated by separation joints or unless Approved.

Traffic Splash Zone and Severe Environmental Conditions

The Traffic Splash Zone is defined as 5.8 m above and 10 m away from the roadway pavement surface and extents, respectively.

Structures are subject to severe environmental conditions (SECs) when exposed to de-icing chemicals, freeze-thaw, and prolonged moisture conditions.

Structure surfaces within the Traffic Splash Zone are exposed to SECs. If a portion of a structural element is within the Traffic Splash Zone, then the entire structural element is to be considered exposed to SECs.

6.2 Concrete Structures

The drawings and specifications shall indicate the concrete strength, exposure class, and concrete mix type to be applied to each concrete element.

The following Standard Technical Specifications applicable to concrete structures and components are included in Appendix C of these Guidelines:

Section 02466	Drilled Concrete Piles
Section 02850	Noise Barriers
Section 03300	Cast-In-Place Concrete
Section 03200	Concrete Reinforcement
Section 03301	High-Performance Concrete
Section 03302	Precast Concrete Supply, Fabrication, and Installation
Section 03483	Mechanically Stabilized Earth Retaining Walls

Durability of concrete structures shall be achieved through:

i. Diligent design and thorough detailing
ii. Use of high-performance materials
iii. Selection of and protection of reinforcing steel
iv. Application of concrete sealers and deck protective systems

6.3 Concrete Cover to Reinforcing

The requirements for concrete cover over reinforcing steel shall be as shown in Table 8.5 of the CHBDC, except as specified in **Table 6.3** of these Guidelines.

Table 6.3 – Surfaces Exposed to De-Icing Chemicals, Cover to Principal Reinforcing[a.]

Structure Element	Concrete Cover[b,c.] and Tolerances
Concrete Decks	
Top Surface	70 + 5/-10mm
Soffit	50 + 10mm
Traffic Barriers	
Front Surface	70 – 5mm
Back Surface	70 – 5mm
Median, Curbs	60 + 10mm / -0mm
Substructures and Retaining Walls[d.]	70 +10mm / -0mm
Precast T, I, and Box Girders[e.]	
Soffit	40 + 10mm / -0mm
Exterior Surface	35 + 5mm / -0mm
Precast Panels for Retaining Walls	60 + 10mm / -0mm

Notes:

[a] Carbon and galvanized steel

[b] Average concrete cover as placed shall conform to the specified values, excluding the tolerances (i.e., tolerances shall apply to construction only).

[c] Concrete cover to stainless steel and non-metallic reinforcement may be reduced by 10 mm.

[d] Front surface within Traffic Splash Zone.

[e] Girders of bridges spanning over the roadways shall be considered exposed to de-icing chemicals.

The applicable concrete covers shall be shown on the Drawings.

For bundled bars, the concrete cover shall be the smaller of the diameter of a single bar having an area equal to that of the bundle and 50 mm, but not less than that given for single bars. Bundled bars shall not be specified for use within 100 mm of surfaces exposed to SECs.

Anchorages and mechanical connections for bars shall have a concrete cover of at least that specified for reinforcing bars.

Anchorages and mechanical connections for post-tensioning tendons shall have a concrete cover sufficient to eliminate concrete splitting, and not less than that specified for post-tensioning ducts.

When deformed reinforcing bars are in contact with other embedded items, such as post-tensioning ducts, the actual bar diameter, including deformations, shall be considered in determining the design dimensions of concrete members in applying specified concrete covers.

6.4 High-Performance Concrete

High-performance concrete (HPC) shall be used for structure components exposed to SECs. Typically, the following elements shall be constructed using HPC:

i. Bridge decks on concrete or steel girders, including diaphragms, blockouts, and grout keys
ii. Exposed CIP concrete superstructures
iii. Bridge substructure components and earth-retaining structures within the Traffic Splash Zone (Clause 6.1.4)
iv. All concrete curbs, medians, bridge sidewalks (pathways), sign and light standard supports, and walls within the Traffic Splash Zone
v.
vi. Bridge abutment back walls, screen walls, and full depth of wing walls
vii. Precast girders
viii. Bridge approach slabs

HPC need not to be used where corrosion-resistant, non-corrosive reinforcing has been specified, subject to Approval.

Use of HPC for specific elements of the structures shall be shown on the Drawings and shall be Approved.

Standard Technical Specification Section 03301, High Performance Concrete, included in Appendix C, shall be used for construction of applicable HPC components, unless otherwise Approved. Any modifications to Section 03301 require Approval.

In accordance with CSA A23.1, Concrete materials and methods of concrete construction, Clause 4.1.1.1.3, where more than one exposure condition applies, if sulphate concentrations are present in combination with determined exposure to chlorides, sulphate-resistant cement shall not be used. HPC shall be used instead.

6.5 Protective Coatings

Post-tensioning Ducts

Sheaths for internal post-tensioning ducts shall be made of bright steel, galvanized steel, or polyvinyl chloride (PVC).

Concrete Inserts

Exposed inserts and plates shall be protected from corrosion by Approved methods, such as stainless steel material.

Corrosion Protection for Reinforcement

The following reinforcing material may be included in the design of the bridge and structure components exposed to severe conditions, as described in Section 6.1.4 of these Guidelines. Approval of the proposed corrosion protection system is required.

i. Low-grade duplex stainless steel
ii. Hot-dip galvanized reinforcing steel grade 400W, meeting requirements of Section 8 of the CHBDC for reinforcing steel.
iii. Non-metallic concrete reinforcing as fibre-reinforced polymers (FRP) upon Approval

iv. Low carbon, chromium reinforcing steel confirming to ASTM A1035/A1035M-20.

Epoxy-coated reinforcing steel shall not to be used except in special cases, upon Approval.

Detailing of reinforcing steel shall be compatible with the type of protection system used. Special care during handling, installation, and concrete placement will be necessary to avoid abrasion of coating.

Galvanized reinforcing shall be fabricated, galvanized, handled, and placed in accordance with Standard Technical Specification Section 03200, Concrete Reinforcement, included in Appendix C. ASTM A767/A767M, Standard Specification For Zinc Coated (Galvanized) Steel Bars For Concrete Reinforcement, shall be used for galvanizing reinforcing steel, as modified by Standard Technical Specification Section 03200.

Use of dissimilar metals in contact may form a galvanic cell and shall be avoided. Alternatively, the dissimilar metals shall be separated by use of Approved non-corrosive materials. Method of separating dissimilar metals shall be clearly shown on the Drawings.

Sealers

Only Approved sealers shall be used. Designers shall refer to the current version of Alberta Transportation list of approved concrete sealers. Classification of sealers conform to Alberta Transportation concrete sealer classification. All sealers shall be applied in accordance with the manufacturer’s recommendation. The drawings and specifications shall indicate what classification of sealer is to be applied to each concrete element.

Penetrating sealers (Type 1c for new concrete, Type 1b for existing and repaired concrete) shall be used in the following structural elements, unless otherwise specified and Approved:

i. Exposed (that is, not paved) surface of bridge decks
ii. All exposed surfaces of medians and curbs, except for surfaces coated with pigmented sealers
iii. Bridge sidewalks and pedestrian bridge decks
iv. Bearing seats

Pigmented sealers (Type 3) shall be applied to the following structure elements:

i. Exterior (side) surface of superstructure
ii. Soffit of superstructure of pedestrian bridges
iii. Soffit of exterior girders
iv. Deck fascia, including soffit of cantilevered deck
v. Concrete railing balustrades all surfaces
vi. Substructure of pedestrian bridges and highway bridges (unless specified otherwise by The City)
vii. Traffic barriers, all surfaces
viii. Other structural installations and elements, such as retaining walls or noise walls, as required by site-specific design considerations and as Approved

Banff Beige and Concrete Gray pigmented (Type 3) sealers are typically used for these applications, unless otherwise Approved.

6.6 Structural Details

Structural detailing shall include provision of air circulation within the structural components. All formwork material shall be removed from the superstructure elements, such as box girders, unless otherwise Approved.

Steel stay-in-place forms shall not be used. Concrete stay-in-place forms may be used, subject to Approval.

Voids, drain holes, and other structure discontinuities shall be detailed to prevent entry of birds, insects, or animals.

Surfaces that are susceptible to nesting of birds shall be protected by use of bird deterrent. Proposed system is to be submitted for Approval.

Bearing seats shall be designed to minimize exposure to salt-laden water runoff or accumulation of debris. The bearing seats shall be sloped at 3% away from the bearing assemblies. Level areas suitably sized for jacking of the superstructure during bearing replacement shall be provided and detailed such that water runoff is not blocked.

Dapped-end girders and step-support configuration are not permitted unless Approved.

Structural elements shall be detailed to minimize the number of pockets, recesses, and other means of water and debris traps. Pockets or recesses in the top surface of bridge decks are not permitted.

Precast concrete element connections using steel hardware exposed to environmental conditions are not permitted.

Acceptable locations of construction joints shall be shown on the Drawings.

Bridge deck joints may be a source of structural deterioration, thereby giving rise to a major bridge maintenance demand. Consideration shall be given to minimizing the use of expansion joints by providing deck slab continuity at intermediate supports and, where feasible, to semi-integral abutment system.

Expansion joint glands shall be resilient to traffic and roadway debris abrasion.

Joints between bridge abutment back wall and approach slab, or between integral superstructure and approach slab, shall be sealed.

Concrete slab elements, such as vehicular bridge integrated sidewalks and pedestrian bridge decks and ramps, shall be detailed to include control joints capable of sustaining local extreme heat temperatures.

6.7 Drainage

A nominal slope shall be provided on the surfaces of concrete elements to facilitate drainage away from the structure. Water shall be directed to appropriate catch basins or settling areas.

The use of swales is recommended adjacent to walls to help direct water away from the structure.

Drainage measures shall be clearly outlined on the Drawings. Preliminary design of the drainage system shall be submitted for review by The City at the preliminary design review stage.

6.8 Bridge Deck Drainage

For minimum grades and slopes, refer to Section 4.0, Bridge Geometry.

Vertical curves on bridge decks shall provide a minimum grade of 1%, unless otherwise Approved. If the longitudinal grade is less than 1%, additional drains or special sloping of the gutters may be required.

Deck drainage shall not be discharged on unprotected embankments or any travelled way (either vehicular, railroad, or pedestrian). When applicable and feasible, drain pipe shall be hidden from the view of oncoming traffic.

Special consideration shall be given to drainage design of bridges with decks on horizontal curves. Additional drainage measures will be required in those areas of superelevated surfaces to avoid ponding.

Long-term deformations, such as creep, shall be considered in the design of bridge deck drainage.

6.9 Deck Drains

Bridge deck drainage requirements shall be determined based on project-specific design and drainage volume analysis, based on the most updated local rainfall data. Bridge drains are generally not required on bridge structures less than 100 m long if they have full-width shoulders, adequate cross-slopes, and adequate catch basins on the bridge approaches.

Drains shall be located in the areas of maximum flow. Drains shall be of minimum 200-mm diameter for roadway bridges and 100-mm diameter for pedestrian bridges. For the protection of pedestrians, one dimension of each opening shall not be greater than 50 mm. The grate inlet top surface shall be set slightly lower than the surrounding finished surface, and the finished surface shall be slightly dished around the inlet. The dishing shall not be deeper than 20 mm.

Bridge drainage systems shall avoid horizontal runs of drain pipe if a reasonable modification to the design of scupper spacing permits the placement of drains adjacent to piers at the low end of spans. Where horizontal runs of drain pipe cannot be avoided, the minimum slope shall be 8% or unless other means of protection against freezing and clogging are used.

The use of scuppers for deck drainage shall be minimized. Scuppers or deck drains shall pipe the drainage to the stormwater drainage system. All drainage hardware shall be galvanized.

Deck waterproofing membrane shall be adequately detailed around deck drains and along the gutter lines to disallow water penetration underside the membrane.

6.10 Drip Grooves

Continuous drip grooves underside of outer edge of superstructure shall be provided.

Drip grooves shall be 20 mm deep and minimum 50 mm wide.

Minimum cover to reinforcing shall be maintained at the drip grooves.

6.11 Utilities on Bridges and Structures

The application process for utility providers appears in The City's Application Process for Utilities on Bridges and Structures in accordance with Bylaw Number 17M2016, Municipal Rights-of-Way.

These Guidelines apply to both newly constructed City-owned bridges and structures and to existing bridges and structures.

No fluid-carrying or gas utility lines shall be placed on or under the bridge superstructure, unless otherwise Approved.

Utility attachments may create interference with future work, including scheduled and unscheduled maintenance of City-owned infrastructure. Such work can result in disruption of the utility in the process. For these reasons it is The City's policy to discourage utility attachments to bridges or structures. Utility Owners are required to seek alternative routes to accommodate their own infrastructure whenever possible.

The City shall retain full ownership of any conduits, ducts, fluid and gas carrying pipes, manholes, pullboxes, and access points it constructs in or on or its bridges and structures.

Should the Utility Owner demonstrate to The City's satisfaction that no other route is feasible, The City retains the right to install the conduit, duct, or fluid and gas carrying pipes, and shall work with the Utility Owner to ensure conduit, duct, or fluid and gas carrying pipe space addresses the need of the applicant in so far as the bridge or structure design allows. Conduit, duct, or fluid and gas carrying pipe space shall be allocated by The City on a fair and equal basis.

All Utility Owners wishing to place infrastructure across or adjacent to bridges and structures will require a current Municipal Consent and Access Agreement (MCAA) or equivalent agreement with The City. As-built Drawings shall be provided to The City according to the terms and conditions outlined in the MCAA.

Licensing rates are available from The City. Carriers shall sign a licensing agreement with The City.

As a condition of the Approval to licence conduit or duct space, or the Approval to attach to City-owned bridges or structures, the Utility Owner shall agree that the infrastructure it deploys is not the sole method of access for any emergency service and that alternative routing can be used in the event that their infrastructure on the bridge or structure is compromised by any act, including fire, flood, or vehicle strike.

Should The City choose not to construct, but grant Approval to the Utility Owner to construct or attach, such construction shall be in accordance with the following:

i. Utilities, if Approved, shall be placed in non-corrosive-type conduits, located in non-structural elements or in low-stress areas of secondary components. All utilities and attachments shall be of non-corrosive material or galvanized steel. The attachments to primary structural elements, if Approved, shall not compromise the structural integrity or long-term durability of structures. Attachments to bridge deck soffit will not be permitted.

ii. At transition points, such as expansion joints, couplings, and fittings, shall be capable of accommodating the bridge transition. An allowance shall be made for a vertical movement due to bridge jacking during bearing replacement.

iii. The proposed technical information regarding utility conduit details, alignment, supports, and attachments to a structure shall be submitted to for Review. All comments and revisions shall be implemented, and final documentation shall be authenticated by a Professional Engineer registered in the Province of Alberta and filed with The City for Approval.

6.12 Steel Structures

The following Standard Technical Specifications applicable to steel structures and components are included in Appendix C of these Guidelines:

Section 05120	Structural Steel Supply and Fabrication
Section 05500	Metal Fabrications
Section 05650	Bridge Bearings
Section 05820	Expansion Joint Assemblies
Section 09719	Coatings for Steel

Uncoated Weathering Steel

The suitability of weathering steel for bridges shall be assessed on a case-by-case basis.

A proposal to use weathering steel shall be submitted for Review, and consideration shall be given to the context of surroundings, aesthetic design, and life-cycle durability.

6.12.1.1 Handling and Cleaning

Weathering steel, if Approved, shall be cleaned and handled in accordance with the Standard Technical Specifications.

Substructures shall be protected from staining by proper detailing of steel girders, application of protective coating in the proximity of the substructure, and channeling of water runoff from the steel girder surfaces along bearing seat concrete to a grooved flute down the substructure wall as applicable.

Painting of the exterior girder and fascia may be required as an aesthetic enhancement.

Corrosion Protection

6.12.1.2 Dissimilar Metals

Careful attention shall be given in selecting combinations of metal components that do not promote corrosion of dissimilar metals.

Provisions shall be made to provide proper separation of dissimilar metals if the use of dissimilar metals is unavoidable.

Use of separation materials or coatings shall be detailed in Drawings where dissimilar metal contact may occur.

6.12.1.3 Stainless Steel

Use of stainless steel as a corrosion protection system is encouraged.

Grade of stainless steel shall be selected for the type of exposure conditions and functional application.

6.12.1.4 Structural Steel Paint System

If Approved, steel structures may be painted with an Approved, high-quality, durable coating system.

All structural steel bridge members that require paint coating shall receive a three-coat paint system in accordance with Standard Technical Specification Section 09719.

A warranty form for the paint system is included in Appendix D of these Guidelines. When a painting system is used. this form shall be included with the Procurement Documents.

6.12.1.5 Galvanizing

Galvanizing of Structural Steel Members

Galvanizing of structural steel shall be performed in accordance with Standard Technical Specification Section 05120, Structural Steel.

Repairs of galvanized elements shall be made using sprayed zinc (metalizing), unless otherwise Approved.

If Approved, galvanized elements may be repaired using zinc-rich paint, such as ZINGA. Zinc-rich paint shall contain a pure zinc content of at least 95%.

Galvanizing of Bolts for Bridges

All anchor bolts, tie-down hardware, and miscellaneous steel (including ladders, platforms, grating) hardware shall be hot-dip galvanized.

ASTM F3125/F3125M Grade A325M (fine thread) bolts, if required, shall be mechanically galvanized when used (mixing not permitted) either with galvanized steel components, or coated with single-coat inorganic paint systems when slip-critical connections are used.

Galvanizing of Bolts for Miscellaneous Structures

Bolts for connections of structural steel members of miscellaneous structures other than bridges, including overhead sign structures, traffic mast arms, and ground-mounted signs, shall be –ASTM F3125M, Grade A325M, and shall be hot-dip galvanized, or stainless steel, unless otherwise Approved.

Design and Detailing

6.12.1.6 Deck Joints

Generally, steel-girder superstructure shall be combined with jointless concrete deck construction.

Deck joints on steel girder superstructures shall be erected by bolting to girders. Bolted connections shall use slotted holes to provide adjustment in all directions.

6.12.1.7 Steel Girders

Vertical connection plates, such as transverse stiffeners, which are used for connecting diaphragms or cross-bracing, shall be rigidly connected to girder flanges.

End-diaphragms shall be a minimum of 50% of girder depth for wide flange girders and 75% of girder depth for plate girders.

Crevice-creating details shall be avoided when possible; therefore, the use of stiffeners and bracing shall be minimized.

6.12.1.8 Fracture-Critical Elements

Fracture-critical elements and primary tension members shall be clearly identified on the Drawings.

WT (or AT) steel grades in compliance with CSA G40.20/21, General requirements for rolled or welded structural quality steel/Structural quality steel, or Approved alternate grades, shall be used for all fracture-critical and primary tension members.

Charpy V-notch test values specified shall be appropriate for the nature of the element and for the design service temperature and shall be consistent with the requirements of the CHBDC.

6.12.1.9 Welding

Field welding is not permitted, unless otherwise Approved. All Approved field welds shall be detailed on the Drawings.

Steel structural elements shall be welded using continuous welds, regardless of structural requirements.

Prior to the commencement of steel fabrication, a meeting shall be set up with the fabricator, Contractor, Engineer, and The City representatives to discuss the fabrication process and QA/QC procedures.

Welding of steel members after galvanizing is generally not acceptable. In some exceptional cases, upon submission of a detailed procedure, welding of steel components after galvanizing may be allowed.

QA/QC requirements for the welding program shall be project-specific, and any Approved variance from the Standard Technical Specification shall be clearly outlined on the Drawings.

6.13 Masonry Structures

The following Standard Technical Specification applicable to masonry structures, such as noise walls, is included in Appendix C of these Guidelines:

Section 02850	Noise Barriers

Only pre-approved masonry products and systems shall be used for noise walls and retaining walls.

Masonry products shall not be used for highway-loaded ramps or retaining walls in Traffic Splash Zones (Section 6.1.4), unless otherwise Approved.

6.14 Other Materials

The composition, properties, and performance of materials not specifically covered in these Guidelines or in the reference standards shall be specified by considering design loads and environmental degradation during the structural component’s Service Life.

All new materials and products proposed for application in bridges and structures shall be pre- Approved or submitted for Review and Approval.

6.15 Inspection and Maintenance Access

Provisions shall be made in bridge design and detailing to accommodate routine bridge condition inspections of all bridge components.

Sizes, location, and clearances shall be designed to enable access to all components for inspection and maintenance activities.

6.16 Overlays

Unless otherwise Approved, vehicular bridge decks approach slabs shall receive a deck waterproofing membrane complete with protection board and two layers of asphalt overlay in accordance with Standard Technical Specification Section 07100 included in Appendix C.

Polymer modified asphalt overlay may be used for some specific bridge locations, such as widening of an existing structure with similar overlay or in deck rehabilitation, in accordance with the Standard Technical Specifications Sections 02510(a) and 02510(c).

6.17 Construction

The quality of materials, construction or performance standards, and performance of final products shall be specified on Drawings or in the Technical Specifications. QA standards and methods shall be specified on Drawings and in the Technical Specifications.

Conformance of the construction with the Technical Specification and Drawings is vital to achieving durability of structures consistent with the Service Life design. Deviation from construction methods from those assumed by the Engineer may cause load effects, built-in stresses, and component resistances different from those anticipated in the design. Construction loads and methods assumed and accounted for by the designer shall be outlined on the Drawings.

The EOR shall be responsible for verification of construction compliance in accordance with the Agreement.

Alternate methods of construction may be proposed by a Contractor to the EOR for review and consideration. A recommendation authenticated by the EOR shall be submitted to The City prior to commencement of the proposed alternate method of construction.

7. SERVICEABILITY LIMIT STATES

7.1 General

Structural components shall be designed to satisfy the requirements for:

i. Crack control

ii. Stress limits

iii. Deformation control

iv. Vibration control (for bridges only)

Structures shall be designed and constructed as robust as necessary to satisfy the required Service Life with a minimum amount of foreseen maintenance.

7.2 Crack Control

Cracks in reinforced and partially prestressed concrete structures are anticipated to occur; however, crack width and spacing shall be controlled by adequate and well-detailed reinforcement.

Precompression of concrete superstructures, thus preventing cracks under tensile stresses through use of prestressed concrete, is required. Partially prestressed bridge components shall have sufficient amount of prestress so that under permanent loads, the cracks caused by live load remain closed.

For best crack control detailing, the reinforcing bars shall be located closer to the tensile face than the prestressing tendons.\

The EOR shall be responsible for verification of construction compliance with relevant requirements of the drawings and specifications to crack control.

Crack Control and Reinforcement

Crack control shall be implemented by limiting the crack widths using one of the method specified in this section.

At SLS, if the tension in concrete exceeds fcr, the crack widths shall be calculated using a method proposed in CHBDC.

Cracks shall not be wider than the following values in **Table 7.2.1**:

Table 7.2.1 - Allowable Crack Widths

Concrete Type	Concrete Exposed to De-icing Chemicals	Concrete not Exposed to De-icing Chemicals
Non-prestressed Concrete	0.25 mm	0.30 mm
Prestressed Concrete	0.15 mm	0.20 mm

Note:

Concrete decks (with or without waterproofing membrane) are considered surfaces that are subject to spray or surface runoff containing de-icing chemicals. Girders of bridges spanning over the roadways shall be considered exposed to de-icing chemicals.

Amount and Distribution of Tension Reinforcement

Crack control shall be achieved by proper distribution of tension reinforcement in the zones of maximum tensile stresses, selection of bar sizes, reinforcement ratios, and control of stresses at SLS.

The conditions of **Table 7.2.2** shall be met to satisfy the crack control requirements:

Table 7.2.2 - Distribution of Tension Reinforcement

Requirement	Concrete Exposed to Chlorides	Concrete Exposed to Freeze Thaw Conditions
Maximum tensile stress in reinforcing steel, f_s	180 MPa	200 MPa
Maximum bar spacing	200 mm	20d or 300 mm, whichever is less
Maximum bar diameter	20M for reinforced concrete; 15M for prestressed concrete	20M for reinforced concrete; 20M for prestressed concrete

Shrinkage and Temperature Reinforcement

Shrinkage and temperature reinforcement normal to the principal reinforcement shall be provided in each face of concrete structural elements.

The shrinkage and temperature reinforcement shall be provided as required by the analysis, but not less than 15M at 250 mm in each face and each direction, unless otherwise Approved.

7.3 Stress Limits

Under the service load conditions, the limitation of stresses may be required for:

i. Tensile stresses in concrete– Limitation of tensile stresses in concrete is an adequate measure to reduce probability of cracking.

ii. Compressive stresses in concrete – Limitation of compressive stress in concrete controls plastic strains and longitudinal cracks.

iii. Tensile stress in reinforcing steel – Limitation of tensile stress in reinforcement reduces uncontrolled cracking.

The stresses at SLS loads shall include any effects of redistribution of moments due to creep, shrinkage, and relaxation of prestressing steel.

7.4 Deformation

Dimensional changes, deflections, and rotations shall be included in the design to provide proper and safe functioning of the structures, avoidance of damage to non-structural elements, and good appearance. Effects of short- and long-term deformations shall be analyzed and included in the design and detailing of structures. Structures shall be designed with camber to compensate for long-term deformations of concrete.

All flexural members shall have adequate stiffness to limit deflections and to control vibration, which may adversely affect the strength or serviceability of the structure. Deflections and vibration control shall be designed in accordance with the CHBDC.

7.5 Vibration

General

Vibrations of structures may affect serviceability as follows:

i. Functional effects (for example, discomfort of pedestrians)

ii. Structural effects on secondary and non-structural elements

The vibration behaviour of structures can be influenced by the following measures:

i. Change of the natural frequency by changing the rigidity of the structure or vibrating mass

ii. Increase of the effectiveness of damping features

Superstructure Vibration

Design and Construction of New Bridges

Dynamic design analysis shall be performed for all bridges with spans longer than 20 m, or with the first flexural frequency less than 6 Hz.

Design to control vertical, transverse, and longitudinal vibrations of bridges used by pedestrians shall be in accordance with the CHBDC.

Wind, traffic-induced vibrations, as well as the load of pedestrians traversing the superstructure shall be considered.

Modifications to the Existing Bridges

Dynamic analysis shall be performed to assess impacts of superstructure modifications, particularly where the original first flexural frequency of the structure has been altered as a result of the modifications.

8. FATIGUE LIMIT STATE (FLS)

Design for FLS shall consider the requirements of Clause 5.11, Dynamic Analysis, of the CHBDC.

8.1 Reinforced and Prestressed Concrete

Fatigue design shall be performed for structural elements, and the requirements of FLS shall be satisfied. Special care shall be exercised in areas of complicated load path. In partially prestressed concrete members, fatigue is considered a critical limit state.

Tack welding of reinforcing bars is not permitted. Tight bends and welded joints of reinforcing steel shall be avoided in areas of high stress range.

8.2 Structural Steel

The fatigue criteria for structural steel shall be in accordance with the CHBDC.

9. DESIGN OF FOUNDATIONS AND EARTH-RETAINING STRUCTURES

9.1 Scope

This section describes the structural design requirements for the following:

i. Foundations

ii. Retaining walls, including MSE walls

iii. Buried reinforced concrete and steel structures

iv. Portal structures

The following Standard Technical Specifications applicable to foundations and earth-retaining structures are included in Appendix C of these Guidelines:

Section 02455	Driven Steel Piles
Section 02466	Drilled Concrete Piles
Section 03483	Mechanically Stabilized Earth Retaining Walls

9.2 Codes and Specifications

The design shall, where applicable, be in accordance with the requirements of:

i. the CHBDC

ii. The Canadian Geotechnical Society, Canadian Foundation Engineering Manual.

9.3 Geotechnical Report

A geotechnical engineer shall provide a geotechnical report that shall include all necessary information for design and construction of foundations and earth-retaining structures.

The report shall be based on suitable subsurface investigation and laboratory tests, and shall describe the soils conditions in detail, and provide recommendations for suitable foundation types with consideration for constructability issues.

The report shall include appropriate design parameters pertaining to permanent conditions and, where applicable, to temporary conditions.

The report shall identify subsurface conditions and seasonal effects that could have a significant impact on construction, such as slope stability or the presence of large boulders or artesian groundwater. Requirements for casing of foundations shall be also identified.

Impact of the proposed structure and its construction on adjacent properties (where applicable) shall be addressed.

The geotechnical report shall be signed and sealed by two geotechnical engineers, both registered in the Province of Alberta.

Coordination between the structural engineer and geotechnical engineer shall take place during planning, design, and construction to provide consistency of structural design with geotechnical data and with the actual site conditions.

9.4 Design

Foundations and retaining walls shall be designed to satisfy ULS and SLS requirements of the CHBDC.

These elements, including MSE walls, shall be designed for a Service Life of 100 years consistent with Section 3 of these Guidelines.

9.5 Loads

General

Permanent and temporary loads that require evaluation include:

i. Horizontal and vertical forces from soil pressure
ii. Forces from hydrostatic pressure
iii. Loads from structures adjacent to the designed structure
iv. Loads from surface traffic
v. Loads from surface storage of materials and equipment
vi. Loads from major underground utility structures
vii. Environmental loads (for example ice, frost)
viii. Loads arising from differential settlement and soil consolidation
ix. Other site- or project-specific loads

Lateral Earth Pressure and Vertical Earth Pressure

Vertical pressure from superimposed earth load shall be calculated per Clause 6.12 of the CHDBC, with a mass density as determined by the geotechnical engineer.

For submerged or partially submerged conditions, recommended densities of the earth shall be obtained from the geotechnical engineer.

Due consideration shall be given to temporary loads arising from construction equipment or from stockpiling of construction material or excavated materials at the ground surface.

A minimum earth load assuming that 1 m of fill may be removed (for example, for road or utility construction), shall also be considered.

Retaining structures shall be designed for horizontal earth pressure due to backfill abutting against the structure and load surcharges resting on the abutting earth. The pressure shall be determined by considering the relevant parameters, including:

i. Geometric characteristics and material properties of the backfill
ii. Displacement characteristics of the retaining wall or structure
iii. Interface conditions between the wall and the backfill
iv. Method and degree of compaction of the backfill material
v. Location of groundwater (existing or future)
vi. Artesian conditions
vii. Live and dead loads imposed by adjacent foundations
viii. Location of the wall or structure relative to ground surface
ix. Effect of construction methodology and staging
x. Bearing capacity of the base strata

The earth pressure acting on a retaining wall or structure may range from active earth pressure to passive earth pressure, depending on the displacement characteristics of the wall and the methods of compaction of the backfill.

Values of loads, earth pressure coefficients, and relevant assumptions shall be shown on the Drawings.

In case of any deviations of the site conditions or construction methods from the original assumptions, design adjustments shall be made, and the changes shall be reflected on Record Drawings.

Water Pressure and Buoyancy

The effects of water pressure and buoyancy shall be considered whenever the presence of groundwater is indicated.

High and low water tables shall be established for the life of the structure, with due consideration given to the possibility of future changes in groundwater elevation.

The design shall consider the effect of water pressures pertaining to construction staging.

Flooding

Local flooding may add load to underground structures or may undermine the stability of superstructures. Design of structures shall make allowance for flood elevations based on the 100-year flood. The elevations used for design shall be subject to Review.

Loads from Adjacent Building Foundations or Other Structures

Horizontal and vertical distribution of loads from foundations of existing buildings shall be determined by the Engineer, in consultation with the geotechnical engineer.

Consideration shall be given to the minimum and maximum loads that can be transferred to the adjacent structure. Where possible, these loads shall be based on the actual design loads for the adjacent structure. In the absence of this information, a rational approach shall be used by the Engineer to evaluate the probable loading from the existing structure.

When performing this analysis, the Engineer shall determine the need for all permanent underpinning of adjacent buildings or other structures.

9.6 Structural Elements

Footings, deep foundation components, ground anchors, MSE walls, and other retaining structures shall be considered as structural elements and shall be designed in accordance with the appropriate sections of the CHBDC and these Guidelines by a qualified structural engineer registered in the Province of Alberta.

Other design responsibilities for MSE walls are outlined in Standard Technical Specification Section 03483, Mechanically Stabilized Earth Retaining Walls in Appendix C.

9.7 Construction Methods

The methods and sequence of construction influences the behaviour and loading conditions applied to a structural system. Consequently, if a structural analysis is based on a particular method or sequence of construction, these conditions shall be defined in the construction documents.

The design and construction of all underground structures, whether temporary or permanent, shall prevent movements of adjacent structures and ground from exceeding acceptable levels. The effects of movement on adjacent structures shall be evaluated by a structural engineer. Allowable limits on movement or differential settlement shall be identified, and measures shall be taken to prevent exceedances of these limits. Protective measures shall be agreed to by The City and the owner of the structure under consideration.

Groundwater inflow shall be controlled during construction in accordance with the relevant Technical Specifications.

9.8 Proprietary Retaining Walls

The City reserves the right to reject any alternate wall system or details that do not conform to the Standard Technical Specifications, City of Calgary Design Guidelines, or the CHDBC.

Investigation shall be conducted to determine whether the location of underground utilities would interfere with the wall systems, including foundation and anchorage system.

MSE walls or bin-type walls shall not be used in situations where maintenance crews of the underground utilities will potentially dig into the straps, mesh, or modules. Conventional retaining walls shall be used in these instances.

Foundations for bridges and overhead sign structures shall not be placed on the reinforced backfill of MSE walls (that is, a separate rigid foundation shall be provided).

9.9 Inspection and Quality Assurance

During construction, installation of foundations, ground anchors, MSE, and other retaining walls shall be inspected by the geotechnical engineer to confirm that the actual soil conditions are consistent with the design assumptions and that the geotechnical aspects of the project are consistent with the design assumptions.

Any impact of actual site conditions or construction methods on the new or existing structure shall be assessed by both the geotechnical engineer and the structural engineer.

Copies of the inspection reports shall be included in the construction records. Any Approved variance from the Drawings or Technical Specifications shall be reflected on the Record Drawings.

Special attention is drawn to inspection and QA of installation of drainage systems. The process of inspecting and acceptance of drainage shall be addressed in the Engineer's QMP.

10. CABLE-STAYED BRIDGES

10.1 General

Cable-stayed bridges shall be designed and constructed according the CHBDC and the supplementary requirements of this section, unless otherwise Approved.

10.2 Reference Publications

Recommended reference publications include:

i. Post-Tensioning Institute (PTI) Recommendations for Stay-Cable Design,

ii. Testing and Installation

iii. Fédération Internationale du béton (Fib) CEB – FIP Acceptance of Stay Cable Systems Using Pre-stressing Steels.

10.3 Limitations

Cable-stayed structures shall be chosen where the context is appropriate. These structures can have very high pylons that may not be suitable in certain urban areas.

10.4 Design

General

The Design Life of cable-stayed bridges shall be 100 years.

System

The City's preference is to use redundant cable-stay systems with systems consisting of multiple tensile elements rather than systems relying on a single tensile element. However, mono-bar stays may be considered upon Approval if the design addresses redundancy.

Analysis of the structure shall include:

i. Elongations and forces during all stages of construction
ii. Service
iii. Pylon deformations
iv. Cable replacement

Loads

Guide deviators shall be installed near the anchorage to protect the stay cable anchorages from the effects of transverse loads caused by:

i. Cable vibration
ii. Deformation of the structure
iii. Change of cable sag
iv. Wind
v. Temperature changes
vi. Live load
vii. Construction tolerance
viii. Other transverse loads specific to the conditions

Each component of the cable-stay system, from stressing-end anchorage, through free length, to saddle (if applicable), to next anchorage, shall have the same safety and Durability considerations under SLS, FLS, and ULS.

Materials

Choice of structural steel material for cable-stay systems shall be based on chemical and mechanical characteristics, as well as on performance or fatigue criteria.

High-quality steels shall be specified for stay cable performance.

High-strength prestressing steels shall meet the criteria outlined in **Table 10.4** for stay cable applications:

Table 10.4 – Standard Classification for Prestressing Steels for Stay Cables

Component	Measure
Stay cable bar diameter	26-50 mm
Stay cable tensile strength	1,030-1,050 MPa

Stay Cables and Anchorages

Cable-stay systems shall be replaceable, either one or several at a time.

Only tested cables and anchorages are acceptable. In the cases where commercially available systems are not used, testing of cables and anchorage assembly shall be specified. Testing shall include axial fatigue testing with bending effect and purely axial fatigue test at 2 million cycles. A minimum factor of safety of 1.5 shall be used for fatigue strength values obtained from the tests.

Stay cables and anchorages shall be designed for fatigue and strength considering all applicable loads and deformations.

Minimum length adjustment capacity shall be provided at the anchorages of stay cables for restressing and detensioning. Instrumentation capable of verifying and controlling cable stress forces throughout the construction process shall be considered when selecting cable stay and anchoring systems.

Cable vibrations, including risk of parametric excitation, as well as train traffic (where applicable) and wind- and rain-induced vibration, shall be evaluated; and appropriate measures shall be employed to mitigate these effects.

Grounding

Lightning protection through grounding shall be included in the design.

Functional Requirements

The design for the specified service life shall be satisfied for exposure conditions defined as “high corrosion risk.”

A clearly defined corrosion protection system shall be submitted and verified or tested as applicable.

Stay cable design shall include protection measures to mitigate against impact, vandalism, fire, and lightning.

Stay cables shall be located to prevent climbing hazards.

Design shall consider birds and wildlife that may come in conflict with the stay cables. If necessary, bird deterrent shall be provided.

Connections and clamps shall be designed to avoid transverse forces or effects that would be harmful to the fatigue resistance and tensile strength of the stay cable.

10.5 Corrosion Protection

Corrosion protection adequate for the entire Service Life of the stay cables shall be specified in the Agreement.

Materials in cable-stay systems shall be designed for the Service Life of the entire system. This includes any planned replacement at predictable intervals. The cost of such replacements shall be included in the life-cycle cost analysis.

Materials and corrosion protection for stay cables on pedestrian bridges shall consider Galfan, stainless steel, or galvanized cables with sleeves. The materials and method of corrosion protection shall be submitted for Approval. Fully locked strands may also be considered, upon Approval.

Recommended soft filling materials include wax with low oil content. Stay pipe material shall be submitted for Approval.

Any exposed metallic surface of anchorage components shall be protected against corrosion. Generally, anchorage components are factory-provided with corrosion protection.

10.6 Construction Considerations

Construction tolerances should be clearly marked on the Plans.

Construction tolerances shall include directional installation tolerance of the bearing plates and guide pipes at ±5 milliradians (mrad) (±0.3 degree [°]) around the theoretical axis of the stay cable and ±10 mm in positioning of the anchorage.

The specialist Contractor or Subcontractor responsible for the bridge erection shall prepare a detailed erection plan and procedure. Limitations of bridge erection over water bodies, CPKC, CN and LRT lines, shall be discussed with the respective right-of-way (ROW) owners or regulatory agencies, as applicable.

Transverse loads on the anchorages shall be kept low by appropriate use of guide deviators. Transverse forces in the transition zone shall be absorbed to avoid fretting corrosion. Any possible effects of angular deviations or fatigue shall be verified by full-scale testing.

10.7 Quality Assurance

The fatigue and ultimate capacity of the cable-stay system shall be verified by testing.

10.8 Maintenance

A maintenance program for the cable-stay system from the system supplier shall be evaluated during design. Allowance for maintenance and inspection of cable-stay systems shall be included in the bridge design.

The warranty period for the performance of the cable-stay systems shall be minimum 10 years.

Project closure documents shall include a maintenance manual for all bridge elements, including cable-stay system.

11. INTEGRAL ABUTMENT BRIDGES

Use of integral abutment bridges shall be limited to those specifically Approved at the planning and early design stages.

11.1 Characteristics of Integral Abutment Bridges

Integral abutment bridges accommodate superstructure movements without expansion joints or bearings. The superstructure is rigidly connected to the substructure, and any movement caused by volumetric changes is facilitated through flexible piling of bridge abutments.

Approach slabs, connected to the abutment and deck slab with reinforcement, move with the superstructure. At its junction to the approach pavement superstructure movement shall be accommodated using flexible pavement joints.

Refer to standard details in Appendix E.

Stability of single span bridges shall be provided by passive pressure behind the back wall. In multi-span bridges, piers shall contribute to the bridge's stability.

11.2 Limitations

Length of Structure

The maximum length for integral abutment bridges shall be as follows:

i. Steel girder bridges: 80 m total bridge length

ii. Prestressed concrete girder bridges: 100 m total bridge length

Span length and configuration shall be considered when selecting an integral type for the bridge.

Geometry

Integral abutment design shall not be used for bridges with curved or flared alignments.

Skew

The maximum skew angle for integral abutment bridge designs shall be 20°. Skew angles greater than 20° shall preclude the use of integral abutment bridge construction.

Grades

The maximum grade between integral abutments shall be 5%.

Piles

Integral bridges require that abutment piles be flexible. Sufficient pile penetration into acceptable soil is required to provide adequate flexibility and sufficient lateral support for piles.

An integral abutment system shall not be considered where the lengths of the piles are less than 5 m or if rigid foundations are required.

The abutment shall be supported on a single row of vertical H-piles. The top of piles shall be embedded a minimum of 600 mm into the abutment and shall be adequately reinforced to transfer the bending forces.

Material properties and splice welding acceptability shall be verified by detailed QA procedures.

Geotechnical Conditions

Integral abutments shall be avoided where excessive settlement of approach fill is expected.

11.3 Design

Loads

Integral abutment bridges shall be designed to resist all vertical and horizontal forces acting on them in all applicable load combinations and stages of construction and service.

Dynamic load allowance shall be included in the design of integral abutments and piles.

Pile

Primary structure movement would typically produce bending about the weak axis of a single row of H-piles. The weak axis of piles shall be perpendicular to the thermal centre of the bridge.

Piles shall be cased with corrugated steel pipes and filled with loose granular material to allow required pile flexibility.

Design Life of corrugated steel pipe casing for integral abutment bridge piles shall be 75 years, with a Service Life of 100-years.

Structural Analysis

A 3D analytical model of the entire bridge shall be created and include soil-pile interaction modelled as a series of springs along the length of the piles. 3 magnitudes of spring stiffnesses, provided by a Geotechnical Engineer registered in the Province of Alberta with APEGA (weak, probably, and strong), shall be used under all applicable load combinations and stages of construction and service to check the design of the bridge structure.

Girder Design

Girders shall be designed assuming no fixity at abutments; however, the superstructure design shall include a check for the effects of fixity.

The beneficial effect of axial compression induced in girders due to earth pressure shall not be included in the design of the girders.

Abutment Design

The maximum bending moment obtained from frame analysis shall be assumed to act at the corners of the idealized frame.

The distribution of moments from wing walls to the abutments shall be considered in the design of horizontal reinforcement of the abutments.

Approach Slabs

Approach slab lengths typically vary from a minimum of 3.0 m to a maximum of 6.0 m, unless otherwise Approved.

Special provisions shall be made to allow free movement of the approach slabs if curbs or barriers are present. Approach slabs shall be installed in a separate concrete pour from the superstructure slab but shall have a positive connection between the approach slab and the abutment.

The approach slab shall be specified to be cast on two layers of 6-mm-thick polyethylene sheets or other Approved, durable, friction-reducing materials. It shall be designed as a structural slab that is supported at each end.

Provisions shall be made for expansion at the end of each approach slab. Refer to standard details in Appendix E for expansion joints at the ends of the approach slab.

A lateral drainage system shall be provided at the end of the approach slab adjacent to the sleeper slab.

12. SEMI-INTEGRAL ABUTMENT BRIDGES

Semi-integral abutment bridges shall be considered where feasible.

12.1 Characteristics of Semi-Integral Bridges

Semi-integral abutment bridges are single- or multiple-span bridge structures with rigid foundations and a continuous superstructure with a jointless deck, integral end-diaphragms, compressible backfill, and movable bearings that can fully accommodate the superstructure articulation.

In semi-integral bridges, the transfer of displacement to the superstructure due to the structural action of piles is minimized. The rotation is generally accomplished by use of a flexible bearing at a horizontal interface with the abutment.

Horizontal displacements not eliminated in a semi-integral bridge system shall be considered in the design. Skewed bridge transverse movements typically can be resisted by the use of abutment shear keys.

A joint capable of accommodating design movement shall be provided at the end of the approach slab. Refer to standard details in Appendix E.

12.2 Limitations

Length of Structure

The overall length of semi-integral abutment bridges shall not exceed 130 m.

Geometry

This type of design shall be used primarily for symmetric, straight girder structures. If Approved, the effects of other geometric constrains, such as curved, flared alignments, shall be thoroughly investigated.

Skew

The effect of skew angle on bridge performance for semi-integral abutment bridges shall be carefully analyzed.

Piles

A single row of piles shall not be used.

The foundation piles shall be stiffened by inclusion of battered piles, or rigid caissons anchored to bedrock may be considered.

12.3 Design

The geometry of the approach slab, and design of the wingwalls and transition parapet, if any, shall be compatible with the freedom required for the integral configuration (girders, deck, backwall, and approach slab) to move freely.

Lateral restraint shall be provided to prevent rotation of the superstructure caused by an eccentric lateral force in the horizontal plane. This force is usually the result of lateral earth pressure acting on both ends of the superstructure.

Use of Retained Soil System

A retained soil system may be used to resist lateral earth pressure; however, the vertical loads from the bridge structure shall be transferred to the rigid foundations (spread footing or group of piles) through the use of columns placed behind the fascia of the retained soil system.

Consideration shall be given to the location of columns so that any conflict with the earth-reinforcing system is avoided.

Articulation of Superstructure

The articulation of the superstructure at the supports of multispan structures shall be designed such that similar movements would occur at each end of the structure.

Positive movement restraint(s) shall be provided in the direction perpendicular to the thermal centre of the bridge.

12.4 Details

Consideration shall be given to thorough detailing of joints, use of appropriate bearings, arrangement of diaphragms, and details of wingwalls and approach slabs.

Approach Slabs

Separation joints shall be detailed to accommodate movement without breaking continuity or restricting movement of the superstructure with respect to the substructure.

The length of wingwalls and approach slabs shall be minimized.

The movement system at the ends of the approach slabs shall be able to accommodate the superstructure deformation.

Drainage

Drainage design and detailing shall prevent surface water from accessing subsurface space under the approach slabs and abutments.

Weeping drains located under the approach slab-to-grade joints shall be connected to a collector and discharge facility.

The joints between the approach slab and the wingwalls shall be sealed to prevent water infiltration.

Surface drainage at the ends of wingwalls shall consider bridge system articulation, and the longevity of the applied materials and joint sealants.

Design details shall include drainage control systems, such as use of impervious swales.

13. BRIDGE DECK JOINTS AND BEARINGS

13.1 General

Deck joints and bearings shall be designed to effectively resist loads and accommodate movements at the ULS, SLS, and FLS.

All exposed surfaces of joints and bearings shall be protected against corrosion.

The method and details of corrosion protection shall be Approved.

13.2 Design Requirements

The selection and location of bearings and joints shall be consistent with the designed articulation of the structure.

The moving components of the joints shall be designed to function in concert with the bearings to avoid binding the joints and adversely affecting force effects imposed on bearings. Thus, whether in an expansion or a contraction mode, the movement range of the joint shall be compatible with that of the bearings supporting that joint.

Besides movement due to temperature variation, the design of expansion joints and bearings shall consider the effects of:

i. Creep
ii. Shrinkage
iii. Skew
iv. Rotation
v. Lateral shear
vi. Vertical shear
vii. Elastic shortening due to prestressing
viii. Traffic loading
ix. Construction tolerances
x. Other effects specific to the designed structure

The restraint of movement may result in significant internal forces. These forces shall be carefully assessed in the design of appropriate elements of the structure.

13.3 Temperature Variation Effects on Deck Joints and Bearings

Bridge movement due to temperature variation (range) shall be calculated from the extreme temperatures (maximum daily mean temperature and minimum daily mean temperature), as specified in the CHDBC.

For the Calgary area, the extreme daily mean temperatures are:

–38 degrees Celsius (°C) and + 28°C

An extra + 5°C to the above shall be applied to account for projected climate change.

13.4 General Policy for Deck Joints

Bridge deck joints are a maintenance problem, and in many instances, induce a source of structural deterioration, thereby affecting the structure life-cycle costs. Minimizing the number of joints on bridge structures shall be considered. Refer to Section 6.6, Durability, Structural Details of these Guidelines.

13.5 Deck Joints - Functional Requirements

Deck joints shall be designed to provide unimpeded passage of traffic across them.

The type of joint and size of joint gap shall facilitate safe passage of pedestrians (high-heel shoes), cyclists, in-line skaters, wheelchair users, and motorists. Maximum openings at joints in pedestrian and bicycle paths shall not exceed 50 mm.

The joint shall provide a good riding surface, relatively free from vibration and noise.

Galvanized steel plates with skid-resistant coating shall be provided over expansion joint gaps at pedestrian bridges and pathways (sidewalks) integral with vehicular bridges.

Galvanized steel cover plates shall be used over the expansion joints at traffic barriers, medians, and curbs.

13.6 Deck Joints - Design and Detailing

Deck joints shall be designed to resist wheel loads, including dynamic load allowance, and shall accommodate movements at the SLS, FLS, and ULS, in accordance with the CHBDC.

Steel extrusions and their anchorage and support systems shall be designed as necessary to resist all anticipated loads, including dynamic load allowance.

Deck joints shall be designed to accommodate movement and rotation of the structure caused by articulation of the structural system.

Special consideration shall be given when the length contributing to expansion is greater than 75 m or the bridge skew angle is more than 25°.

Modular type deck joints are recommended for joint movements in excess of 100 mm.

The minimum joint opening shall be specified in accordance with the manufacturer's recommendations. When setting the joint, either the design width shall be adjusted by the amount of anticipated movement due to creep and shrinkage, or the joint shall be set to the minimum width for installing the seal, whichever results in the wider opening.

Strip seal deck joints shall be used unless otherwise Approved. Compression seals shall not be used unless otherwise Approved. Sealed joints shall remain watertight at the SLS.

Elastomeric strip seal joints with continuous watertight seal shall be placed so that, at the minimum gap opening, the entire seal remains below the roadway surface.

The joint gland shall be continuous for the full roadway and walkway and turned-up at ends. Expansion joint glands may be discontinued at bridge barriers that run between a roadway and a sidewalk. However, reliable drainage provisions shall be made to prevent stormwater from damaging the structure.

Generally, armour plates are not required over the roadway strip seal joints, unless otherwise Approved. A full steel armour plate is required over the barrier's joint. The joint materials shall be resistant to both corrosion and ultraviolet rays and shall not be conducive to electrolytic action.

Armour plates shall be galvanized steel, resistant to abrasion and damage by snow plows. The armour plates shall be detailed to eliminate formation of air voids during placing concrete. Armour plates shall be anchored to concrete by anchor studs spaced at 200 mm maximum.

The joint shall be designed for minimum maintenance and ease of access for parts replacement.

Deck joints shall provide a Service Life warranty for a minimum of 5 years. The City warranty forms in Appendix D shall be used.

13.7 General Design Policy for Bridge Bearings

Bridge bearings shall accommodate the movements of the superstructure and transmit loads to the substructure supports.

The type of bearings to be used depends on the amount of translation and rotation, as well as the magnitude of the loads.

13.8 Bearing Types and Specifications

The choice of a type of bearing shall be determined by suitable analysis.

In general, simple span prestressed concrete girders, simple span steel girders, and some continuous spans may be supported on composite neoprene bearing pads (elastomeric bearings). Large movements may be accommodated by using Polytetrafluoroethylene (PTFE) or Teflon bearing surfaces complying with ASTM D4894, Standard Specification for Polytetrafluoroethylene (PTFE) Granular Molding and Ram Extrusion Materials.

Some structures with large bearing loads or multidirectional movement may require other bearing devices, such as pot, spherical, or disc bearings.

The proposed bearing type and make shall be Approved.

Movement stop devices shall be included with bearing design and shall be an integral part of the bearing system.

13.9 Bearing Design

Bearings shall be designed to support and transfer loads and to accommodate translations and rotations in the structure. The design shall be based on the CHBDC.

If the bearing is proprietary, it shall be designed to satisfy the critical load combinations at the ULS and SLS. The following load information shall be included on Drawings:

i. Dead Load: at ULS and SLS
ii. Total Load: at ULS and SLS
iii. Lateral Loads: at ULS and SLS
iv. Rotations
v. Translations
vi. Other information affecting design of bearings

Bearing design and shop drawings shall be stamped and signed by a Professional Engineer registered in the Province of Alberta. The design shall be submitted for review by the EOR.

The EOR shall be responsible for integration of bearings with other elements of the structure.

The bearings shall be installed in strict accordance with the manufacturer's recommendations, unless directed otherwise in writing by the Engineer.

13.10 Bearing Detailing

The bearing shall provide shock-absorbing qualities relatively free from rocking and noise.

Bearings shall be designed as necessary to resist all anticipated loads, including dynamic load allowance.

The bearing shall absorb and dissipate the stresses and transfer a portion thereof without causing overstress to the substructure.

Elastomers used in bearings, such as pots and discs, shall provide a Service Life equal to or greater than that of the bearing.

The bearing shall be designed for minimum maintenance and for ease of access to avoid excessive jacking of the superstructure during parts replacement. Bearings shall be replaceable without removing permanent anchorages. Maximum jacking shall not exceed the amount of vertical relaxation recovery of the elastomeric material plus 5 mm.

Location of areas designated for superstructure jacking shall be clearly marked on the Drawings.

The bearing assembly shall be capable of sealing off moisture from the inner components of the bearing assembly.

The bearing materials shall be resistant to both corrosion and ultraviolet rays and shall not be a catalyst or vehicle for electrolytic action. Steel elements of bearing assemblies shall be galvanized, unless otherwise Approved.

Bearings shall be designed so that bearing installation does not require field welding to masonry plates, girder sole plates, or directly to girders.

Bearings shall be detailed perpendicular to ground regardless of girder or abutment seat slopes.

14. TRAFFIC BARRIERS

Structural design of bridge barriers and railings shall be in accordance with the CHBDC. Designers are encouraged to use the TAC Guide to Bridge Traffic Combination Barriers as an additional reference.

14.1 Barrier Selection and Detailing Criteria

The following factors shall be included in selection, design, and detailing of traffic, pedestrian, bicycle, and combination bridge barriers.

Durability in a Highly Corrosive Environment

Design and detailing shall conform to relevant requirements of Section 6.0, Durability of these Guidelines.

Ease of Repair

Modular construction and removable connections to anchorage systems shall be considered.

Visibility

Visibility through and over the barrier shall be confirmed to maintain adequate sight distances.

Snow Accumulation on Bridge Decks

Snow drifts will accumulate on bridge decks, especially where solid barriers are used. Accommodation of snow removal operation shall be assured by proper geometric and structural design.

Where the barrier is located between the vehicular and pedestrian traffic, it shall include a solid protection against splash.

Drainage and Joint Details

Drainage and joint detailing shall include drain paths and their interruptions or changes at the barrier interfaces with other elements of the bridge, such as sidewalks, abutments, and approach slabs.

Construction joints in barriers shall be positioned over the drains from sidewalk to roadway.

Bicyclist

Consideration shall be made for bicycle rails where bicyclists are allowed to travel on roadway shoulders.

14.2 Traffic Barrier Joints

Traffic barrier joints shall be designed to perform adequately during vehicle impacts, as well as to accommodate bridge movements and barrier deformations.

The following aspects shall be assured in the design and detailing of the joints:

i. For rigid barriers (that is, concrete traffic barriers), adequate barrier stiffness shall be provided on each side of the joint.

ii. For semi-rigid barriers (that is, post and railing barriers), moment and shear continuity across the joint shall be provided.

Detailing of joints shall include ease of installation and maintenance of strip seals.

Spacing of control joints in concrete barriers shall be assessed based on overall bridge design parameters, including:

i. Geometry

ii. Bridge deck design

iii. Articulation system

iv. Amount of predicted volume changes

v. Temperature gradient

In general, concrete traffic barriers shall have full contraction joints with discontinued longitudinal reinforcing at 3 m (maximum) and increased amount of vertical reinforcing near the joints, as specified in the CHDBC. Contraction joints shall be groove-formed and sealed. Refer to Appendix E of these Guidelines for a standard drawing of a bridge barrier section.

15. HIGHWAY ACCESSORY SUPPORTS

15.1 General Considerations

The visual impact of signing and lighting installations shall be considered with regard to context-sensitive fit.

Supports shall be designed to minimize hazards.

Overhead and cantilever highway accessory support structures located on bridge superstructures shall not be located in areas where they will be subject to the vibrations caused by live load deflections of the superstructure. Location of accessory supports directly on the substructure is preferred.

Number of accessory supports within the bridge area shall be minimized. Multiple purpose poles and structures shall be considered.

15.2 Design and Construction

Refer to Appendix A for the Highway Accessory Supports Guidelines for Structural Design and Construction.

16. NOISE BARRIERS

16.1 Design

Loads and Load Combinations

Noise barrier support components shall be proportioned to satisfy ULS, SLS, and FLS in accordance with the CHBDC.

Noise barriers shall be designed to load combinations and load factors included in Table 3.1 of the CHBDC. When applicable, traffic collision loads and bridge deformation loads shall be included in the design.

The design wind load shall be based on a 1 in 25-year return period. A gust factor of 2.5 and applicable horizontal drag coefficient shall be used.

Foundations

Foundations shall be designed according to Section 9.4 of these Guidelines.

Foundation design shall be based on site-specific geotechnical information.

Where a limited number of boreholes is available, the design shall be based on the worst soils conditions likely to be encountered in the vicinity of the designed barrier.

Alternatively, the Canadian Foundation Engineering Manual may be used as reference to the design of smaller noise barrier foundations in the areas of previously identified soil types.

In most cases, foundations for noise barriers shall be drilled shafts; however, in cases where shallow rock formations exist, spread footings may be used.

Provisions for controlling the effects of frost heaving shall be included in the foundation design.

Standard Details and Site-Specific Design

Several proprietary noise barrier systems are available. The materials, load carrying mechanisms, and capabilities vary with each system; however, these systems shall conform to the criteria outlined in these Guidelines and the CHBDC.

Noise Barriers on Bridges

Location of noise barriers on bridge structures requires Approval.

For noise barrier retrofit onto existing bridges, the design shall include verification that the dead load and live loads from the wall do not overstress any component of the bridge, including the existing parapets, slab overhang, girders, and superstructure members.

The dead load of noise barriers can affect the overload capacity and deflection of some bridges. Consideration of impact of barrier to access for bridge inspections shall also be made.

16.2 Durability and Maintenance Requirements

All exposed steel components shall be hot-dip galvanized. Alternate protection systems for steel or aluminum elements shall be subject to Approval.

The surface texture selected for noise barriers shall prevent graffiti or enable graffiti to be easily removed.

Corrosion protection systems shall be employed as required by specific exposure conditions. Suitability of a proposed corrosion protection system shall be submitted for Review.

The provision of corrosion-protected reinforcement shall be as determined on a project to project basis. The location of the noise barrier panels, in relationship to the offset distance from the roadway, shall be evaluated to determine whether provision of corrosion-protected reinforcement is warranted.

If the location of noise barrier panels may subject the panels to splashing from the roadway surface, provision of corrosion-protected reinforcement shall be specified.

16.3 Functional Requirements

Barriers shall generally be used when the noise barrier is located within the clear zone. Location of the noise barrier is subject to Approval.

Barriers can obstruct sunlight, as well as noise. Special consideration shall be given to possible roadway icing and other induced environmental conditions caused by the placement of the wall.

Surface runoffs shall be directed away from the noise barrier.

Provisions shall be made to allow access to the back-side of the wall for maintenance or emergency access. The designer shall consult with The City regarding the specific access needs.

For noise barriers that must bridge over utility conduits, provisions shall be made to accommodate differential settlement in the noise wall substructures.

The posts for noise barriers shall be detailed as plumb vertical elements, regardless of the ground slope.

For noise barriers located on bridges, provisions shall be made for flexibility of the walls to accommodate deflections and horizontal movement of the bridge.

16.4 Construction

Contractors for construction of noise barrier walls shall be prequalified with the City of Calgary under category Noise Barriers. Standard Technical Specification for construction of Noise Barriers, included in the Appendix C shall be used.

Site-specific design, complete with calculations, detailed drawings and material specifications shall be submitted for Review and Approval. Such submission shall be authenticated by an Engineer registered in the Province of Alberta. Engineering Consultants for design of noise barrier wall projects shall be prequalified with the City of Calgary under category Other New Transportation Structures.

A Letter of Assurance of Engineering Field Review and Compliance (as stipulated in Section 17 of these Guidelines and included in Appendix B) shall accompany each site-specific construction project submission.

17. CONTRACT DOCUMENTS

17.1 Drawings

The Drawings shall specify all necessary details of a bridge or structure, geometry, specified materials, the design loads, and proprietary product names.

The articulation system shall be indicated on the Drawings, which shall include location and type of bearings, deck joints and prestressing, and other information, including the list provided in **Table 17.1**.

Refer to attached Appendix B for a standard drawing title block.

Table 17.1 – Typical List of Drawings

Drawing Title	Description
Cover Sheet	City of Calgary logo, project title, and consultant logo.
Index	List of drawings.
Site Plan	Name of contract, procurement number, date, and project location; include north arrow. May be combined with Index.
General Arrangement	Overall structure geometry, including layout, elevations, and typical cross-section(s). Calculated critical clearances and nominal clearance box. Include work points, ROWs, and extent of contract. Drainage path shall also be identified.
Information Drawings	Utilities, detours, and removals.
Data Sheet	All design loads, design standards, and general construction staging. Values of lateral distribution factors. Bending moment and shear force live load capacity diagrams with numerical values at critical points.
Hydrotechnical Information	If applicable, include high water level, 100-year flood, flow rates, and clearances required to structure elements, soffit, piers and abutments
Geotechnical Information	Borehole locations and profiles, including underground utilities.
Foundation Layout	Piling layout and details, including anticipated pile tip elevations and pile capacities. Geometry of pile layout referenced to a control line.
Foundation Details	Applied factored and unfactored loads for the critical load combination at ULS and SLS.
Abutments Layout	Abutment geometry: plan and elevation, including concrete finish.
Abutment Details	Details and reinforcement.
Piers and Substructure Layout	Pier geometry: plan and elevation, including concrete finish.
Piers Details	Details and reinforcement.
Girder and Superstructure Layout	Overall layout of girders for complete structure. Construction and post-tensioning sequence, and location of bearings and diaphragms, expansion joints, handrails, and drains.
Girder Details and Reinforcement	Girder geometry, including prestressing, post- tensioning, and reinforcing details, including duct grouting details. Post –tensioning profiles, and camber and haunch diagrams. Locations of post-tensioning anchorage clearly marked at the exterior face of concrete components. Structural steel design camber diagrams for staging and final.
Diaphragms	Diaphragm geometry, including reinforcing and associated details.
Bearings Layout	Overall layout of bearings for complete structure.
Bearing Details	Bearing details, type of finish, and required design loads and movements, including a bearing setting table. Location of lifting jacks and required lifting capacity.
Deck Layout	Deck geometry, elevations, and survey control points.

Table 17.1 – Typical List of Drawings

Drawing Title	Description
Deck Details and Reinforcement	Reinforcing and associated details, including construction sequence, location of construction joints, location of deck drains, and concrete finishes.
Expansion Joints	Overall layout and sections of expansion joints for the complete structure, as well as a details and joint setting table with amount of total movement anticipated.
Approach Slabs	Approach slab geometry and reinforcing and associated details.
Bridge Barrier Layout	Overall layout of barriers and barrier geometry.
Barrier Details and Reinforcement	Reinforcing and details, including joint details and concrete finishes.
Handrail Layout	Overall layout of handrails, including panel lengths.
Guardrail and Handrail Details	Splice and expansion details, and anchorage and type of finishes.
MSE Walls and Retaining Walls	Layout details and design assumptions for internal and global stability design.
Slope Protection	Slope protection geometry, and reinforcing and associated details, including connection to the abutments and concrete finishes. .
Miscellaneous Details	Project-specific details, including deck drains, waterproofing, and lighting and highway accessory support structures.
Landscape Details	Information on finished grading, drainage, and landscaping within the project scope and contract area.
Electrical Details	As applicable to the project, information on electrical requirements to facilitate lighting, grounding, signage, or signals.

Notes:

Applicable notes shall be included on the pertinent Drawings

17.2 Specifications

Project specifications, other than, or supplementing, The City's Standard Technical Specifications included in Appendix C of this document shall be consistent with the design guidelines included in this document.

Project Specifications shall adhere to the City's Section numbering format. The Consultant shall be consistent in developing additional Section numbers, if a standard number is not provided for that Section.

17.3 Preliminary Design Report

Items in the Preliminary Design Report shall include:

i. General layout

ii. Geometry (including clearances, lengths, widths)

iii. ROWs

iv. Drainage concept

v. Location of substructure and foundation elements

vi. Utilities

vii. Anticipated retaining structures

viii. Railings

ix. Articulation of structure

x. Railings

xi. Fencing

xii. Life-cycle cost analysis

xiii. Constructability

xiv. Major risks

xv. Aesthetics

xvi. Comparison of options (minimum three options, unless otherwise Approved)

xvii. Surface protection and finishes

xviii. Permanent vertical loads, including bearing pressure at SLS and deformations at construction and at SLS

xix. Service Life prediction and maintenance projection for major replaceable components

17.4 Quality Control and Quality Assurance

A QMP outlining methodology and measures of QA/QC throughout all stages of design and construction shall be submitted for Review.

Construction methods, reference to applicable standards and specifications, requirements for QC, and measures of QA shall be included in the Drawings and Technical specifications.

Drawings and Technical Specifications shall be submitted for Review at the following stages:

i. **Concept and Planning** - Based on concept design. Information on bridge geometry, clearances, alignment, and hydraulic information, if applicable.

ii. **Preliminary Design Report** – A short form report considering bridge geometry, loads, and clearances required, a preliminary analysis and **cost estimates (Class 3), including life-cycle costs**. Other elements of the report shall include:

    i. Constructability

    ii. Construction schedule

    iii. Durability

    iv. Aesthetics

    v. Environmental issues, such as drainage, minimizing construction footprint, and erosion control

iii. **Design Brief** – Information summarizing the accepted design approach and features of the structure. Brief shall be submitted using the standard design brief format included in Appendix B.

iv. **Detailed Design Drawings at 60% Progress** – Drawings including all structural element sizes and geometry.

v. **Detailed Design Drawings at 80-90% Progress** – Drawings including most details, reinforcing, and general notes.

vi. Specifications and Special Conditions at 95% Progress

vii. 100% Complete Drawings, Specifications, and Special Conditions – Issued for Procurement

viii. **Class 1 Complete Design Engineer's Cost Estimate** – In itemized **Price Schedules** (as part of procurement front- end documents) – Pay items shall be consistent with Measurement and Payment Clauses of the Technical Specifications.

ix. **Issued for Construction (IFC) Drawings and Specifications** - Including the content of the procurement addenda.

x. **Record Drawings**

xi. **Revisions** - To the Drawings and Technical Specifications shall be clearly marked on the documents and recorded in a revisions log.

For both new bridge and transportation structure designs and also for rehabilitation designs for existing bridge and transportation structures:

- Drawings and Technical Specifications shall be authenticated by a Professional Engineer registered in the Province of Alberta as the Engineer of Record for the project and by an Association of Professional Engineers and Geoscientists of Alberta (APEGA) registered permit holder.
- As part of the QMP, an independent review of both the preliminary design and detailed design drawings are required. This review shall be carried out by a Professional Engineer other than the Professional Engineer (Engineer of Record) responsible for the design. Note this requirement should not be confused with required quality control (QC) checking of the Engineer of Record's work throughout design by another or other qualified Professional Engineers. A quality audit report of the findings of the independent review shall be submitted for Review. A certification letter bearing the signature and seal of the independent design reviewer or, alternatively, the signature and seal of the independent design reviewer on the IFC Drawings shall be submitted to The City. The certification letter shall be submitted to the City within 2 weeks of the 100% Drawing, Specification, and Special Conditions submission. This independent review shall be carried out by another Consultant when the design Consultant does not have adequate in-house capabilities to provide this check or if so directed by The City. Typically, an independent design review involves a complete re-analysis of all aspects of the original structural design, preferably by a methodology other than that used in the original design.

17.5 Project Closure Documentation

The following documentation shall be submitted to The City within 4 weeks of CCC, unless noted otherwise below:

i. **Design notes:** One set of design calculations, accompanied by an updated version of the project design brief, in both hard copy and electronic formats. Where possible, hard copy shall be submitted on double-sided paper. Electronic copy shall be submitted in Adobe Portable Document Format (PDF). The Design notes package shall be submitted to the City within 2 weeks of 100% Drawing, Specification, and Special Conditions submission.

ii. **IFC drawings:** One PDF electronic copy.

iii. **Quality summary report:** One copy in both hard copy and electronic PDF formats. The report shall include:

   i. QMPs

   ii. All review and inspection reports

   iii. All QA test results, QC test results, and any non-conforming material test results

   iv. All non-conformance reports with follow-up inspections, corrective measures, and penalties

iv. **Project summary repor**t: One copy n both hard copy and electronic PDF formats. The report shall include a summary of construction, including changes and reports documenting authorized deviation from the IFC documents.

v. **Shop drawings:** One set in both hard copy and electronic PDF formats.

vi. **Record Drawings:**in accordance with APEGA requirements for authentication and guidelines for producing record drawings.

   i. One set of Autodesk AutoCAD format electronic drawings

   ii. One full size set of mylar (original)

   iii. One copy in PDF

vii. **Updated Block Profile Drawings, if applicable:**

   i. One full size set of mylar for Review

   ii. One set of Autodesk AutoCAD format electronic drawings

viii. **Product information in both hard copy and electronic PDF formats:** A list of products and their product technical data sheets, maintenance requirements, and application and installation record.

ix. **Maintenance manual:** One copy in both hard copy and in electronic PDF formats. Maintenance manual shall be for elements, such as lighting, electrical, or other special applications to the project, such as MSE walls. Maintenance manual shall address any regular maintenance requirements, as well as instructions for repair or replacement of elements.

x. **Contract documentation:** One set in both in both hard copy and electronic PDF format. Include all contract documentation, such as:

i. Submittals
ii. Requests for information with responses
iii. Site instructions
iv. Field orders
v. Change orders
vi. Contemplated change notices

xi. **Reports** (as applicable) in both hard copy and electronic PDF formats:
i. Geotechnical Investigation
ii. Environmental Assessments
iii. Hydrological Assessments

xii. Signed and sealed **Contractor's warranty forms** (Appendix D).

xiii. **Construction progress photos** in .jpg format capturing main construction activities.

xiv. For all proprietary engineered products, a **Letter of Assurance of Engineering Field Review and Compliance** is required (Appendix B).

xv. Calculations for all bridge element quantities and dimensions, in accordance with the Ontario Structure Inspection Manual (OSIM).

Copies of all electronic file submissions shall be provided on a Universal Serial Bus (USB) flash drive.

END OF THE DOCUMENT

APPENDIX A – SUPPLEMENTARY GUIDELINES

A1 HIGHWAY ACCESSORY SUPPORTS GUIDELINES FOR STRUCTURAL DESIGN AND CONSTRUCTION

1. DESIGN STANDARDS

The design shall be in accordance with CAN/CSA-S6, latest edition and the latest edition of the Canadian Electrical Code. The fatigue design shall be carried out in accordance with Section 11 of AASHTO “Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals”, latest edition and Interims, AWS Standard D1.5, latest edition and with modifications contained in this document. Design for fatigue shall be required for all sign structures, cantilevered or overhead bridge type, traffic signals, and high-mast (over 30 m high) luminary structures.

The design shall be carried out by a Professional Engineer registered to practice in the Province of Alberta under the Engineering and Geosciences Professions Act (formerly known as the APEGGA Act).

2. FUNCTIONAL AND PERFORMANCE CRITERIA

2.1 General

1. Highway accessory structures and their components shall be designed to provide safe, durable and functional life of the structure. The design shall result in structures that do not experience excessive deflections, permanent deformations, or failure due to fatigue loads.
2. Overall attention to roadway user safety shall be a major consideration for the design and details of highway accessory structures and their components regarding aspects such as, but not limited to, positioning and where necessary, placement in clear zones.
3. The appearance of highway accessory supports should consider function and aesthetics. Structural supports should be designed and located so as not to distract the motorist’s attention or obstruct view of the highway or other signs. The aesthetic effect of signing or lighting installations have on the environment should be evaluated.

2.2 Sign Support Structures

1. Minimum vertical clearance below the sign panels for overhead and cantilever sign support structures shall be 5.8 metres, unless noted otherwise in the Contract Documents.
2. The deflection for cantilevered sign structures shall not exceed 200 mm vertically. The 200 mm range is defined as the sum of the potential upward and downward displacement of the cantilever structure.
3. This criterion is included to minimize potential vibration damage to the structure, and ensure visibility of the information to motorists.
4. For the overhead bridge type support structures, the maximum deflection shall be limited to 1/480 of the span length.
5. The arms of signs and signals shall be tapered or built as truss members.
6. The preliminary design information shall be submitted to the City for review prior to proceeding to the final design.

2.3 Luminaires

1. For luminaires less than 10 metres in height, the pole shall be designed to have a maximum deflection in any direction at the pole top, under maximum loading, of 150 mm.
2. For luminaires greater than 10 metres in height, the pole shall be designed to have a maximum deflection in any direction at the pole top, under maximum loading, of 200 mm.

3 STRUCTURAL DESIGN

3.1 Sign Support Structures – Sign Panel Size

The design sign panel area shall be taken as the largest of:

1. Actual area of sign panels as increased by an additional 15% to compensate for future sign loading.
2. Actual area of sign panels plus an additional area of 0.915m x sign width to compensate for future addition of three extra panels.

The proposed sign mounting locations shall be configured so as to produce the maximum loading effects on the support structure and foundation.

3.2 Luminaires – Sign Panel Size

1. Unless otherwise specified, the design sign panel area shall be 1.44 m^2, with the centre of the sign panel located at 2.5 m height from the base plate.

3.3 Wind Load

1. Structures and structural elements shall be designed for horizontal drag loads at the Serviceability Limit States and the Ultimate Limit States, and where appropriate, shall be designed for fatigue, as specified in this document.
2. The hourly mean reference wind pressure shall be as per Table A3.1.1 of CAN/CSA-S6, latest edition and shall be taken for the following return periods:
   - 50 years for overhead sign structures, luminaires support structures, and traffic signal structures exceeding 16 m in height.
   - 25 years for luminaires support structures less than 16 m in height and traffic signal support structures where locations and safety considerations permit, and when approved by the City.
3. The design wind pressure shall be as follows:

   Pz =qCgCeCh,
   Where: q shall be taken from CAN/CSA S6, latest edition, Table A3.1.1 for an appropriate return period as defined above;
4. The gust factor Cg for all elements of highway accessory support structures shall be 2.5 as specified in Clause 3.10.1.3 of CAN/CSA S6, latest edition.

5. Wind induced horizontal drag coefficient Ch shall be as specified in table A3.2.2, CAN/CSA S6, latest edition.
6. Exposure coefficient Ce shall be as specified in Clause 3.10.1.4 of CAN/CSA S6, latest edition.

3.4 Design for Fatigue

General

The provisions of the AASHTO "Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals" for structural fatigue design are based upon an Infinite Life Fatigue Design approach, which considers a Constant Amplitude Fatigue Limit (CAFL). Fatigue critical details shall be designed with nominal stress ranges that are below the CAFL values for the applicable detail categories.

Most common fatigue details are categorized and illustrated in the AASHTO Specifications. CSA W59, latest edition may be referenced for other connection details.

7. The fatigue importance factor (IF) shall be based on the following guidelines as it relates to applicable importance categories, used in the wind-induced, limit-state fatigue loads.
   i. **Category I** - critical cantilevered or overhead bridge type support structures installed on major highways or expressways that do not have vibration mitigation or damping devices installed on them. If such mitigating devices are installed, they will be moved down to Category II. Structures classified as Category I present a high hazard in the event of failure.

      Use Category I for the following conditions:

      - Structures without proven vibration damping devices;
      - ADT (average daily traffic) >10,000 in one direction, regardless of number of lanes or ADTT (average daily truck traffic) >1,000;
      - Cantilevered sign structures with span >17m or high-mast towers >30m high

   ii. **Category II** – cantilevered or overhead bridge type support structures installed on other roads and highways. All structures not meeting the criteria for either Category I or Category III should be classified as Category II. This would include any structures with damping devices that would otherwise meet the Category I criteria
   iii. **Category III** – cantilevered support structures installed at low-risk locations.

      Use Category III for the following conditions:

      - Speed limits of 60 km/h or less

iv. The following wind load effects shall be included in the fatigue design:

- Galloping: Equivalent static vertical shear pressure shall be taken as 1000 x IF (Pa)
- Natural Wind Gust for yearly mean wind speed 5 m/s
- Truck-induced Gust for vehicle speed of 30 m/s, unless otherwise specified in the Contract Documents.
- Vortex Shedding (applicable only to luminaires structures with taper less than 12 mm/m)

2. Anchor bolts with nuts both above and below a base plate cannot be preloaded below the level of the bottom nut. The fatigue resistance of the bolts that are not preloaded or that have the dimension from underside of the lowest nut to top of concrete exceeding two (2) bolt diameters, shall be governed by fatigue stress category “E”.
3. Should base plates be required to bear on concrete through grout pads, such pad depths shall be minimized. Where non-preloaded anchor bolts are utilized with grout pads and the grout pad depth dimension exceeds two (2) bolt diameters, the anchor bolt design shall be governed by fatigue stress category “E”. Note: In the case of preloaded anchor bolts, Engineer-of-Record to determine method to reach required design preload and provide details on drawings.

3.5 Dead Loads

The dead load shall consist of all permanent loads due to weight of the materials and components of the structure. The dead load shall also include weight of secondary structural elements such as luminaires, sign structures, traffic signals and any other appurtenances attached to the support structure.

1. Sign Support Structures

   The unit weight for the dead load of the sign components shall be taken as 0.15 kN/m2. For sign support structures the sign panel area shall be taken as defined in Item 3.1 of this document.

2. Luminaires

   The actual weight shall be taken for the dead load of the luminaires’ components and attachments. The proposed weight of attachments shall be increased by additional 15% to compensate for future alterations of the loading applied to the support structure.

3. Traffic signals

   The actual weight shall be taken for the dead load of the anticipated components and attachments. The proposed weight of attachments shall be increased by additional 15% to compensate for future alterations of the loading applied to the support structure.

3.6 Ice Accretion

Ice accretion shall be in accordance with CAN/CSA-S6, latest edition. Ice accretion of four (4) mm shall be considered.

3.7 Load Combinations

Load combinations and load factors shall be as per Table A3.2.1 of the CAN/CSA-S6, latest edition. Normal and transverse load combinations shall be applied as per Clause A3.2.3, Figure A3.2.1, and Table A3.2.3.

4 QUALITY MANAGEMENT SYSTEM

4.1 General

1. The Contractor shall maintain an approved quality management system throughout the contract. The quality management system shall meet the requirements of one of the following:
   i. The latest issue of ISO 9001
   ii. The Q-base code (the Q-base code contains the basic requirements of the ISO standard, but it is intended for small companies (i.e. Less than 10 employees) who are not ready to advance to full ISO certification).
   iii. Alternative quality management systems that fully meet the objectives of the above standards may be accepted by the Engineer. The Contractor shall provide the Engineer with evidence of a documented quality management system.
2. The purpose of the quality management system is to ensure that the product meets the quality requirements of the contract, is delivered on time, and is produced in a cost-effective manner. The Contractor’s quality management system shall apply to all stages of the design, procurement, manufacturing, testing and delivery of the product.

4.2 Design Calculations and Working Drawing Submissions

The Contractor shall submit to the Engineer a complete set of design calculations and drawings, prepared and sealed by a professional Engineer registered by the Association of Professional Engineers and Geoscientists of Alberta (APEGA). As Constructed Calculations and Drawings will be required at the completion of the contract.

1. Calculation Content

   The design calculations shall:

   - Be detailed enough to allow for a technical review of the design to ensure it meets the requirements of the contract.
   - Include a list of all assumptions made as part of the design.

- Include, as a minimum, calculations for the following structural components:

  Shaft

  Horizontal arm or truss

  Shaft or arm flange connections

  Base plate

  All welded connections

  Anchor bolts

  Foundation

- Identify all horizontal, vertical and overturning loads at the base of the structure.

2. Calculation Format

   The calculations shall be presented in an orderly manner logically progressing through the structure.

3. Drawing Content and Organization

   - Shop Drawings shall clearly indicate a list of materials and components, methods of construction, erection diagrams, connections, explanatory notes and all other information necessary for completion of work.
   - The first Drawing sheet for each structure shall contain the design criteria, list of material and components, and the structure elevation. Show the design combination and forces governing the design.
   - The Drawings shall be detailed enough to allow for technical review of the design to ensure that it meets the requirements of the contract.
   - All details required for the fabrication of the final product shall be included in the Drawings. Show all splice locations and details on Shop Drawings.
   - Show Anchor Bolt orientations.
   - Show maximum sign area that the structure is capable of supporting for the specified wind pressure.
   - Erection procedure, including preload procedure for anchor bolts, if applicable, shall be shown on the Drawings.

4. Drawing Format

   The drawing format shall be as follows:

   - AutoCAD format (most current release.)
   - Produced on ISO a1 size paper (other sizes shall meet the approval of the Engineer).
   - Metric units only
   - Legible when reduced to 1/2 size or microfilmed.

4.3 Review of Design Calculations and Drawings

The Engineer will review the design calculations and Shop Drawings as follows:

1. Design calculations and Shop Drawings will be reviewed by the Engineer solely to ascertain conformance with the general design concept. Responsibility for approval of detail design inherent in the calculations and drawings rests solely with the Contractor. The review by the Engineer shall not constitute approval.
2. Review by the Engineer shall not relieve the Contractor of responsibility for errors or omissions in the calculations and drawings or for proper completion of the work in accordance with the contract documents. The Engineer shall review all design calculations and shop drawings and return any comments to the Contractor five working days after receipt
3. The Contractor is responsible for verification and correlation of field dimensions, fabrication processes, techniques of construction, installation and co-ordination of all parts of the work.
4. After the Engineer review, the calculations and drawings will be returned to the contractor. The Contractor shall revise the drawings and calculations to the satisfaction of the Engineer prior to fabrication.
5. The Engineer may require adjustments to the design calculations and drawings. If it is deemed by the Contractor that such revisions affect the contract price, this must be presented in writing to the Engineer for consideration. Written approval to proceed must be granted the Contractor by the Engineer prior to proceeding with fabrication and installation of work.

5 MATERIALS

5.1 General Material Requirements:

1. All materials shall be new.
2. The Contractor shall provide mill test certificates for all sheet steel, steel reinforcement, bolt assemblies and anchor assemblies to the Engineer prior to fabrication. The mill test certificates shall contain all chemical and physical properties of the steel to be used in fabrication.

3. The use of aluminum is not acceptable, unless specifically stated otherwise by the Engineer.

5.2 Structural Steel

1. Pole shafts Grade 350WT*

   Structural steel for handhole reinforcement, connection flanges and base plates shall conform to CAN/CSA-G40.20/G40.21, latest edition, Grade 300WT or greater, as required.

   * For luminaire pole shafts < 16 m 300W may be used

2. Silicon content of steel shall be less than 0.04% or shall be between 0.15% to 0.2%
3. All steel shall be free of surface defects and internal discontinuities.

5.3 Concrete

1. All concrete used for highway accessory support bases shall conform to CAN/CSA A23.1, latest edition and shall have the following properties:*

28-Day Strength	min. 30 MPa at 28 days
Cement	Type HS**
Slump	max. 80 mm
Air Entrainment	5-7%
Max. Size of Aggregate	20 mm
Max W/Cm***	0.45

* Refer to Table 2 of CAN/CSA A23.1, latest edition for other acceptable concrete properties for various site-specific exposure conditions.
** If the exposure is a combination of chlorides and sulphate, use HPC.
*** Water to cementitious materials ratio.

2. The City may undertake, through an independent CAN/CSA certified testing firm, random sampling, inspection and testing for the purposes of determining the compliance with the Specification and other Contract Documents.

5.4 Reinforcing Steel

1. Reinforcing steel for substructures within Traffic Splash Zone (10 m from edge of pavement) shall be galvanized to 3 m (minimum) depth below foundation grade or full depth of foundation, whichever is less.
2. Reinforcing steel to conform to CSA G30.18, latest edition, Grade 400W and Specification Section 03200

6 FABRICATION

1. Fabrication shall be performed in an enclosed area, which is adequately heated. Field welding will not be allowed.

6.1 Submissions

2. Welding Procedures

   Welding procedures shall be submitted for each type of weld used in the structure. The procedures shall bear the approval of the Canadian Welding Bureau and shall also be reviewed by the Engineer.

3. Proposed Fabrication Sequence

   Prior to commencement of fabrication, the Contractor shall present for review an outline of the fabrication sequence that clearly describes the order of make-up and assembly of all the component parts, as well as shop assembly, inspection stations.

4. Mill Certificates

   Mill certificates shall be provided for all material before fabrication commences. Fabrication shall only be allowed with materials having mill certificates properly correlated to the materials used on the project and that have been reviewed and accepted by the Engineer. Mill test reports are to be submitted for review at least four weeks prior to the scheduled start of fabrication. Test reports for all materials shall be written in English.

   The Contractor shall have all steel, including billets, bars and fasteners, originating outside of Canada or the U.S. verified by a certified laboratory in Canada by testing to the specified material standards, and shall include a determination of boron content (not permitted to exceed 0.0008%).

   This laboratory shall be certified by an organization accredited by the Standards Council of Canada to comply with the requirements of ISO/IEC 17025 for the specific tests, or type of tests, required by the material standard specified on the mill test report. Preparation and collection of samples for testing shall be directed and witnessed by, or completed by, personnel employed by the testing lab. A verification letter, signed and sealed by a Canadian registered Professional Engineer in the field of metallurgy and bearing the signature of an authorized officer of the testing laboratory, shall be provided by the laboratory and shall include references to the appropriate mill test report(s), material specification number(s), testing standards, date of testing, and statements indicating material compliance with the requirements of the Contract documents.

5. Galvanizers' Certificates

   Prior to commencement of galvanizing, the Contractor shall provide galvanizers' qualifications and certifications.

6. Schedules

   The Contractor shall provide and keep current a complete fabrication schedule in a form satisfactory to the Engineer.

6.2 Bolted Connections

1. Connections shall be in accordance with ASTM A325, latest edition, and shall be snug tight plus 1/3 turn (turn-of-nut), complete with nuts and washers, galvanized. The top 150 mm of anchor bolt should be threaded.
2. Anchor bolts: to be fabricated from DYWIDAG thread bars conforming to the requirements of ASTM A722/ A722M latest edition, Standard Specification for High-Strength Steel Bars for Prestressed Concrete. Anchor bolts shall be supplied with steel nuts and washers, all galvanized.
3. Bolts and anchor bolts shall be sized to accept galvanized nuts without damaging the protective coating.
4. Anchor bolt top and bottom cage plates shall be labeled to ensure they are matched with the appropriate leg.

6.3 Welding

1. Certification

   Welding to CSA W-59, latest edition. Fabricators shall be certified by the Canadian Welding Bureau in accordance with CSA W47.1, latest edition for Division 1 or for Division

2. Filler Metals

   Low hydrogen filler, fluxes and low hydrogen welding practices shall be used throughout. The low hydrogen covering and flux shall be protected and stored as specified by AWS Standard D1.5, latest edition. Flux cored welding or use of cored filler wires in the submerged arc process or shielding gas processes are not considered as conforming to low hydrogen practice. These methods will not be permitted. However, metal core welding process utilizing low hydrogen electrodes with AWS designation of H4 will be allowed. The deposited weld metal shall provide strength, durability, and impact toughness and corrosion resistance equivalent to base metal.

3. Cleaning Prior to Welding

   Weld areas must be clean, free of mill scale, dirt, grease, and other contaminants prior to welding.

4. Longitudinal Seams

   All longitudinal seams shall be made by an approved semi or fully automatic submerged arc or metal core welding processes.

5. Weld Penetration

   The full penetration welds shall be completed using properly fitted backing bars or back gouged to sound metal. The longitudinal seams shall have a minimum 60% penetration; however, if backing bar is used for longitudinal seam, the weld penetration shall be 90%. The following welds shall have 100% penetration:

   - Column to base plate*
   - Member to flange plate
   - Flange plate to gusset plate.
   - Longitudinal seam welds within 150 mm of circumferential welds and 150 mm beyond hand holes (when provided) shall be full penetration groove welds. Transition between full and partial penetration welds shall be ground smooth.
   - Longitudinal seam welds, on the female section of the slip joint, shall be full-penetration groove welds for a length equal to the minimum splice length plus 150 mm.
   - Backing bar splices

     * Luminaires and traffic signal supports not greater than 16 m in height may be socket-type connections with a continuous fillet weld on the inside of the base plate at the end of the shaft and another continuous fillet weld on the outside at the top of the base plate.

     The backing bar for full penetration weld shall be properly fitted and the member prepared to a sharp edged 45-degree chamfer. The groove weld shall be placed in a minimum of two passes by using 100°C of preheat (unless higher preheat is required as per AWS D1.5 Table 12.3) and maintain a root opening of 5 mm. A rod size, no greater than 4.0 mm, shall be used for the first pass. A reinforcing fillet weld shall be placed all around the joint.

6. Tack and Temporary Welds

   Tack and temporary welds shall not be allowed unless they are to be incorporated in the final weld. Tack welds, where allowed, shall be of a minimum length of four times the nominal size of the weld, and shall be subject to the same quality requirements as the final welds. Cracked tack welds shall be completely removed prior to welding over.

7. Run-off Tabs

   Run-off tabs shall be used at the ends of all welds that terminate at the edge of a member. They shall be tack welded only to that portion of the material that will not remain a part of the structure, or where the tack will be welded over and fused into the final joint. After welding, the tabs are to be removed by flame cutting, not by breaking off

8. Methods of Weldments Repair

   Repair procedures for unsatisfactory weldments shall be submitted for approval by the City and Engineer prior to repair work commencing.

9. Arc Strikes

   Arc strikes will not be permitted. In the event of accidental arc strikes, the Contractor shall submit to the City and Engineer for approval a proposed repair procedure. The repair procedure shall include the complete grinding out of the crater produced by the arc strike. These areas will be examined by the Engineer to ensure complete removal of the metal in the affected area.

10. Plug and Slot Welds

    Plug welds or slot welds shall not be permitted.

11. All plate material for main members and any plate material welded to the main member shall be flame cut using an automatic cutting machine. Shearing is not allowed.

12. Additional splices, other than those shown on the shop drawings, will require review by the Engineer. The Contractor shall bear the cost of inspection of these splices.

13. Lapped joints in the tubular members shall be of sufficient length to develop the full strength of the lapped members. The ends of the plates in the joint shall not be chamfered over more than 50% of their thickness.

14. Each column, arm, extension, clamp and bracket shall be fabricated from one piece of sheet steel unless approved otherwise.

15. Intermediate circumferential butt welds shall not be allowed, however horizontal members greater than 12 m span may have a bolted splice.

16. Columns, arms, extensions and clamps shall be brake press formed or roll formed. The brake press knife shall have a radius suitable for the thickness of the material and nature of the bend.

17. All plate edges shall be free of notches and gouges.

18. The depth or projection of any imperfections on the inner or outer surfaces shall not exceed 15% of wall thickness. Any depth or projection up to 33% of wall thickness may be repaired by welding. Any excessive projecting weld metal shall be removed.

19. The diameter of bolt holes in base plates shall be 10 mm larger than the bolt diameter.

20. Punching of full size holes will not be permitted. The holes shall be circular and perpendicular to the member and shall be deburred to ensure a proper faying surface.

21. Hand holes with cover plates on top and bottom of columns are to be provided for illuminated sign structures or when required as per special provisions.

22. Hand hole (when required) shall be stiffened by providing a reinforcing rim with semi-circular ends. The rim shall be welded to the member with a full penetration groove weld supplemented with an all-around fillet weld.
23. Only low stress stamps shall be used for identification marks. The stamps and specific location shall be shown on the shop drawings and approved by the Engineer.

6.4 Dimensional Tolerances

All fabrication shall meet the tolerances described below:

1. Straightness

   The straightness of any item shall not exceed the overall length divided by 300 from the surface at any point. This shall be measured with a straight line joining the surface at both ends. The difference between the straight line and the surface shall then be measured to determine the straightness.

2. Twisting

   The twist in the overall length of any column, arm, or extension shall not exceed 7°.

   The base plate shall be installed true and accurate at 90 degrees to the axis of the column, arm, or extension with a deviation of not more than 0.5 degrees.

3. Length

   The specified length of any item shall be within 0 to 60 mm or 0 to +5% (whichever is less) with the exception of sign bridge spans which shall be within 5 mm of the specified dimensions in unloaded condition. The tolerance for height shall be 0 to +60 mm.

4. Across the Flat Dimensions

   The average of all across the flats dimensions from a given cross section shall be within 1% of the specified dimension. In addition, the ratio of the maximum to minimum across the flats dimensions shall be less than or equal to 1.05.

5. Tolerance for Flatness of Base Plates and Flange Plates

   Surfaces of column base plates shall be flat to within 3 mm tolerance in 305 mm, and to within 5 mm tolerance overall. Faying surfaces of flange plates shall be flat to within 2 mm tolerance overall.

6. Arm Rise

   Arm rises apply to unloaded structure in the standing position.

6.6 Pre-Assembly

After welding and fabrication, but prior to galvanizing, the Contractor shall pre-assemble all structures complete with welded sign clamps to check the fit and geometry. Pre-assembled structures shall be inspected by the Engineer.

Following inspection by the Engineer, the structures shall be disassembled for galvanizing.

6.6 Galvanizing

1. Galvanizing shall conform to:
   - ASTM A-123, "Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products", latest edition.
   - All materials to conform to chemical composition restrictions as recommended in ASTM A385, “Standard Practice for Providing High-Quality Zinc Coatings (Hot Dip), latest edition.
2. Qualifications of galvanizers: galvanizers shall be certified in accordance with CAN3 - Z299.4, latest edition. Certification to be submitted to the City.
3. Minimum zinc retention to be 600 g/m^2.
4. All steel components including anchor bolts, high strength bolts, nuts and washers shall be galvanized after fabrication.
5. All steel surfaces shall be free of oil, grease, welding slag, paint, varnish, rust, or anti-spatter compounds prior to galvanizing.
6. Galvanizing shall be continuous and uniform in appearance, colour and texture.
7. Any sharp edges caused by galvanizing drippings shall be filed smooth and coated with an approved cold galvanizing compound.
8. All threaded holes or threaded couplings shall be retapped after galvanizing and painted with an approved cold galvanizing compound.
9. All loose galvanizing slag and spatter shall be removed from all components after galvanizing.
10. The galvanizer shall safeguard against embrittlement in accordance with ASTM A143/ A143M, latest edition.
11. Repair of galvanizing shall only be done if bare areas are infrequent, small, and suitable for repair. A detailed repair procedure shall be submitted and approved prior to its use. It should be noted that repairs may require complete removal of the galvanized coating and regalvanizing. Repair shall comply with ASTM A780, latest edition, and method A3 metalizing. The thickness of the metalizing shall be 180 μm, and the repair tested for adhesion. The finished appearance shall be similar to the adjacent galvanizing. The Engineer will determine the acceptability of repaired areas.

6.7 Testing and Inspection

1. Quality Assurance

   The Engineer will implement a Quality Assurance program by auditing the Contractor's Quality Management System and shall reserve the right to inspect the products during all stages of fabrication at any time in the fabricator's plant. The Contractor's Quality Management System shall be submitted to the Engineer, and include quality control of all materials and workmanship, including galvanizing and painting. The Contractor shall co-operate with the inspection agency and shall furnish the inspector with all Quality Control data and information requested.

2. The Engineer's Review

   The Engineer's inspections and review of the products shall not constitute final acceptance. Final acceptance of any product will not be granted until it has been installed and is operating to the satisfaction of the Engineer. Testing by the Contractor

   i. The Contractor shall provide quality control throughout the course of fabrication. All test records made by the fabricating shop in the course of normal quality control shall be open to the Engineer for inspection. Testing and inspection made necessary by the repair of faulty work shall be paid for by the Contractor.

   ii. The Contractor shall arrange to have all full penetration welds inspected either by ultrasonic testing or radiographic inspection methods by a company certified to CSA-W178.1, latest edition. A copy of test results shall be provided to the Engineer.

   iii. Engineer does not require destruction of product for testing penetration of seam welds; however, the Contractor shall provide evidence that seam welds meet the requirements of the approved CWB weld procedure by performing periodic random testing of test samples. Sample seam welds for each CWB approved seam weld procedure required by this specification shall be cut, etched and checked for penetration. Testing for all approved seam weld procedures shall be done by a company certified to CSA-W178.1, latest edition. The testing company shall provide evidence that the samples were taken randomly from the production run.

   iv. The frequency of seam weld testing shall be as follows:
      - For a continuous production, each plate thickness shall be tested at the beginning of the machine set-up, at 50% production and at the completion.
      - The testing interval shall not exceed two (2) days.
      - If the production is for a day or less, only one (1) testing is required.

v. The results of seam weld testing shall be provided to the Engineer within seventy-two (72) hours of the testing. All the cost associated for seam testing including re-testing when required and non-destructive inspection of full penetration welds shall be borne by the Contractor

vi. The Contractor shall be responsible for all travel, boarding and lodging costs for a City's representative to attend the pre-job meeting and two additional trips during the course of fabrication when the sign structures are being fabricated outside the province of Alberta.

3. Testing by the Engineer

   The visual, radiographic, ultrasonic, magnetic particle and any other inspection that may be specified or required will be performed by the Engineer or by his testing agencies at the Engineer's expense.

4. Inspection Station

   To ensure that each stage of inspection is performed in an orderly manner, during the fabrication, Inspection Stations will be set up at specific points. Certain items of the work will then be checked, and deficiencies shall be corrected, prior to the work being sent to the next stage of fabrication. These check points are to be agreed to by the City and Engineer and the Fabricator prior to commencement of fabrication. The City and Engineer reserves the right to stop detrimental fabrication between checkpoints if deemed necessary.

5. Non-Destructive Methods of Examination

   The methods of non-destructive examination shall be in accordance with the following standards:

   - Radiography – CSA W59, Latest Edition
   - Ultrasonic – CSA W59, Latest Edition
   - Magnetic Particle – ASTM Standard E-709, Latest Edition

6. Inspection Schedule

   All welds will be visually inspected.

   Ultrasonic inspection will be performed on full penetration welds.

7 INSTALLATION

7.1 Miscellaneous

Any product damaged in shipping or during installation shall be replaced at no extra cost to the City.

Prior to construction, the Contractor shall confirm utility conflicts with the sign bases, and immediately inform the Engineer of these conflicts

The Contractor shall not erect the structural steel until the substructure concrete has been cured a minimum of three days and achieved 80% of the 28-day specified concrete strength requirement.

All components shall be handled with care to prevent stress to the components through bending or twisting. The use of steel chairs as slings will not be permitted. Any damage to the components through overstress, scratching or denting shall be required or replaced at the contractor's expense to the satisfaction of the Engineer.

Pole shafts shall mount directly on concrete bases and where necessary, shall be true to plumb using galvanized levelling shim plates. The shim plates must be located so that a minimum of 75 mm of distance is provided from shims to grout edge. The method of forming and pouring the grout shall be submitted to the Engineer for approval. Dry-pack methods of constructing grout pads will not be approved.

Handhole bolts shall be coated with anti-seize lubricant.

All scratches in poles and all field-drilled holes shall be repaired by metalizing, as specified in Section 6.7.11 of this document or, at the discretion of the Engineer, they may be repaired by coating with Crown No, 67007 cold galvanizing compound spray type (or approved alternative, i.e. Zinga). The application of the cold galvanizing compound shall conform to the Manufacturer's instructions.

7.2 High-Tensile-Strength Bolted Connections

Bolted parts shall fit solidly together when assembled. Contact surfaces shall be free of dirt, grease, burrs, pits and other defects that would prevent solid seating of the parts. Connections shall be assembled with a hardened washer under the bolt head or nut, whichever is the element turned in tightening. Surfaces of bolted parts in contact with the bolt head and nut shall be parallel.

7.3 Bolt Tension

All structural bolts shall be tightened by using turn-of-nut method to ensure the minimum bolt tension specified in **Table 1** is achieved in every bolt after all bolts in the connection have been fully tightened:

Table 1 BOLT TENSION

Specified Bolt Size (A325M Bolts)	Minimum Bolt Tension		Commonly Supplied Equivalent Imperial Size(A325 Bolts)	Minimum Bolt Tension	
	Kilonewtons	pounds-force		Kilonewtons	pounds-force
M16X2	94	21,180	5/8	85	19,200
M20X2.5	147	33,050	3/4	126	28,400
M22X2.5	181	40,700	7/8	175	39,250
M24X3	212	47,660	1	227	51,500
- -	- -	- -	1 1/8	251	56,450
M30X3.5	337	75,760	1 1/4	319	71,700
- -	- -	- -	1 3/8	380	85,450
M36X4	490	110,160	1 1/2	463	104,000

For initial tightening there shall first be enough bolts brought to a "snug tight" condition to ensure that the parts of the joint are brought into full contact with each other. Snug tight is defined as the tightness attained by a few impacts of an impact wrench or the full effort of a man using an ordinary spud wrench.

Following this initial operation, bolts shall be placed in any remaining holes in the connection and brought to snug tightness. After all bolts have been taken to the snug tight condition, the Contractor shall match mark the outer face of each nut and protruding end of bolt to have a common reference line to determine the relative rotation. All bolts in the joint shall then be tightened additionally by the applicable amount of nut rotation specified below, with tightening progressing systematically from the most rigid part of the joint to its free edges. During this operation there shall be no rotation of the part not turned by the wrench.

Amount of rotation of nut relative to bolt, regardless of which is turned:

- 1/3 turn where bolt length is four (4) bolt diameters or less
- 1/2 turn where bolt length is over four (4) bolt diameters and not exceeding eight (8) bolt diameters
- 2/3 turn where bolt length exceeds eight (8) bolt diameters

Notes:

Rotational Tolerance: +1/6 turn (60°) over, nothing less than the minimum specified under Length of bolt measured from underside of head

1. The Contractor shall provide safe and adequate access meeting Occupational Health and Safety requirements to all working areas, including all necessary scaffolding to enable the Consultant to carry out his inspection. The Contractor shall provide a competent workman to assist the Consultant in the checking of bolt tightening work.
2. The Contractor shall visually check 100% tightening of the bolts by observing matchmarking. In addition, the Contractor shall check 10% of all the bolts by “Calibrated Wrench Tightening” in accordance with CSA S6, Annex A.10.1.6.8, Inspection of Turn of Nut Tightened Bolts. The wrenches shall be calibrated at least once each working day in a device capable of indicating actual bolt tension. A minimum of three typical bolts of each diameter and length shall be tested from the bolts installed.

8 FOUNDATION

8.1 Design

The Contractor shall have the foundations designed and sealed by an Engineer licensed to practice by the Association of Professional Engineers and Geoscientists of Alberta (APEGA). The Contractor shall submit design calculations and Shop Drawing for review by the Engineer. The design shall be based on loads provided by the sign structure Design Engineer.

The Contractor shall undertake any geotechnical work at his own cost in order to obtain sufficient site-specific information necessary to perform foundation design in accordance with Guidelines and Standards referenced in this document.

The Contractor shall determine the type and size of foundation required and shall carry out the necessary design.

Foundations shall be designed to allow for local frost conditions.

Foundation base shall be designed so that base plate elevation is minimum 150 mm above ground

8.2 Construction

1. Excavation and Backfill

   The Contractor shall excavate holes to a minimum of 300 mm larger than the base and the base shall be installed in the centre of the excavation.

   The backfill around the base shall be placed in thin layers and shall be thoroughly compacted for the full depth.

   The maximum allowable width of excavation shall be site-confirmed and include safe slope and shoring as required. A rigid traffic barrier system shall be used as a protection within a roadway.

   All backfill material shall be free of organics.

Cementitious materials shall not be used as backfill, unless specified otherwise in the Contract Documents.

The disturbed area around installations shall be restored to the original contours.

Soft spots shall be removed and cleaned and the soil at the bottom of holes shall be thoroughly compacted to provide a firm bearing. These areas shall be inspected prior to construction of the foundation.

2. Drilled Cast-in-Place Piles

All pile drilling equipment, drilling procedures and pile materials placement shall be submitted for review by the Engineer before the installation has started.

Temporary casing shall be used where risk of collapse of the pile holes exists due to ingress of water.

Drilled pile holes shall be covered until the time of filling them with concrete. The covers shall be of sufficient strength to sustain any construction potential construction load.

Adequate spacers shall be used to ensure minimum 100 mm concrete cover to reinforcing steel.

Specified shape and dimensions of concrete piles above grade shall be obtained by use of suitable forms.

Pile installation in cold weather conditions shall be managed by use of insulated forms and tarps, over sizing pile diameters and other forms of protection. The requirements of CAN/CSA A23.1, latest edition for cold weather concreting shall be met.

9 ROADWORK

Where the existing median is to be reconstructed to accommodate the pedestal for a sign bridge, the face of the median shall maintain the standard barrier profile as required on the adjacent median sections.

10 WARRANTY

As per the General Conditions, the Contractor shall warrant that all of the products are free from defect (material and workmanship) for a two-year period starting from date of issuance of The City's Substantial Completion Certificate.

For all galvanizing finishes, the Contractor shall provide a warranty for a five-year period, starting from the date of issuance of The City's Substantial Completion Certificate. The attached Warranty forms for galvanizing of steel structures shall be signed and sealed jointly by the Supplier and Installer.

END OF DOCUMENT

APPENDIX B – DESIGN SUBMITTALS

NOTES

NAD 83
COORDINATES

ISSUED FOR REVIEW

NO.	DESCRIPTION	DATE (YYYY-MM-DD)	BY	APPD

PERMIT

SEAL

	BY	DATE (YYYY-MM-DD)
DESIGNED		
DRAWN		
CHECKED		

SCALE

CONSULTANT'S LOGO

PROJECT

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SEC: -- - TWP: --- RGE: -- W -th M

SHEET TITLE

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--

FILE NO.	ENG DWG NO.
--	--

SHEET ID.	SHEET COUNT
---	-- of --

SHEET SIZE ANSI D 25 mm 0

PROJECT TITLE

Prepared By:
Date:

DESIGN BRIEF

City Structural Title Block:

Design Codes: CAN/CSA-S6 (latest edition)
Other References: The City of Calgary Design Guidelines for Bridges and Transportation Structures (latest edition)

PROJECT TITLE

Prepared By:
Date:

Project Scope & Short Description of Structure:

ITEM	REV	DESCRIPTION
Geometry		**Span No. and Length(s):** **Horizontal Alignment:** **Vertical Alignment:** **Skew:** **Lane Widths:** **Bridge Width:** **Clearance Box:**
Design Parameters		**Live Load:** **Pedestrian Load:** **Fatigue Limit State:** **Roadway Class:** **Traffic Volume:** **Wind Load:** **Temperature Range:** **Earth Pressures:** **Ice Loads:** **Earthquake:** **Soil Bore Hole Data:** **Geotechnical Features:**

ITEM	REV	DESCRIPTION
Structural Materials		**Concrete:** **Stainless Steel Rebar:** **Galvanized Rebar:** **Reinforcing Steel:** **Prestressing Steel:** **Post-Tensioning Steel:** **Structural Steel:** **Other Materials:**
Abutments		**Type:** **Foundation:** **Bearing Seat:** **Backwall:** **Wingwalls:** **Curtain Wall:** **Roof Slab:** **Approach Slab:** **Pigmented Sealer Colour:** **Finishes & Sealing:** **Slope Protection:** **Drain Troughs:** **Special Features:** **Additional Comments:**

ITEM	REV	DESCRIPTION
Piers		**Type:** **Foundation:** **Footing Elevation:** **Footing Shape:** **Bracing:** **Nose Plates:** **Pigmented Sealer Colour:** **Finishes & Sealing:** **Special Features:** **Additional Comments:**
Bearings		**Type:** **Expansion:** **Fixed:** **Orientation:** **Corrosion Protection:** **Special Features:** **Additional Comments:**
Girders		**Method of Analysis:** **Girder Type:** **Girder Number and Spacing:** **Continuity:** **Transverse Connectivity:**

ITEM	REV	DESCRIPTION
		Wheel Line Distribution: **Diaphragms:** **Pigmented Sealer Colour:** **Finishes:** **Special Features:** **Additional Comments:**
Deck Slab		**Nominal thickness:** **Total Deck Width:** **Haunches:** **Crown or Superelevation:** **Wearing Surface (Current & Future):** **Curbs:** **Sidewalks:** **Barriers:** **Railings:** **Median:** **Deck Drains:** **Utilities:** **Deck Joints:** **Special Features:** **Additional Comments:**
Expansion Joints		**Type:**

ITEM	REV	DESCRIPTION	
		Expansion: **Location:** **Special Features:** **Additional Comments:**	
MSE Retaining Wall		**Type:** **Maximum Panel Size:** **Length of Wall:** **Maximum Height of Wall:**	
Other		**Lighting:** **Signage:** **Utilities:**	
Construction		**Special Features:** **Approving Authorities:**	
Features			
Preliminary List of Drawings		**Drawing No.**	**Drawing Title**
		1 2 3 4 5 6 7 8 9	Cover Sheet Index Site Plan General Arrangement Information Drawings Data Sheet Hydrotechnical Information Geotechnical Information Foundation Layout

PROJECT TITLE

Prepared By:
Date:

ITEM	REV	DESCRIPTION	
		10	Foundation Details
		11	Abutment 1 Layout and Details
		12	Abutment 2 Layout and Details
		13	Abutment Details – Sheet 1
		14	Abutment Details – Sheet 2
		15	Girder Layout
		16	Girder Details – Sheet 1
		17	Girder Details – Sheet 2
		18	Diaphragms
		19	Bearings Layout
		20	Bearing Details
		21	Deck Layout and Details – Sheet 1
		22	Deck Layout and Details – Sheet 2
		23	Expansion Joints
		24	Approach Slabs Layout and Details
		25	Bridge Barrier Layout
		26	Bridge Barrier Details & Reinforcement
		27	Guardrails and Handrails Layout
		28	Guardrails and Handrails Details
		29	MSE Walls/ Retaining Walls
		30	Slope Protection
		31	Miscellaneous Details
		32	Landscape Details
		33	Electrical Details

ITEM	REV	DESCRIPTION
Scheduling		Detailed Design Schedule 60%, 90%, 100% Complete Drawings 90%, 100% Complete Technical Specifications 60% and Pre-Tender Cost Estimate Construction Schedule and Completion Date
Unresolved Major Items		
Primary Contact:		

ASSURANCE OF ENGINEERING FIELD REVIEW AND COMPLIANCE

To: The City of Calgary

Re: ______________________________
Project
____

I herby give assurance that

(a) I have fulfilled my obligations for field reviews;
(b) I have enclosed documents supporting all approved changes to the plans and specifications prepared by me which was issued for this project;
(c) The components of the project are in general conformance with the plans, specifications and other project-related documents;
(d) I have enclosed Record Drawings reflecting all approved changes to the Drawings and Specifications;
(e) I am a registered Engineer in Alberta (APEGA).

____
Signature

____
Date

____
Name

I have signed on behalf of:

____
Firm

____
Name

____
Address

____
Postal Code

APPENDIX C – STANDARD CITY SPECIFICATIONS

02455	DRIVEN STEEL PILES
02466	DRILLED CONCRETE PILES
02510 (b)	BRIDGE DECK ASPHALTIC CONCRETE PAVING – MULTIPLE LIFTS
02850	NOISE BARRIERS
03200	CONCRETE REINFORCEMENT
03300	CAST IN PLACE CONCRETE
03301	HIGH PERFORMANCE CONCRETE
03302	PRECAST CONCRETE SUPPLY, FABRICATION AND ERECTION
03483	MECHANICALLY STABILIZED EARTH RETAINING WALLS
05120	STRUCTURAL STEEL SUPPLY AND FABRICATION
05500	METAL FABRICATIONS
05650	BRIDGE BEARINGS
05820	EXPANSION JOINT ASSEMBLIES
07100	BRIDGE DECK WATERPROOFING
09719	COATINGS FOR STEEL

DRIVEN STEEL PILES

1 GENERAL

1.1 Work Included

.1 This section outlines the requirements of the Contractor for all materials, equipment, labour, and incidentals, including the following:

- .1 Making sure existing underground and overhead utilities are safe;
- .2 Excavating, backfilling, and grading for the support of piling equipment;
- .3 Excavating below the cut-off elevation around all piles;
- .4 Pre-auguring holes to assist pile driving (if required and permitted by the Engineer);
- .5 Supplying, setting up, and driving steel piles at the locations and depths shown on the Drawings or as otherwise directed by the Engineer;
- .6 Splicing piles (if required and permitted by the Engineer);
- .7 Testing of piles, as specified in the Agreement;
- .8 Cutting piles to the specified elevation;
- .9 Preparing piles for capping;
- .10 Removing all excavated materials from the site.

.2 This section does not cover the supply, fabrication, and installation of steel sheet piles.

1.2 Related Work Specified in Other Sections

.1 Drilled Concrete Piles — Section 02466

1.3 Reference Standards

Perform the Work of this section in accordance with the latest edition of the following standards available at the Effective Date, except where specified otherwise. Provide one copy onsite of CAN/CSA S6:

.1 ASTM International (ASTM):

- .1 ASTM A29 / A29M - 16, Standard Specification for General Requirements for Steel Bars, Carbon and Alloy, Hot-Wrought
- .2 ASTM A108, Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished
- .3 ASTM A123/A123M, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
- .4 ASTM A143/143M, Standard Practice for Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement

.5 ASTM A153/A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

.6 ASTM A252, Standard Specification for Welded and Seamless Steel Pipe Piles

.7 ASTM A563M, Standard Specification for Carbon and Alloy Steel Nuts

.8 ASTM A780/780M, Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings

.9 ASTM D1143/D1143M, Standard Test Methods for Deep Foundations under Static Axial Compressive Load

.10 ASTM D3689/D3689M, Standard Test Methods for Deep Foundations under Static Axial Tensile Load

.11 ASTM D3966/D3966M, Standard Test Methods for Deep Foundations Under Lateral Load

.12 ASTM D4945, Standard Test Method for High-Strain Dynamic Testing of Deep Foundations

.13 ASTM D7383, Standard Test Methods for Axial Rapid Load (Compressive Force Pulse) Testing of Deep Foundations

.14 ASTM F1554, Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength

.15 ASTM F2329/F2329M, Standard Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners

.16 ASTM F3125/F3125M, Standard Specification for High Strength Structural Bolts and Assemblies, Steel and Alloy Steel, Heat Treated, Inch Dimensions 120 ksi and 150 ksi Minimum Tensile Strength, and Metric Dimensions 830 MPa and 1040 MPa Minimum Tensile Strength

.17 ASTM F436M, Standard Specification for Hardened Steel Washers Inch and Metric Dimensions

.2 CSA Group (CSA):

.1 CAN/CSA S6, Canadian Highway Bridge Design Code

.2 CSA W178.1, Certification of welding inspection organizations

.3 CSA W178.2, Certification of welding inspectors

.4 CSA W47.1, Certification of companies for fusion welding of steel

.5 CSA W48, Filler metals and allied materials for metal arc welding

.6 CSA W59, Welded steel construction

.7 CSA G40.20/G40.21, General Requirements for Rolled or Welded Structural Quality Steel/Structural Quality Steel

.3 Canadian General Standards Board (CGSB):

.1 CAN/CGSB-48.9712, Non-destructive testing — Qualification and certification of NDT personnel (ISO 9712:2012, IDT)

.4 International Organization for Standardization and International Electrotechnical Commission (ISO/IEC):

.1 ISO/IEC 17025, General requirements for the competence of testing and calibration laboratories

1.4 Definitions

.1 **Extended Warranty Period** means a period starting from the issuance of The City's Substantial Completion Certificate and lasting for 5 years.

1.5 Regulations

.1 Abide by all current bylaws and regulations of the Province of Alberta and The City of Calgary (The City).

.2 Public safety shall be preserved in accordance with these same regulations.

1.6 Geotechnical Report

.1 Refer to the project-specific geotechnical report.

.2 Read and understand the requirements of the geotechnical report prior to commencing the Work.

1.7 Existing Structures, Services, and Utilities

.1 Confirm and establish the locations and extents of all underground and overhead structures, services, and utilities in the work area prior to commencement of the Work by communicating with the applicable owners, authorities, or agencies.

.2 Clearly mark such locations to prevent disturbance or damage.

.3 Place markers to indicate types and locations of underground and overhead structures, services, and utilities, and show such information on As-Built Drawings.

.4 Protect all underground and overhead structures, services, and utilities, and confirm they are not damaged by piling operations.

.5 Repair any damage done to existing structures, services, and utilities at no additional cost to The City.

.6 Verify the location of all existing features in the field.

1.8 Qualifications

.1 The firm undertaking the Work of this Section must be experienced in the successful installation of this type of piling with similar capacities and under similar conditions. If required by the Engineer, provide satisfactory information to verify appropriate expertise and experience.

.2 Shop qualification: The Contractor shall be fully approved by the Canadian Welding Bureau (CWB) per CSA W47.1, Division 1 or Division 2, or by an equivalent Agency approved by the Engineer.

.3 Welder qualifications: Only welders, welding operators, and tackers approved by the CWB or by an equivalent Agency approved by the Engineer in the particular category shall be permitted to perform weldments. Their qualifications shall be current and available for examination by the Engineer.

.4 All welders employed in the field to weld load-carrying structures in the field are to possess valid "S" Classification, Class "H" certificates issued by the CWB. If the structures have pipe or hollow structural sections, welders are to possess valid "T" Classification Class "O" certificates.

.5 Weld inspection: The Contractor shall be responsible for engaging an independent quality control organization for welding inspection on all structural steel fabrication. The organization and individual undertaking weld inspection shall be fully approved by the CWB under the requirements of CSA W178.1. Visual inspectors shall be certified under the requirements of CSA W178.2 Level 3. Inspectors performing non-destructive testing shall be qualified for the relevant testing method in accordance with the requirements of CAN/CGSB-48.9712, Level 3.

1.9 Submittals

.1 Schedules: The Contractor shall submit and keep current a complete fabrication and installation schedule in a form satisfactory to the Engineer.

.2 Mill certificates: Fabrication shall only be allowed with materials having mill certificates properly correlated to the materials used on the project that have been reviewed and accepted. The Contractor shall have all steel, including billets and fasteners, originating outside of Canada or the United States (U.S.) tested and verified by a metallurgical testing company and laboratory located in Canada. This laboratory shall be certified by an organization accredited by the Standards Council of Canada to comply with the requirements of ISO/IEC 17025 for the specific tests or type of tests required by the material standard specified in the mill test report, including boron content. A verification letter shall be provided by the certified laboratory and shall include references to the appropriate mill test report(s), material specification number(s), testing standards, testing date(s), and statements indicating compliance of the material to the requirements of the Agreement. Material test reports and a mill certificate verification letter shall bear the signature of an authorized officer of the testing laboratory and be signed and sealed by a Professional Engineer registered in the Province of Alberta in the field of metallurgy. The Contractor shall submit all mill certificates including any additional testing as noted above to the Engineer for review and acceptance a minimum of 20 Business Days prior to the scheduled start of pile installation.

.3 Shop drawings: Fabrication drawings or the equivalent shall be submitted by the Contractor a minimum of 10 Business Days prior to commencement of fabrication for review and acceptance.

.4 Welding qualifications: The Contractor shall submit in writing evidence of qualifications for welding under the CWB W47.1 Divisions 1 and 2, a minimum of 10 Business Days prior to the commencement of fabrication.

.5 Welding procedures: Welding procedures shall be submitted for each type of weld used in the structure. The procedures shall bear the approval of the CWB and shall be approved by the Engineer prior to use on the structure. Such approval does not relieve the Contractor of any responsibility.

.6 Weld material: The Contractor shall submit a certificate of the welding consumables.

.7 Pile Driving Plan: The Contractor shall submit details and specifications of the proposed pile driving plan with drawings a minimum of 14 days prior to the commencement of pile installation for review and acceptance by the Engineer. The Engineer's review and acceptance of the Contractor’s pile driving plan will not relieve the Contractor of the full responsibility for the methods and procedures required to achieve the pile capacity and tip elevations specified in the Agreement.

.8 If, during the course of the Work, the required pile set criteria and tip elevations are not achieved, or the Work is not being completed in accordance with requirements of the Agreement, the Contractor’s pile driving plan and proposed pile remediation plans shall be revised and resubmitted to the Engineer for review and acceptance before any further pile driving occurs.

.9 Compile all piling-related submissions into a single package. Details shall include the following, at a minimum:

1. Technical Specifications, setup, and configuration of pile driving equipment, including:
    1. Hammer Data: Type, manufacturer, model number, serial number, maximum rated energy and range in operating energy, stroke at maximum rated energy and range of operating stroke, ram weight, and modifications
    2. Striker Plate Data: Weight, diameter, thickness, and composition
    3. Hammer Cushion Data: Manufacturer, area, thickness per plate, number of plates, total thickness, composition, type, and elastic properties
    4. Helmet Data: Weight and composition
    5. Pile Cushion Data: Material, area, thickness per sheet, number of sheets, total thickness of cushion, type, and elastic properties
    6. Results of the Contractor’s Wave Equation Analysis of Piles (WEAP)
2. Pile layout, schedule of installation, driving sequence, and driving frames
3. Type of piles, sizes, and details (including orientation and batter)
4. Pile tip and cut-off elevations
5. Driving methods, procedure, and driving sequence
6. Details of driving frames
7. Pile driving tools and accessories

8. Pile lengths, splicing details, and anticipated splicing locations
9. Grade of steel
10. List of welders and proof of certification
11. Written evidence of qualifications for welding under the CWB W47.1, Divisions 1 and 2.
12. Cold weather protection methods
13. Environmental Construction Operations (ECO) plan that includes a seepage water management strategy for open-ended pipe piles
14. When specified in the Agreement, Pile Driving Analyser testing procedures and contact information with qualifications of independent testing agency

.10 Submit one complete copy of all welding inspection and testing reports to the Engineer.

1.10 Schedule

.1 Notify the Engineer a minimum of 10 Business Days prior to the commencement of pile driving to permit scheduling inspections and witnessing tests. Keep the Engineer informed of all ongoing operations with a minimum of 24 hours advance notice.

1.11 Field Records

.1 The Contractor is to submit a pile driving record to the Engineer. Records shall include the following:

1. Pile number, hammer model, and serial number
2. Surveyed location of each pile
3. Sequence of placing within each foundation unit
4. Pile plumbness
5. Final tip and top of pile elevations
6. Size and lengths of piles
7. Date and time of placing piles
8. Number of blows per 250-millimetre (mm) movement for the entire length of each pile; set per blow for the last 10 blows
9. Driving force of each hammer blow
10. Identification of piles requiring drilling
11. Details of unusual occurrences
12. Inspector’s name

.2 Submit three copies of all field records and drawings to the Engineer.

1.12 Pile Driving Set Criteria and Tip Elevation Requirements

.1 The Engineer will determine an estimated initial pile driving set criteria (blows per 25 mm or mm/blow) for each foundation element using the pile driving hammer information provided in the Contractor's pile driving plan and WEAP.

.2 The first driven production pile for each foundation element will be considered a test pile. When the foundation element contains more than 15 piles, the first 2 driven production piles in that foundation element shall be considered test piles. Test piles shall be driven with the same type and size of equipment to be used for the entire foundation element and completed on the same working day. Information from the test pile installations will be used to confirm the pile design and acceptability of the pile driving equipment.

.3 Test piles shall be driven to the estimated initial pile driving set criteria determined by the Engineer prior to driving any of the other piles within the foundation element. The test pile elevations determined by the Engineer may vary up to 15% from the tip elevation shown on the drawings. The test piles shall be subjected to testing using a Pile Driving Analyzer (PDA) to determine pile load capacity.

.4 The Engineer will review the estimated initial pile driving set criteria based on the actual pile driving data recorded during test pile driving, and provide the Contractor with a pile driving set criteria and tip elevations for the remaining piles in the associated foundation element. The Contractor shall drive piles to both the tip elevation and pile driving set criteria determined by the Engineer.

.5 When specified in the Agreement, pile driving set criteria will be determined by the Engineer using the following bearing formulas.

.1 For piles driven with diesel or hydraulic hammers, the bearing formula will be as follows:

$$P = (165 \times E \times F) / (S + 5) \qquad \textbf{[1]}$$

Where:

P = Pile service limit state (SLS) extreme load as defined on the Drawings (kilonewtons [kN])

E = Rated (potential) energy output of hammer (kilojoules [kJ]) at the corresponding number of blows per minute based on the published hammer data sheet

F = Efficiency factor = 0.8 or as determined by the Engineer

S = Pile driving set criteria = Average penetration per blow for the last 10 to 20 blows (mm per blow)

The bearing formula for piles driven with diesel or hydraulic hammers will only be applied when:

1. The head of the pile is not crushed or deformed
2. The rate of penetration is acceptable to the Engineer
3. A driving extension is not used

.2 For piles driven with gravity hammers, the bearing formula will be as follows:

$$P = (1650 \times W \times H) / (S + 25) \quad \textbf{[2]}$$

Where:

P = Safe bearing value (kN)

W = Weight of striking parts of hammer (tonnes)

H = Height of fall (metres [m])

S = Average penetration per blow for the last 5 to 10 blows

The bearing formula for gravity hammers will only be applied when:

1. The hammer has a free fall
2. The head of the pile is not crushed or deformed
3. The rate of penetration is acceptable to the Engineer
4. The amount of rebound after the blow is acceptable to the Engineer; otherwise, the height of the bounce will be deducted from "H"
5. A driving extension is not used

Section 3.1.1 describes the use of gravity hammers.

1.13 Inspection and Testing

.1 The Contractor shall retain the services of independent testing agencies for the following scopes of work:

1. Testing of welds
2. Testing of steel piling splices
3. PDA testing, also referred to as Dynamic Load testing
4. Static Load testing, where specified in the Agreement.

.2 The Contractor shall have all steel piling splice welds visually inspected.

.3 The Contractor shall perform ultrasonic testing for a minimum of 20% of all full-penetration compression splice welds for all piles for each structural component (that is, each pier, each abutment). Ultrasonic testing shall be completed for all full-penetration compression splice welds for where visual inspection indicates some defect.

.4 The Contractor shall perform ultrasonic testing for 100% of full-penetration welded splices in tension.

.5 PDA testing and reporting shall conform to ASTM D4945.

.6 the Contractor shall perform PDA testing at the following frequency:

- The greater of two piles or 15% of the total production piles for each foundation element (each abutment, each pier)

- For pile walls or structures where more than 40 piles are to be installed, the greater of 6 piles or 10% of the total production piles in each wall.
- The remaining pilings will have their capacities evaluated based on the field-adjusted WEAP analysis produced from the PDA testing process
- At least one PDA test is required for each hammer to be used

PDA testing shall be completed on these noted production piles at the end of initial driving for the pile termination depth and upon re-strike when re-striking (re-tapping) is specified, with the termination depth as defined by minimum specified pile embedment and termination criteria established by WEAP to satisfy the design capacity requirements. Required pile setup time until re-strike occurs and all associated details will be outlined in the Agreement. If re-striking (re-tapping) test results do not meet the specified requirements, the Contractor shall continue pile driving until results acceptable to the Engineer are achieved. A signal matching analysis using Pile Dynamics Inc.'s (PDI's) Case Pile Wave Equation Program (CAPWAP) shall be completed on at least 1 of the tested piles at each abutment, each pier, each pile wall, or each structure.

.7 PDA testing shall be completed by an independent testing agency specializing in this type of Work. The independent testing agency shall be engaged by the Contractor, supply and install all testing equipment, and analyze the test results in accordance with this specification. The Contractor shall be responsible to coordinate and manage all associated PDA testing activities.

.8 When performing PDA testing, use the same pile driver as used for pile installation. The pile driver shall be capable of mobilizing the ultimate pile capacity in a single blow without additional data interpretation.

.9 Piles selected for PDA testing shall be representative of other piles in the same structure, considering spatial variation and soil conditions within the foundation element (that is, opposite ends of each abutment, each pier, and each retaining wall).

.10 When performing PDA testing, the Contractor's PDA testing agency shall prepare a daily field report summarizing the preliminary test results, including driving stresses, transferred energy, and estimated pile capacity, to the Engineer within 24 hours of testing. Upon review of the daily field report, pile tip elevations may be revised by the Engineer. The final test results shall be submitted to the Engineer within 3 Business Days of testing completion for each foundation element. The testing report for each foundation element shall be prepared in accordance with the requirements of ASTM D4945. As a minimum, the report shall include the following:

1. Pile and driving system information and performance
2. Pile installation data
3. PDA testing equipment and procedure
4. Energy imparted
5. Maximum driving stresses
6. Hammer blow rate

7. CAPWAP input parameters, including quake and damping factors
8. Refined WEAP based on the CAPWAP
9. Shaft friction, end bearing, and total pile capacity

This testing report, signed and sealed by a Professional Engineer registered in the Province of Alberta and employed by the independent testing agency, shall confirm adequacy of the pile driving criteria established in the initial WEAP, and propose modifications where appropriate. The Engineer will provide the Contractor written acceptance, rejection, or a list of items requiring review and resubmission of the testing report within 3 Business Days of its receipt.

.11 When driven piles exhibit lower driving resistances or shorter penetrations than normal, the Engineer may require additional tests over and above the minimum number of tests or PDA tests. The Engineer will determine the scope and number of additional tests to be completed, and this additional testing will be paid for at the unit price bid or negotiated when pile driving to elevations are specified.

.12 During piling and at the completion of driving within a foundation element, the pile tops shall be measured to confirm whether pile heave has occurred. Piles that have heaved during piling installation shall be re-driven to the depth and capacity required by the Agreement or as determined by the Engineer.

.13 The Engineer will use the test results to determine the subsequent termination criteria, requirements for modification of driving procedures or equipment, and pile acceptance. Any work done on the foundation elements (including pile caps, cut-off, welding) prior to received approval of test results from the Engineer will be at the Contractor's own risk.

.14 At the discretion of the Engineer, additional PDA testing may be requested to address:

1. Modifications of the hammer
2. Modifications of the driving system
3. Modifications of the pile type
4. Installation procedures
5. Pile capacity
6. Pile embedment
7. Observed unusual blow counts or penetrations
8. Evidence of structural damage to piles
9. Time-related capacity effects
10. Observations of any other behaviour different from normal installation

.15 If the Contractor demobilizes from the foundation element before the Engineer's acceptance is received, all remobilization costs will be at the Contractor's expense.

.16 Static Load testing, when specified in the Agreement, shall be completed by an independent testing agency specializing in this type of Work. The independent testing agency shall be engaged by the Contractor, supply and install all testing equipment, and analyze the test results in accordance with this specification. The Contractor shall be responsible to coordinate and manage all associated static load testing activities.

Static load testing and reporting shall be completed in accordance with ASTM D1143 for piles subjected to axial loads, ASTM D3689 for piles subjected to axial tensile loads, and ASTM D3966 for piles under lateral loads and as outlined in the Agreement. As a minimum, the report shall include the following:

1. Site plan showing locations of test pile and nearest test holes
2. Test hole logs and summary of subsurface conditions
3. Type and dimensions of test and anchor piles
4. Test pile material, including basic specifications
5. Pile installation details
6. Final pile top and tip elevations
7. Ground surface elevation
8. Date and type of load test
9. Temperature and weather conditions during the test
10. Description of instrumentation used to monitor pile performance during testing, including their locations
11. Description of test setup and testing procedures
12. Tabulation of time, load, and displacement readings
13. Interpretation and analyses of test results, including failure load and the criterion used to estimate it, shaft friction, and end-bearing resistance (as applicable)
14. Pile load-movement curve
15. Pile time-load and time-movement curves

The static load test report shall be submitted to the Engineer for review and acceptance within 7 Business Days of completion of testing.

.17 Osterberg or Statnamic tests may be proposed by the Contractor in substitution for static load testing. Osterberg tests shall conform to ASTM D1143, Standard Test Method for Piles under Static Axial Load using the Quick Load Test Method for Individual Piles. Statnamic tests shall conform to ASTM D7383, Standard Test Methods for Axial Compressive Force Pulse (Rapid) Testing of Deep Foundations. The Contractor shall submit details of all proposed testing measures in the piling plan, and the Engineer, at their sole discretion, will accept or reject the Contractor’s substitution proposal.

1.14 Quality Control and Quality Assurance Inspection and Testing

.1 The Contractor’s plan for Quality Control (QC) and Quality Assurance (QA) shall be included in the Quality Management Plan (QMP) and submitted to the Engineer for review prior to starting any steel fabrication. All QA/QC, including testing, as part of the Contractor’s QMP shall be paid for by the Contractor.

.2 Testing by The City: In addition to the Contractor’s responsibility for QA/QC, The City may appoint a testing agency to perform independent QA testing as deemed necessary by The City. These inspections will be performed by testing agencies appointed by and paid for by The City. This testing is independent of the Contractor’s QMP and shall not replace the Contractor’s QC testing and QA review documentation.

.3 Testing by the Contractor: The Contractor will engage a testing agency, certified in accordance with CSA-W178.1, to perform QC testing. Additional testing made necessary by material substitutions, the repair of faulty work, and additional unspecified material splices shall be paid for by the Contractor. Any test records made by the fabricating shop in the course of QC shall be submitted to the Engineer within the Contractor’s QA review documentation for review and acceptance.

.4 Testing is the responsibility of the Contractor and shall include all methods, means, materials, equipment, and labour necessary to accomplish the requirements identified within this specification.

.5 Testing of welds includes visual examination of all welding procedures at the plant and in the field, plus magnetic particle, ultrasonic, x-ray, or other means deemed necessary by the testing agency to permit certification of welds.

.6 Provide a copy of ultrasonic test results to the Engineer within 3 Business Days of testing. The Engineer may require additional testing.

.7 Unless otherwise noted, evaluation of flaws shall be to CSA W59.

.8 Steel work shall be inspected for surface defects and exposed edge laminations during fabrication and blast cleaning. Significant edge laminations found shall be reported to the Engineer for evaluation. Following rectification, these areas shall be re-tested for acceptance by the Engineer.

.9 No protective treatment shall be applied to the Work until the appropriate inspection and testing has been carried out.

.10 All loose rust and scale, slag residue, and weld spatter shall be removed prior to inspection.

.11 Notify the Engineer no less than 48 hours prior to commencement of shop work.

.12 The Contractor shall verify, in the presence of the Engineer, the hammer performance using the PDA or other approved equivalent. Hammer performance shall be verified to confirm that the actual potential energy (rated energy) is not less than 90% of the stated potential energy.

1.15 Acceptability

.1 Failure to comply with the requirements of these Technical Specifications will result in the structure being considered potentially deficient.

.2 Additional testing, inspection, and evaluation may be required where evidence points to a potentially deficient structure and shall be paid for by the Contractor. The Engineer will determine the scope of additional ultrasonic testing to be completed and the acceptability of the weld. If welds are determined unacceptable by the Engineer, the Contractor shall be responsible for the costs and schedule implications for any corrective action required.

.3 The Contractor shall pay all costs for additional testing, inspection, and analysis required to demonstrate the adequacy of a structure that does not meet the requirements of the Agreement. The Contractor shall be responsible for any project costs associated with schedule delays related to demonstrating the adequacy of the structure.

.4 The Contractor shall reinforce by additional construction, or replace as directed by the Engineer at the Contractor’s expense, all direct and indirect costs, and all structures or material judged inadequate by structural analysis or by testing and inspection at any time up to the end of the Warranty Period.

.5 The Engineer may order further testing, inspection, and analysis at any time. If additional testing is outside the scope of this Agreement, The City of Calgary will pay for those tests, inspections, or analysis that meet the specified requirements; and the Contractor will pay for those that do not.

1.16 Defective Piles

.1 Piles damaged by driving, or which are driven out of specified tolerance (with further details provided in Section 3.2, Installation), orientation, or driven below the cut-off elevation must be repaired at Contractor’s own expense and at the Engineer’s discretion. The Contractor shall submit a repair procedure to the Engineer for review and acceptance before any further piling is installed. The Contractor’s repair procedures, as a minimum, shall include one of the following:

1. The defective piling shall be withdrawn and replaced with new, and if necessary, longer piles.
2. Replacement piling shall be driven adjacent to the defective piles.
3. The defective piles shall be spliced and driven deeper or built-up.
4. A sufficient portion of the pile cap will be extended and reinforced, if applicable.

.2 Notwithstanding these requirements, the Engineer may choose to reject any pile that fails load tests; is out of alignment, orientation, or position; is driven below cut-off elevation; is damaged during driving; or otherwise fails to meet the Technical Specifications.

.3 Rejected piles will be pulled out and replaced with new piles as directed by the Engineer, at no additional cost to The City. Only if specifically approved by the

Engineer, piles may be abandoned if cut off 600 mm below the design cut-off elevation.

.4 The equipment and methods used to drive piles shall not result in deformation of the steel.

.5 Manipulation of piles to adjust position, considered by the Engineer to be harmful, will not be permitted.

.6 Piling on which the galvanized coating has been damaged, as determined by the Engineer, shall be replaced or repaired at the Contractor’s own expense. Where repair of damaged galvanizing is adequate, field touch-up shall be performed per Section 2.4.

1.17 Survey Verification

.1 The Contractor shall perform and submit the results of a survey of all pile locations with respect to the control line, centreline of bearings, or centreline of ramps or approach structures.

.2 Include actual surveyed positions on the as-built drawings.

2 PRODUCTS

2.1 Materials

.1 Metals are to be free from defects impairing strength, durability, and appearance of the best commercial quality for the purpose specified.

.2 All materials are to be new.

.3 All materials are to have a total maximum boron composition of 0.0008%.

.4 All exposed fastenings are to be of the same material, colour, and finish as the metal to which applied, unless otherwise noted.

.5 Materials shall conform to the following standards:

1. Steel-rolled sections: Conform to CSA G40.21M, Grade 350W.
2. Steel plates and bars: Conform to CSA G40.21M, Grade 300W.
3. Steel pipe: Conform to ASTM A252, Grade 2.
4. Welding materials: Conform to CSA-W59.
5. Welding electrodes: Conform to CSA W48 Series.
6. High-tensile bolts, nuts, and washers: Conform to ASTM F3125, Grade 325 or 490. .
7. Anchor bolts, nuts, and washers: Conform to ASTM F1554, Grade 55. Nuts and washers shall conform to ASTM A563A, Heavy HEX and F436M, respectively.
8. All stud shear connectors shall conform to the chemical requirements of ASTM A29 and A108, Grades 1015, 1018, or 1020. In addition, they shall meet the mechanical properties specified in CSA W59, Appendix H, for

Type B studs. Certified mill test reports for the stud material shall be provided.

9. Grout: Grout will be non-shrink, non-metallic, flowable, with a compressive strength of 50 megapascals (MPa) at 48 hours (approved anti-washout, as required).

2.2 Fabrication

.1 Low hydrogen filler, fluxes, and welding practices shall be used.

.2 Steel piles shall conform to a straightness tolerance of 1.5 mm maximum per metre of length.

.3 Pile tip reinforcements shall be installed as indicated on the Drawings.

.4 Cutting, preparation, and welding shall be performed in accordance with CSA-W59.

.5 When the air temperature is below 10 degrees Celsius (°C), all material to be welded shall be preheated to 100°C for a distance of 80 mm beyond the weld and shall be sheltered from the wind.

.6 When the air temperature is below 0°C, welding shall not be permitted unless suitable hoarding and heating, accepted by the Engineer, is provided.

.7 All welds that have been repaired shall be visually inspected and shall undergo non-destructive testing. Unauthorized weld repairs may be rejected.

.8 Defective welds shall be repaired or replaced for acceptance by the Contractor's ultrasonic testing agency and the Engineer.

2.3 Steel Splices

.1 Steel pile splices shall be in accordance with the Agreement. All field welding shall be in accordance with CAN/CSA S6 and CSA W59.

.2 Supply full length piles where feasible to minimize field splicing during installation. For fully integral bridge abutment piles, the top 5 m of each pile driven shall not include a spliced section.

.3 The number of splices shall be kept to a practical minimum. The number and location of splices are subject to review by the Engineer.

.4 Splices in river environments and other water bodies shall be located below the low-water level, unless otherwise encased in concrete.

.5 Where the upper portions of piling are specified to be galvanized, excess piling shall be removed from the ungalvanized portion of the piling so that the galvanized portion extends to the elevation shown on the Drawings. Splicing within the galvanized portion of the piling shall be avoided. If splicing within the galvanized portion becomes necessary, the galvanizing shall be removed to the extent required to complete the splice in a manner acceptable to the Engineer.

.6 The spliced areas and any other damage galvanized areas shall be metallized in accordance with ASTM A780, Method A3 to a thickness of 180 micrometres (µm) and tested for adhesion. All costs associated with metallizing and testing will be considered incidental to the Work, and no separate or additional payment will be made.

.7 For steel pipe piling splices, methods acceptable to the Engineer shall be used to match out-of-round piling. Weld procedures shall be suitable for any steel pipe pile where out-of-round conditions are present.

2.4 Finishes

.1 Galvanizing: Hot dipped galvanizing shall conform to ASTM A123M, ASTM A153M, and ASTM F2329; minimum 610 grams per square metre (g/m2) of coating.

.2 Field touch-up of damaged galvanizing: Zinc metalizing conforming to ASTM A780/780M Method 3. Metalizing shall be 180 μm thick.

2.5 Delivery, Storage, and Handling

.1 Handle, haul, and store piling in a manner that avoids damage to the piling materials. Loading and unloading shall be by crane, loader, or other appropriate hoisting equipment.

.2 Prevent damage of the galvanized pile surfaces. Fabric slings, wood blocking, or other methods acceptable to the Engineer shall be used to support and separate galvanized piling when handling, hauling, or storing.

.3 Make sure stress exercised during handling and installation remains below acceptable thresholds.

.4 Avoid damaging piles during insertion into any templates and driving process.

.5 Support piles to avoid bending stress during the driving process.

3 EXECUTION

3.1 Equipment and Driving Methods

.1 All pile driving equipment, driving methods, and procedures shall be reviewed and accepted by the Engineer before pile driving commences. Acceptable driving equipment includes diesel hammers, hydraulic hammers, vibratory hammers, driving frames, or other equipment as determined by the Engineer. The use of multi-component drop hammers will not be permitted under any circumstances. The use of gravity hammers will not be permitted, except when the required capacity is less than 350 kN, and the Engineer determines the gravity hammer and leads are acceptable. Where the use of a gravity hammer is acceptable by the Engineer, the Contractor shall provide the Engineer acceptable proof of its weight, including the weight of the follower.

.2 Hammers shall be selected with suitability and drivability in mind.

.3 Hammers shall be sized as required to drive piles to design elevation.

.4 A driving cap or follower shall be provided to maintain alignment of the pile and hammer. The driving cap or follower shall be of adequate dimensions to allow driving the pile without trimming or reducing the cross-section of the pile.

.5 The Contractor shall verify that ground conditions at the pile driving site are adequate to support the equipment to properly install piles and permit load testing.

.6 Driving equipment shall be sufficiently rigid and designed to permit adequate horizontal and vertical control of piles during driving.

.7 Driving equipment shall include fixed leads to hold piles in position and in axial alignment with hammer, and able to develop full inertia of driving machine in resisting lateral displacement. The use of hanging leads is not permitted.

.8 A pile driving machine digital computer output listing output energy will be provided to the Engineer at the end of each day for review and acceptance.

.9 In cases of low-overhead clearances, suitable equipment shall be selected capable of splicing and driving piles.

.10 In no case shall the total energy developed be less than 35 kJ per blow.

.11 The maximum rated driving energy of the pile driver shall not exceed 600 joules per square centimetre (J/cm2) of steel in the pile cross-section.

.12 To prevent damage to piles and to hold axis of pile in line with axis of hammer, provide suitable cushion and cap on piles being driven.

.13 Gravity or drop hammers shall be weighed in the presence of the Engineer or a valid “certificate of weight” shall be furnished.

3.2 Installation

.1 The driving of piles with driving extensions shall be avoided if practicable and shall be done only under written permission of the Engineer. When driving extensions are used, 1 pile from each group of 10 shall be a long pile driven without extensions and shall be used as a test pile to determine the average capacity of the group. Driving heads, mandrels, or other devices shall be provided in accordance with the manufacturer's recommendations so that the pile may be driven without damage and unnecessary trimming.

.2 For monitoring pile installation, the Contractor shall paint markings on each pile at 0.25-m intervals, with a label at each 1.0-m interval starting from the toe of the pile.

.3 The Contractor shall confirm that the piles are in proper position and alignment by using installation driving frames and fixed leads.

.4 The tolerance on plan location for the top of the pile is not to exceed 50 mm in any direction. For fully integral bridge abutments, the variation in position between the centre of the pile casing and centre of the pile shall not be more than 25 mm from the horizontal position shown on the Drawings.

.5 Piles shall not be driven with a variation of more than 20 millimetres per metre (mm/m) from the vertical or the batter, as shown on the Drawings.

.6 After driving, piles shall not deviate from true vertical alignment more than 2% of the pile length, nor more than 150 mm, except for fully integral bridge abutments where this dimension is 50 mm, off-centre from the true location ground line with tops accurately positioned at cut-off elevations shown on the Drawings.

.7 Final driven H-pile orientation (measured in plan-view) shall be within 10 degrees of the orientation shown on the Drawings.

.8 If installation tolerances are not met, the Contractor shall make immediate changes to piling procedures. Any pile out of the specified tolerance shall be corrected at the Contractor's expense for acceptance by the Engineer.

.9 The Contractor shall verify that the ground conditions at the pile driving site are adequate to support the required equipment.

.10 The Engineer shall have right to inspect all equipment to verify adequacy for installation requirements.

.11 The Engineer shall have right to inspect all piles prior to driving and reject any piles that are damaged, out of dimensional tolerance, or have other manufacturing or material defects.

.12 Steel piles shall consist of structural steel shapes or pipes of the section shown on the Drawings or otherwise specified.

.13 When pipe piles are to be driven closed-ended, pipe pile tips shall have welded end-plates installed.

.14 At the completion of driving open-ended pipe piles, and if specified in the Drawings or special conditions, the thickness of accumulated material in the pipe pile shall be measured, and the interiors cleaned out to the required elevation. All material, either loose or adhering to the walls of the pipe piles, shall be removed for acceptance by the Engineer prior to installing any reinforcing steel or placing concrete. Driving of any type of piles within 3 m of a pipe pile or integral pile that contains freshly placed concrete shall not be undertaken until the concrete has been placed and cured for a minimum of 3 Business Days.

.15 After installation of driven closed-ended or open-ended pipe piles, and if specified in the Drawings or special conditions, pipe piles shall be filled with pile concrete in accordance with City Specification 02466, Drilled Concrete Piles. Pile concrete shall not be placed until the pile is reviewed and accepted by the Engineer. Any reinforcing required projecting from the pile shall be installed and secured prior to concrete placement. If water is observed to ingress into the pile, the concrete shall be placed only after the water has been removed from the pile or only by tremie concrete and methods, after the ingress of water has reached an equilibrium elevation, in accordance with City Specification 02466, Drilled Concrete Piles, Section 3.4 Concrete Placement.

.16 Piles shall be cut off level at the required elevation. If capping is required, the connection shall be made according to details shown on the Drawings.

.17 The Contractor shall supply and secure temporary caps on all open pipe piles or drilled holes.

.18 The Contractor shall drive piles in accordance with reviewed sequence drawing using either a hydraulic hammer, diesel hammer, or high-frequency vibrator, subject to the approval of the Engineer. Do not use driving methods that would cause damage to nearby or existing structures.

.19 Do not damage piles during driving operations. Pile driving should be stopped immediately if abrupt high-resistance to penetration is encountered.

.20 Hammer blows shall be concentric and in direct alignment with the pile axis at all times and in direct contact with the pile.

.21 Do not drive piles within 6 m of any concrete less than 72 hours old.

.22 A properly sized driving cap or helmet and cushions shall be used to prevent damage to the pile heads during driving.

.23 Pile driving shoes shall be provided by the Contractor to improve drivability and reduce the risk of pile damage.

.24 Piles shall be installed under the supervision of the Engineer's geotechnical representative.

.25 Pile sections shall be verified to be in alignment during splicing operations. Flame-cut and grind ends square with the pile axis before welding.

.26 Hold piles securely and accurately in position while driving. To maintain a centred pile group with respect to the supported concrete structure foundation with consideration of pile horizontal position tolerances, the Contractor shall drive piles set in groups starting at the centre and working outward. Check potential pile heave within a distance of 10 pile diameters from the pile being driven. Piles that heave must be re-driven to the depth and capacity required by the Agreement or as determined by the Engineer.

.27 Piles shall be installed to the pile tip elevation shown on the Drawings, or as required to meet the pile capacity requirements, as determined by the Engineer.

.28 Should practical refusal be met prior to reaching depth to pile tip elevation shown on the Drawings, the Engineer may require re-striking (re-tapping), re-driving, or specified load testing.

.29 Notify the Engineer if pile tip elevations are not obtained.

.30 After pile driving operations have commenced, the Engineer may revise the required pile tip elevations, if necessary, using the pile driving data.

.31 Where piles are to be driven to practical refusal to develop the full structural capacity of the pile, practical refusal shall be taken as less than 2 mm per blow over the final 150 mm of driving using an appropriately sized pile driver.

.32 Where piles are to be driven to a set determined in accordance with the dynamic formula specified in the Agreement or by the application of the WEAP that verifies the pile resistance, this set shall be established on the first pile of every 10 piles driven in a pile group. The other piles shall be controlled by the pile penetration rate in blows per millimetre that correlates to the set. When new conditions, such as change in hammer size, change in pile size, or change in soil material occur, new sets shall be determined.

.33 When re-striking (re-tapping) is required, 10% of the piles in each pile group rounded up to the next whole number, but no fewer than two piles, shall be re-tapped no sooner than 72 hours after installation of the individual pile to confirm that the ultimate axial resistance has been sustained.

.34 When the re-striking (re-tapping) tests indicate that the ultimate axial resistance has not been achieved on any one pile, all piles in the group shall be re-tapped.

.35 Where the re-striking (re-tapping) reveals that the ultimate axial resistance of the piles has not been achieved, the piles that have not achieved the ultimate axial resistance shall be re-driven to the specified resistance.

.36 Appropriate hammer size and maximum driving energy shall be as determined by WEAP and confirmed by PDA testing.

.37 PDA testing, when required in the Agreement, will be repeated at the Contractor's expense if initial hammers undergo any major repairs or are replaced during the Work.

.38 Pile driving stress shall not exceed 90% of the specified minimum yield strength of the pile.

.39 Pile driving may only be interrupted because of pile splicing, the attachment of test apparatus, or equipment failure or malfunction. If driving is interrupted, the pile shall be driven a distance of at least 250 mm before the driving resistance may be used to confirm the pile capacity. Driving of the last 3 m of all piles shall be uninterrupted.

.40 Piles that do not meet the requirements of this specification, including those piles that are damaged, broken, misplaced, improperly driven, or out of alignment, shall be corrected by the Contractor, as directed by the Engineer. This may include extracting the rejected piles and driving new piles or additional piles. All corrective work shall be at the Contractor's expense.

.41 After completion of pile installation, after acceptance by the Engineer, cut off top of piles to elevations indicated on the Drawings. Piles cut off before acceptance by the Engineer are at the risk of the Contractor.

.42 The length of pile supplied shall be sufficient so that there is no damaged material below the cut off. Damaged material at the pile head shall be cut off.

3.3 Guarantee

.1 The Contractor shall warranty, in writing, the performance of the galvanized finish for the Extended Warranty Period. The Contractor shall provide in the warranty for the replacement of the galvanizing at no cost to The City in the event that the galvanized surface does not perform satisfactorily under the expected environmental exposure. Verify the galvanized components are installed in a manner that will not void the warranty.

.2 The General Contractor, Supplier, and installer are required to complete an Extended Warranty Form stating the requirements of sub-section 3.3.1.

4 MEASUREMENT AND PAYMENT

4.1 Measurement

.1 Measurement of mobilization and setup shall be lump sum and will not be separately measured.

.2 Measurement of driven steel pile installation will be by the metre of driven piles acceptably installed and remaining in the completed structure, as measured by the Engineer to the nearest 0.1 m. The quantity measured will be the actual length installed from the pile tip to the top of pile.

4.2 Payment

.1 Payment of mobilization and setup shall include full compensation for all transportation, labour, material, and equipment required to mobilize the rig onsite and setup overall pile locations ready to commence driving. No separate payment shall be made for mobilization and demobilization of the rig to and from the Project Site.

.2 Payment of driven steel pile installation shall be on a unit price bid for the type and size specified, and will be full compensation for the supply and driving of steel piles to the elevations and dimensions shown on the drawings; cleaning of pile holes as required; testing of piles; and all labour, equipment, tools, and incidentals necessary to complete the Work acceptable to the Engineer.

.3 No additional payment will be made for re-striking (re-tapping)

.4 The Contractor shall nave no claim against The City resulting from any delays caused by these requirements.

END OF SECTION

1 GENERAL

1.1 Work Included

.1 This section outlines the Contractor's requirements for the supply, excavation, and installation of reinforced cast-in-place (CIP) concrete drilled piles.

.2 The Contractor shall furnish all labour, Materials (including reinforcing steel, dowels and bearing anchor bolts), services, and Construction Equipment (including casings and dewatering equipment where required), and shall install all piles at the locations and depths shown on the Drawings or as otherwise directed by The City's Engineer.

.3 Alternate installation methods compatible with the design may be used if acceptable to The City's Engineer.

.4 Such acceptance shall not be considered to relieve the Contractor of their full responsibility for the means, methods, and procedures to carry out the Work, considering the Project Site conditions, Technical Specifications and other relevant Project documents contained in the Agreement.

.5 The Contractor shall cooperate with all testing and inspection personnel employed by the City to perform field tests and inspections.

.6 The Contractor shall provide and maintain all necessary excavation, sheeting, and bracing, access roads, excavated banks, causeways, embankments, runways, and ramps as necessary:

  .1 For equipment and Materials (including concrete delivery) access to and from pile locations

  .2 To control groundwater and surface water to keep the Work area sufficiently dry

  .3 For field layout required for pile work, including setting and maintaining a location stake for each pile and giving cut-off grades on all piles

  .4 For removal and replacement of all overhead and underground obstructions as required

.7 Should the Contractor elect to use barges for drilling and installation, it is the Contractor's sole responsibility that barges have all required approvals, adequate draft, stability, and anchorage for the duration of the Work.

1.2 Related Work Specified in Other Sections

.1	Concrete Reinforcement	Section 03200
.2	Cast-In-Place Concrete	Section 03300

1.3 Reference Standards

.1 Perform the Work of this section in accordance with the latest edition of the following standards available at the Effective Date, except where specified otherwise. Upon request, provide one copy onsite of the reference standards in either in hard copy or digital format.

.2 ASTM International (ASTM):

.1 ASTM A36/A36M, Standard Specification for Carbon Structural Steel

.2 ASTM A252/A252M, Standard Specification for Welded and Seamless Steel Pipe Piles

.3 ASTM A283/A283M, Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates

.4 ASTM C260/C260M, Standard Specification for Air-Entraining Admixtures for Concrete

.5 ASTM D3740, Standard Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction

.6 ASTM D4285, Standard Test Method for Indicating Oil or Water in Compressed Air

.7 ASTM D6760, Standard Test Method for Integrity Testing of Concrete Deep Foundations by Ultrasonic Crosshole Testing

.8 ASTM E329, Standard Specification for Agencies Engaged in Construction Inspection, Testing, or Special Inspection

.3 CSA Group (CSA):

.1 CAN/CSA S6, Canadian Highway Bridge Design Code

.2 CSA A23.1/A23.2, Concrete materials and methods of concrete construction/ Test methods and standard practices for concrete

.3 CSA A283, Qualification Code for Concrete Testing Laboratories

.4 CSA A3000/3001, Cementitious materials compendium (consists of A3001, A3002, A3003, A3004, and A3005)

.5 CSA G30.18, Carbon steel bars for concrete reinforcement

.6 CSA W48, Filler metals and allied materials for metal arc welding

.7 CSA W59, Welded steel construction

.8 CSA W186, Welding of Reinforcing Bars in Reinforced Concrete Construction

1.4 Definitions

.1 All defined words or phrases shall have meaning given the City of Calgary Standard General Conditions and the Agreement, unless noted otherwise.

.2 “Casing (Liner)” means a steel cylinder or cylinders used to resist earth and water pressures, to serve as concrete form, and to protect personnel.

.3 "Cold Weather" means conditions when the water temperature is at or below 10 degrees Celsius (°C), or when the water temperature is at or likely to fall below 10°C within 96 hours after concrete placement.

.4 "Dry Method" means a method of pile installation when concrete is placed in the dry. A Casing shall be used to maintain sidewall stability, as necessary to control seepage and sloughing conditions.

.5 "Probe Hole" means a small-diameter hole (that is, less than 100-millimetre [mm]) usually drilled using appropriate methods to a required depth below the pile bottom.

.6 "Piling Subcontractor" means the specialty drilling contractor employed to complete the CIP concrete pile installation.

.7 "Tremie Method" means a procedure for placing concrete under water using a watertight steel pipe or tube to place concrete without washing out cement fines.

1.5 Submittals

.1 Submit all items described in this section to The City's Engineer for review and acceptance.

.2 Pile Drilling Plan:

- .1 Submit a pile drilling plan a minimum of 15 Business Days prior to starting the Work. At a minimum, the plan shall include the following:
  - .1 Summary of Piling Subcontractor experience, Project personnel resumés, recent projects, and client contact information;
  - .2 All equipment specifications, setup, and configuration of the piling equipment;
  - .3 Piling sequence including global positioning system survey coordinates locating the centre of piles and estimated timing;
  - .4 Drilling methods, procedure and drilling sequence (including methodology to address the presence of boulders, hard rock stringers, or occurrences of pile wall sloughing and/or ingress of water);
  - .5 Detailed installation method, including (where applicable):
    - .1 Type and number of drilling rigs and equipment;
    - .2 Casing diameter, thickness and length;
    - .3 Method to install and remove temporary casing or method to install permeant casing;
    - .4 Drilling fluid type and associated drilling fluid management considerations (Note: The use of drilling fluids must be reviewed and accepted by the City's Engineer. Drilling fluids and management, as a minimum, shall meet the requirements of Federal Highway Administration (FHWA) NHI-18-024 GEC 10, Appendix D, Subsection x3.4 – X3.6.);

.5 Reinforcing steel securing and placement; and

.6 Concrete mix and placement methodology (Tremie method plan, if applicable);

.6 Procedure and equipment to maintain plumbness;

.7 List of drilling tools, augers, bits, and attachments for belling and cleaning;

.8 List of casing lengths and their diameters to be available onsite;

.9 Method of gas detection (if required);

.10 Availability of pile hole video inspection equipment and associated specifications;

.11 Formwork at pile-to-column connection or pile-to-pile cap, wall, or footing, as applicable;

.12 Reinforcing steel mill test reports;

.13 Reinforcing steel cage lift design drawings;

.14 Inspection and testing plan;

.15 Cold Weather protection methods;

.16 ECO plan including a Care of Water plan to manage seepage water encountered as well as a Waste Management plan including procedures for handling and disposing of excavated materials and spoils;

.17 Sample pile monitoring / drilling records

.3 If during the course of the Work, the required pile capacities and tip elevations are not achieved, or the work is not being completed in accordance with the Contract requirements, the Contractor shall revise the pile drilling plan and resubmit it to the City's Engineer for review and acceptance before any further piling Work occurs.

.4 Acceptance of the Contractor's pile drilling plan by the City's Engineer shall not relieve the Contractor of their full responsibility for the means, methods, and procedures to carry out the Work according to the Agreement.

.5 A Drilled Concrete Pile preconstruction meeting shall occur after the Contractor's pile drilling plan has been reviewed by the City's Engineer and a minimum of one (1) week prior to commencement of the work. The Contractor's project manager, piling subcontractor's project manager and field superintendent(s) shall attend this meeting at a date, time and location acceptable to the City's Engineer.

.6 Concrete:

.1 Submit concrete mix designs for review in accordance with Section 03300, Cast-In-Place Concrete.

.1 When superplasticizer is used, the supporting documentation submitted for review shall be based on the mix design with superplasticizer.

.2 Any proposed changes to a concrete mix design during fabrication shall be subject to review and acceptance by The City's Engineer prior to the Contractor making the change.

.3 Calibration results of the air meter used for testing plastic concrete when requested by The City's Engineer.

.2 Submit a concrete placement plan in accordance with Section 03300, Cast-In-Place Concrete.

.3 Submit a thermal monitoring plan for mass-poured concrete in accordance with Section 03300, Cast-In-Place Concrete.

.7 Concrete records shall be in accordance with Section 03300, Cast-In-Place Concrete. Submit accurate records of poured concrete items, indicating date and location of pour, water and air temperature, and test samples taken.

.8 Submit Workplace Hazardous Materials Information System (WHMIS) Safety Data Sheets (SDSs) for any chemicals and products used onsite.

.9 Submit product data sheets for proprietary patch materials at least 10 Business Days prior to intended installation date.

.10 Submit product data sheets for non-shrink grout at least 10 Business Days prior to intended installation date.

.11 Submit inspection, test results (including destructive testing results) and reports no later than 24 hours after test reports are received from third party testing agency;.

.12 Welding Qualification Data:

.1 Submit Welding Procedure Specifications (WPS) in accordance with CSA W59 for all welded joints in steel Casing.

.2 Submit test reports showing successful passage of qualification tests for all non-prequalified WPSs.

.3 Submit copies of Canadian Welding Bureau (CWB) certification for welders to be employed in the Work.

.4 If recertification of welders is required, recertification shall be at the Contractor's expense.

.13 Shop Drawings:

.1 The Contractor shall submit Shop Drawings at least 15 Business Days prior to commencing concrete Work, with the following:

.1 Shop Drawings for all drilled pile and pile cap reinforcing steel.

.14 Drilling Records:

.1 Submit copies of the drilling report for each pile immediately after drilling.

.2 Each report shall indicate the names of the Contractor's superintendent, and the Piling Subcontractor superintendent responsible for the Work.

.3 For each pile installed, the report shall indicate the following information, signed by the drilling superintendent:

.1 Pile number and location

.2 Pile shaft diameter

.3 Bottom elevation

.4 Top elevation

.5 Pile length

.6 Pile plumbness

.7 Theoretical volume of concrete in pile

.8 Actual volume of concrete placed

.9 Reinforcing steel size and depth actually placed

.10 Drilling start and finish time

.11 Concreting start and finish time

.12 Variation from specified tolerances, including surveyed location and plumbness

.13 The construction method (which shall be dry method, casing method, or tremie method)

.14 Groundwater conditions (including water elevation in hole for wet piles)

.15 Elevation of top and bottom of any casing left in place

.16 Description of temporary casing (including purpose, diameter, wall thickness, and length)

.17 Description and elevation of any obstructions encountered and whether removal was achieved

.18 Description of pile bottom, including amount and extent of loose material

.19 Method of concrete placement

.20 Any difficulties encountered in drilling or concreting operations

.21 Any deviations from Technical Specifications

.22 Any remedial measures completed

.15 Post-Construction Survey:

.1 After completion of pile placement, conduct a survey of the as-constructed structure.

.2 No construction of pile caps, pier caps, or footings, as applicable, shall commence until this survey has been reviewed and accept by The City's Engineer.

1.6 Project Conditions

.1 The Contractor shall review their Piling Subcontractor's methods and procedures related to drilled piles, including the following:

.1 Geotechnical report

.2 Existing utilities and subsurface conditions

.3 Coordination with temporary controls and protections

.2 If field conditions differ from the data and design recommendations outlined in the geotechnical report prepared by the City's Engineer, the Contractor shall notify the City's Engineer immediately

.3 Existing Utility Facilities:

.1 The Contractor shall identify and locate existing underground Utility Facilities before excavating drilled piles.

.2 If Utility Facilities are to remain in place, the Contractor shall provide protection from damage during drilled pile operations.

.4 Should uncharted or incorrectly charted Utility Facilities, designated to remain in service, be encountered during excavation, the Contractor shall adapt the drilling procedure if necessary to prevent damage to the Utility Facilities. The Contractor shall cooperate with The City and Utility Owners in keeping Utility Facilities in operation without interruption.

.5 The Contractor shall repair damaged Utility Facilities to the satisfaction of the Utility Owner at no cost to The City

1.7 Quality Control, Quality Assurance, and Inspection and Testing

.1 Quality Control

.1 A minimum of 15 Business Days prior to starting the piling work, the Contractor shall submit proposed Quality Control (QC) procedures for review by The City's Engineer of the following items:

.1 Falsework erection as required

.2 Cold weather concrete procedure as required

.3 Thermal monitoring plan

.4 Curing

.5 Formwork removal

.6 Joints

.7 Inspection and testing plan

.8 Partial pile surveys as the Work proceeds.

.2 The Contractor shall employ a qualified and licensed Professional Land Surveyor registered in the Province of Alberta to perform all surveys, layouts, and measurements for drilled pile work, including any layout of anchor rods and reinforcing steel dowels embedded in drilled piles.

.3 The surveyor shall conduct the layout work for each drilled pile to the lines and levels required prior to beginning excavation; and shall make and record actual in-place measurements of the following:

.1 Each drilled pile plan location

.2 Shaft diameter

.3 Bottom and top elevations

.4 Other specified data

.5 Deviations from specified tolerances

.4 The surveyor shall record and submit all information pertinent to each drilled pile, and cooperate with other testing and inspection personnel to provide data for all required reports.

.5 The Contractor shall verify that surveys have been converted from grid coordinates to ground coordinates and confirm proper locations of drilled piles as per the Agreement prior to proceeding with the Work.

.6 Before and after excavating, the Contractor shall verify the lay-out of each drilled pile to lines and levels required. The Contractor shall confirm actual measurements of each drilled pile's location, shaft diameter, bottom and top elevations, deviations from specified tolerances, and other specified data.

.2 Quality Management

.1 The Contractor shall record and maintain information pertinent to each drilled pile and cooperate with any City testing and inspecting companies to provide data for required reports.

.2 The Contractor shall provide access and Material for any additional testing at no cost to The City.

.3 Inspections and testing by the City's Engineer does not augment or replace the Contractor's requirement to conduct QC/QA nor relieve the Contractor of their contractual responsibility.

.3 Inspections and Testing

.1 Testing agencies retained for the Work shall be qualified according to CSA A283, ASTM D3740, and ASTM E329 as applicable.

.2 The City's Engineer shall inspect and approve the bearing strata and other design conditions before the Contractor is permitted to place the reinforcing cage and concrete.

.3 Project Geotechnical Report:

.1 A Geotechnical Report has been prepared for this Project and is available for information only.

.2 The opinions expressed in this report are those of the Design Geotechnical Engineer and represent interpretations of subsoil conditions, tests, and results of analyses conducted by the Design Geotechnical Engineer.

.3 The City shall not be responsible for interpretations or conclusions drawn from this report.

.4 The Contractor may elect to make additional test borings and conduct other exploratory operations necessary for drilled piles to confirm the soil and groundwater conditions.

.5 The Geotechnical Report is included with the Agreement.

.4 Concrete testing shall be in accordance with Section 03300, Cast-in-Place Concrete.

.5 Mass-Poured Concrete:

.1 Mass-poured concrete, as defined by Section 03300, Cast-in-Place Concrete, shall be monitored for internal temperatures.

.2 The Contractor shall make all necessary mitigation measures so that internal temperatures of any concrete mass pour stays within CSA A23.1/A23.2 limits.

.3 As a minimum, three groups of thermocouples measuring the concrete core and surface temperatures are required per pile.

.4 Thermocouples shall be situated and located per the accepted thermal monitoring plan.

.6 Crosshole Sonic Logging (CSL) – General:

.1 The Contractor shall complete CSL testing to confirm pile integrity for the following circumstances:

.1 All piles with concrete placed under water (define as a drilled pile hole with a seepage rate more than 300 mm per hour (25 mm in 5 minutes) and/or having more than 75 mm depth of standing water at the base of the drilled hole)

.2 All piles with concrete placed using tremie concrete placement methods

.3 When specified on the Drawings.

.2 Long Structural Elements:

.1 In the case of long structural elements, such as continuous linear retaining walls with more than 10 concrete piles placed under water, the Contractor shall test the piles until three (3) consecutively placed piles are determined to be acceptable. Then testing may be reduced in frequency to a minimum 10% of such piles at locations identified at the Engineer's discretion. If there are issues with the proceeding pile quality then the Engineer may elect to require an increase in testing at the Contractors cost.

.3 The Contractor shall hire an independent CSL testing agency that has a minimum 5 years experience in CSL testing. A Professional Engineer registered in the Province of Alberta, in good standing and employed the by the independent CSL testing agency shall supervise the independent CSL testing and prepare a CSL testing report. The CSL testing report shall be authenticated by a Professional Engineer licensed to practice in the Province of Alberta and validated by a Responsible Member.

.4 The Contractor's independent CSL testing agency shall take and record CLS measurements at depth intervals of 50 mm or less from the bottom of the tubes to the top of each pile.

.5 The Contractor shall submit the authenticated CSL testing report to the City within 5 Business Days of testing completion. The CSL testing report shall include test summaries (as per evaluation criteria outlined in this specification) results in graphical and tabular form, analyses, and an opinion of the pile concrete's integrity and suitability for the intended use.

.6 CSL testing shall conform to ASTM D6760, except as described otherwise herein.

.7 The CSL equipment shall have the following minimum requirements:

.1 A computer-based CSL data acquisition system for display of signals during data acquisition, with a minimum 12-bit analog to digital (A/D) converter with a sampling frequency of at least 500,000 hertz (Hz), and capable of recording all pulse signals for full analysis and individual inspection.

.2 Ultrasonic transmitter and receiver probes capable of producing records at a minimum frequency of 40,000 Hz, with good signal amplitude and energy through good quality concrete. The probes shall be less than 28 mm in diameter and shall be able to freely descend through the full depth of properly installed access tubes in the piles.

.3 Two depth sensors to independently determine transmitter and receiver probe depths.

.4 Ability to trigger the recording system time base with the transmitted ultrasonic pulse.

.7 CSL - Access Tube Preparation:

.1 The Contractor shall install access tubes in the pile per ASTM D6760.

.2 The Contractor shall clearly label the access tubes for identification by the Contractor's independent CSL consultant.

.3 The Contractor shall provide nominal 50-mm inner diameter (ID) standard weight Schedule 40 steel tubes for probe access in each pile. The tubes shall be meet the requirements of ASTM A53/A53M or an equivalent acceptable to the City's Engineer. There shall be one tube for each 0.3 m of pile diameter with a minimum of 4 tubes per pile.

.4 The Contractor shall use round tubes with a regular ID free of defects and obstructions, including any tube joints, to permit the free, unobstructed passage of the probes.

.5 Tubes shall be watertight and free from corrosion, with clean external faces to provide a good bond between the concrete and the tubes.

.6 Tubes may be extended with mechanical couplings. When couplings are used, the Contractor shall record their locations

.7 Duct tape or other wrapping material to seal the joints and butt welding of joints shall be prohibited.

.8 Tubes shall be installed in a manner such that the CSL probes pass through the entire length of the tube without binding.

.9 The Contractor shall confirm that the access tubes are plumb, and verify that unobstructed passage of the probes is achievable before the CSL consultant arrives.

.10 The Contractor shall fit the tubes with a watertight shoe on the bottom and a removable cap on the top.

.11 Tubes shall be spaced at least 40 mm away from the main axial reinforcing steel.

.12 Tubes shall be secured to the interior of the reinforcement cage at a minimum of 1 m intervals.

.13 Tubes shall be installed uniformly and equidistantly around the circumference such that each tube is spaced parallel for the full length and at the maximum distance possible from each adjacent tube.

.14 Tubes shall be extended to within 125 mm of the bottom of the pile, to at least 1.0 m above the top of the concrete, and to at least 0.6 m, but not more than 1.5 m, above the ground surface.

.15 Tubes shall not be damaged during installation of the reinforcement cage.

.16 After placement of the reinforcement cage, the Contractor shall fill the access tubes with clean, fresh water prior to pouring. The water shall be a minimum of 4 degrees Celsius prior to pouring.

.17 The Contractor shall cap tube tops to prevent debris from entering the access tubes.

.18 The Contractor shall not hammer, apply excessive torque, or impose other stresses that could break the bond between the tube and concrete when removing caps from the tubes.

.19 If CSL tube debonding occurs or test equipment does not pass through the entire length of the CSL tub, the Contractor may be required to core drill a 50 mm diameter hole to the depth of debonding or blockage for each affected CSL tube at locations acceptable to the City’s Engineer.

.8 CSL - Testing:

.1 The pile shall be tested no sooner than 3 Days after placement of all concrete in any pile, but within 21 Days after placement on production piles.

.2 CSL testing shall be carried out with the transmitter and receiver probes in the same horizontal plane in parallel tubes unless test results indicate potential defects; in which case, the questionable zone may be further evaluated with angled tests (source and receiver vertically offset in the tubes).

.3 Using the labelling established for the tubes, CSL testing shall be performed between all adjacent perimeter access tube pairs and across at least all major diagonals within the pile.

.4 In the event that Defects are detected in piles, additional logs in other diagonal tube pairs may be required to estimate the extent of the Defect.

.5 Probes shall be lowered from the top, effectively measuring the access tube lengths.

.6 Probes shall be pulled simultaneously, with CSL measurements taken at intervals of 50 mm or less from the bottom to the top of the pile.

.7 Defects indicated by late pulse arrival times and significantly lower amplitude and energy signals shall be immediately reported to The City’s Engineer.

.8 Additional tests, such as offset elevation CSL testing, may be required to further evaluate the extent of such Defects.

.9 If debonding between the access tube and the concrete is indicated by the CSL results, an alternative test method shall be required to determine the integrity of the concrete in the debonded region if additional coring is not considered viable.

.10 The criteria for evaluation of the concrete from the CSL test shall be as follows:

.1 Satisfactory (G) (Good): Factory acceptance test (FAT) increase 0 to 10% and energy reduction less than 6 decibels (db)

.2 Anomaly (Q) (Questionable): FAT increase 11 to 20% and energy reduction of less than 9 db

.3 Flaw (P/F) (Poor/Flaw): FAT increase 21 to 30% or energy reduction of 9 to 12 db

.4 Defect (P/D) (Poor/Defect): FAT increase greater than 31% or energy reduction greater than 12 db

.5 No Signal (NS) No signal received indicating an intrusion or other severe defect absorbed the signal.

.11 Flaw or Defect zones shall be indicated on the logs, listed in a table, and their horizontal and vertical extent and location discussed in the CSL report text prepared by the Contractor's independent CSL testing company.

.1 Flaws shall be addressed if they affect more than 50% of the profiles.

.2 Defects shall be addressed if they affect more than one profile (a profile is the result of a complete investigation from bottom to top between two tubes) at the same cross-section.

.3 Flaws or Defects covering an entire cross-section define a full layer concern, which will require repair.

.12 Addressing a Flaw or Defect means, at a minimum, carrying out additional evaluation by tomography if the concern is localized (for example, not across the full section); and, depending on the depth to the concern, carrying out additional measures, such as core drilling, repair, or replacement, or possibly repeating tests after a longer waiting time.

.13 Testing by other methods (gamma-gamma, low strain, high strain) may also be required.

.14 The log for each tube pair shall be clearly identified and oriented relative to the structure.

.15 The City's Engineer shall evaluate the results and determine whether the pile construction is acceptable or not.

.16 If the pile is accepted by The City's Engineer, then the Contractor may proceed with construction.

.17 If The City's Engineer determines that the pile is not acceptable, the pile shall be cored, repaired, or replaced by the Contractor at the Contractor's expense and with no increase in Contract time.

.18 After all CSL testing has been completed, and after acceptance of the pile by The City's Engineer, the Contractor shall remove the water in the tubes, place grout tubes extending to the bottom of the access tube, and fill all access tubes in the piles with grout from the bottom up using tremie methods.

.9 Any concrete found to not meet specified criteria based on the tests performed shall be removed and replaced by the Contractor at no additional cost to The City.

.10 The pile shall not be considered acceptable until The City's Engineer has reviewed and accepted CSL or further tomography reports and determined whether further remedial action is required.

1.8 Defective Piles

.1 Should a pile be rejected and the remedy for that pile, finally, not be acceptable to The City's Engineer, the Contractor bears all the responsibility, costs of redesign, and effects from delays.

.2 A drop in concrete elevation of more than 2% of the pile diameter between the time of initial pour and set shall be considered a defective pile.

.3 Manipulation of reinforcement to adjust position, considered by The City's Engineer to be harmful, shall not be permitted unless directed by The City's Engineer.

.4 Defective piles shall be repaired by the Contractor at their expense. No compensation shall be made for remedial work or losses or damages due to the remedial work of drilled piles found flawed, defective, or not in accordance with the Agreement

.5 If the City's Engineer determines a drilled pile is unacceptable, the Contractor shall submit a remedial action plan proposal with supporting calculations to The City's Engineer for review and acceptance at least 10 Business Days prior to commencement of the remedial work.

.1 The remedial action shall be designed by the Contractor and signed and sealed by an Engineer.

.6 No compensation shall be made for remedial work or losses or damages due to the remedial work of drilled piles found flawed, defective, or not in accordance with the Agreement. The Contractor's repair procedures and expected schedule impact, as a minimum, shall account for the following:

.1 The defective pile shall be redrilled and replaced by new, and if necessary, longer and larger piles with a bridging pile cap.

.2 The defective concrete shall be removed and replaced.

.3 A sufficient portion of the pile cap shall be extended and reinforced.

1.9 Delivery, Storage, and Handling

.1 The Contractor shall provide continuous concrete delivery from the plant for each pour.

.2 Waste Management and Disposal (as per approved ECO Plan):

.1 Divert unused concrete materials to a local, suitably designated disposal facility. Acquire all such associated required permits.

.2 Divert unused admixtures, additive materials (pigments, fibres) or other Hazardous Substances to an official Hazardous Substances collections site as accepted by The City's Engineer.

.3 Do not dispose unused admixtures, additive materials or other Hazardous Substances into sewer systems, lakes, or streams; on to the ground; or to other locations where it will pose health or environmental hazards.

.4 Prevent admixtures, additive materials and other Hazardous Substances from entering drinking water supplies or streams.

.5 Using appropriate safety precautions, collect liquid or solidify liquid with inert, non-combustible material, and remove for disposal.

.6 Dispose of waste in accordance with applicable local, provincial, and federal requirements.

2 PRODUCTS

2.1 Concrete

.1 Concrete shall conform to the requirements of Section 03300, Cast-In-Place Concrete.

.2 Nonshrink grout for underwater crack repairs shall be one of the following approved products or an accepted equivalent product:

- .1 BASF Rheomac UW 450
- .2 Euco Tremie Grout
- .3 Sikagrout 328 with Sikament 100 SC

.3 Bonding agent shall consist of one of the following:

- .1 Cement-sand bonding agent to consist of portland cement and sand in a ratio of 1:1 by volume, mixed with enough water to form a stiff mixture. The consistency of the mixture shall be such that it can be applied with a stiff brush to the existing concrete in a thin, even coating that will not run or puddle.
- .2 Bonding agent recommended by proprietary patch material supplier.

.4 Patch materials for underwater repairs shall be one of the following approved products or an accepted equivalent product:

- .1 Euco-Speed Blue Line
- .2 Five Star Structural Concrete Underwater Hand Pack (HP)
- .3 Sika MonoTop 611 with Sikament 100 SC

2.2 Reinforcing Steel

.1 Reinforcing steel shall conform to the requirements of Section 03200, Concrete Reinforcement.

.2 Reinforcing support and positioning devices shall be made of noncorrosive material that supports and aligns reinforcing steel within the shaft and that provides the appropriate side and bottom cover to the reinforcing steel.

2.3 Steel Casing

.1 Where required, permanent steel casing shall conform to the IFC Drawings.

.2 Temporary steel Casing shall conform to ASTM A283 Grade D, ASTM A252 Grade 2, or ASTM A36.

2.4 Equipment

.1 Continuous flight auger equipment shall not be permitted.

.2 Hydraulic oscillating and rotating equipment shall be permitted for the installation of temporary or permanent casings.

.3 Equipment made of aluminum material shall not come in contact with the plastic concrete.

.4 Placing Equipment:

- .1 Consolidating Equipment shall conform to CSA A23.1.
- .2 Internal vibrators used to consolidate concrete components containing galvanized steel reinforcement shall have a resilient covering that will not damage the galvanized reinforcement during use.
- .3 External form vibrators are not permitted.
- .4 Mixer for Bonding Agents shall be a stationary mixer, power driven, and capable of uniformly mixing the Materials.

.5 Compressor – Air Blasting:

- .1 The compressor for air blasting shall have a minimum capacity of 3.5 cubic metres per minute (m^3/min).
- .2 The compressed air shall be free of oil or other contaminants when tested in conformance with ASTM D4285.

.6 The mixing plant shall be capable of producing tickets in accordance with CSA A23.1.

.7 Concrete shall be produced at a batching plant. The use of mobile mixers shall not be permitted.

3 EXECUTION

3.1 Excavation

.1 Requirements:

.1 Excavate holes for drilled piles to dimensions and required bearing strata or elevations as shown on the Drawings unless directed otherwise in the field by the City's Engineer.

.2 Bearing strata shall have the load carrying capacity confirmed in the field by the City's Engineer.

.3 Do not excavate shafts deeper than elevations indicated in the Drawings unless approved by The City's Engineer.

.4 Excavate the bottoms of drilled piles to a level plane within 1V:12H tolerance.

.5 Monitor sidewall stability during drilling.

.6 If sidewall instability is encountered that the City's Engineer considers excessive, use alternative drilling methods, such as temporary casing.

.7 Drilled pile design dimensions and depths shown on the Drawings shall be considered minimums and are based on bearing and friction in assumed strata.

.8 If bearing stratum is not capable of maintaining the assumed capacity, the foundation system may be revised as directed by The City's Engineer. Revisions would be paid for in accordance with the Agreement.

.9 Remove loose material from the bottom of the shaft.

.2 Explore the bearing stratum of each pile by a means recommended by the City's Engineer.

.3 Equipment:

.1 Provide adequate equipment so Work is expedited to the fullest extent possible.

.2 Use equipment fully capable of excavating shafts to depths, diameters, and sizes indicated in the Drawings and within the specified tolerances.

.3 Maintain equipment in satisfactory operating condition and provide sufficient quantity of equipment to maintain the projected schedule of the Work.

.4 Using bits or augers with a power-driven, rotary-type rig, sufficient for excavating a shaft of a diameter specified on the Drawings from the ground surface to a depth as specified on the Drawings.

3.2 Reinforcing Steel Placement

.1 Place concrete reinforcing in accordance with Section 03200, Concrete Reinforcing.

.2 Obtain the City's Engineer's acceptance of formwork and placement of reinforcing steel and inserts before placing concrete

.3 Before placing, clean reinforcing steel and dowels of loose rust, scale, dirt, grease, and other material that could reduce or destroy the bond.

.4 Fabrication and Erection:

.1 Fabricate and erect reinforcing cages in shafts as one continuous unit with any applicable CSL tubes.

.2 Where piles extend into a pile cap, take care to ensure reinforcement extending from the piles does not interfere with the pile cap reinforcing. Use either temporary or permanent pile cap reinforcement to provide a proper fit between the pile reinforcement and pile cap reinforcement.”.

.3 Place reinforcement accurately and symmetrically about the axis of the hole and hold securely in position during concrete placement.

.4 Verify depths of drilled piles prior to completing tying reinforcing steel cages.

.5 Reinforcing steel shall be delivered to the site and cut as required.

.6 Splices are limited to near the base for the longitudinal reinforcing steel as required for proper top-of-pile fit.

.7 Add additional reinforcing steel ties or spirals as required to provide stability of the cage and maintenance of shape and configuration as required for proper lifting, handling, and placement. Such ties shall not interfere with free-falling concrete placement or tremie pipe operations.

.8 Provide cover to reinforcing steel of not less than 100 mm.

.9 Provide spacer devices to maintain side and bottom cover.

.10 Install spacer devices in accordance with the manufacturer’s instructions.

.5 Do not allow reinforcing cage to move vertically or horizontally during concrete placement.

.6 Should the cage collapse, the entire pile shall be rejected and shall be removed in its entirety.

.7 Inserts and Accessories:

.1 Use templates to set anchor bolts, levelling plates, and other accessories furnished under the work of other sections.

.2 An Engineer or a qualified and licensed Professional Land Surveyor registered in the Province of Alberta shall determine the plan location and elevation of such devices.

.3 Provide spacers (capable of sliding on any temporary Casings required), blocking, and holding devices to maintain required position during concrete placement.

.4 Protect exposed ends of dowels and anchor bolts from mechanical damage and exposure to weather by greasing, wrapping and taping with polyethylene or other suitable material.

3.3 Concrete Placement

.1 General:

.1 Continuous flight auger concreting method shall not be permitted.

.2 Fill drilled piles with concrete immediately after inspection and approval by the City's Engineer.

.3 Place concrete continuously and in a smooth flow without segregating the mixed Materials.

.4 Where pile diameter is less than 900 mm, limit the maximum vertical freefall of concrete to 1200 mm. Maximum vertical freefall height for pile diameters equal to or larger than 900 mm will be 1500 mm unless approved by the City's Engineer. The maximum freefall height will be dependent on the concrete mix design, reinforcing cage configuration, proposed rate of pour and proposed mechanical vibration equipment.

.5 Do not allow freefall concrete to hit steel reinforcement.

.6 Do not allow freefall concrete to run down casing or the face of hole wall.

.7 Place concrete by tremie when underwater.

.8 Concrete (nontremie) may be placed by the dry method where no more than 75 mm of standing water sits at the base of the drilled hole and seepage rate is less than 300 mm an hour (25 mm in 5 minutes), provided the poured concrete has a minimum 10% reserve strength above the design strength.

.9 Provide mechanical vibration for consolidation.

.10 Allow concrete for a pile to cure for a minimum of 48 hours prior to drilling or concreting an adjacent pile.

.11 Do not use aluminum pipe or equipment for placing concrete.

.2 Place concrete using a tremie or concrete pump. Do not introduce air or water pockets into the tremie concrete through the placing equipment.

.3 Tremie Method:

.1 Position the pipe of a tremie or the hose of a concrete pump vertically and ensure the pipe or hose is long enough to reach the lowest point of the concrete deposit

.2 Fill the drilled shafts with concrete using a tremie or concrete pump, sealed at the bottom, extending from above the water surface to the bottom of the drilled shaft.

.3 With the sealed tremie on the bottom of the shaft, fill the tremie pipe to the top extending above the water surface.

.4 Maintain a continuous flow of concrete at a minimum rate of 15 cubic metres per hour (m^3/h) through the pipe or hose

.5 Pick up the filled tremie approximately 300 mm off the bottom of the shaft to allow the weight of the concrete to displace the seal at the bottom of the tremie.

.6 At no time is the tremie to be pulled to such a height as to clear the surface of the concrete already placed in the shaft.

.7 Keep the discharge end of the tremie pipe continuously immersed a minimum of 1.5 m in the freshly placed concrete at all times during placement once concrete is flowing through the pipe.

.8 Pour all concrete through the now open tremie, taking care to maintain a sufficient head of concrete to completely displace all water and suspended cuttings of material and to provide enough pressure to prevent reduction in pile diameter by earth pressure on the fresh concrete.

.9 Place the concrete in each pile above the cut-off elevation and then dip out excess concrete while fresh to the cut-off elevation.

.10 Deposit all concrete through the tremie or pumpline to provide a single continuous flow, without aggregate segregation. Place concrete in its final position and to its full depth in a continuous placing operation.

.11 Do not disturb, puddle or vibrate concrete after placement.

.12 Locate tremie or concrete pumps a maximum distance of 5 m apart and a maximum of 2.5 m from forms.

.4 Place concrete only in water that has a temperature 2°C or greater. Insulation of forms shall be acceptable to maintain temperatures within the forms to 2°C or greater.

.5 Monitor the internal temperature of mass-pour concrete at all times during the pour and hydration (hardening) periods per the accepted thermal monitoring plan.

.6 Use separate cranes to deliver the tremie concrete, and to move and position the tremie or concrete pump.

.7 When a placement operation is completed and Work is to continue, prepare the construction joint by removing surface laitance to expose the coarse aggregate.

.8 Dewater at least 24 hours after the concrete placement is completed.

.9 Above-Grade/Dry Surface Finish:

.1 Repair honeycombing or cavities using Approved Type OH-V or FP products from the most current Alberta Transportation Approved Concrete Patching Materials for Bridges List. Install as per the manufacturer’s instructions.

3.4 Cold Weather Concreting Above Grade / Dry

.1 During the 7-Day curing period, maintain the concrete surface temperature at or above 10°C.

.2 When cold temperatures are probable during the curing period, the concrete placement plan shall include the protection measures as necessary to maintain the concrete temperature above 10°C.

.3 Use hoarding and heating to maintain appropriate temperatures if required.

.1 Design the hoarding for the worst conditions that can be reasonably anticipated from local weather records, forecasts, site conditions, and past experience for the time period when the protection is required.

.2 Monitor the conditions, and modify the hoarding as required.

.3 Use heating equipment of sufficient capacity to establish and maintain the specified curing conditions throughout the curing period.

.4 Vent heating equipment used within the housing outside the hoarding.

.5 Open flame heating equipment shall not be permitted.

.4 Protection measures for CIP concrete are listed in Table 1.

Table 1 – Cast-in-Place Concrete Protection Measures

Anticipated Minimum Ambient Air Temperature (°C)	Required Protection
+10 to 0	Insulation with minimum R value of 0.67 over moisture vapour barrier
-1 to -10	Insulation with minimum R value of 1.33 over moisture vapour barrier
-11 to -20	Hoarding and heating
Less than -20	Hoarding and heating

.5 Where concrete or proprietary patch materials are to be cast against existing concrete, maintain existing concrete surfaces within the affected area and within 500 mm of the affected area, at a minimum temperature of 10°C for a minimum of 2 Days prior to placing new concrete or patch material. Follow manufacturer's instructions where required.

3.5 Above-Grade Concrete Surface Patch Repairs

.1 Use form and pump techniques or the manufacturer's written instructions in the case of underwater repairs to install patch material. Finish patches flush with existing surfaces.

.2 Surface and ambient temperature restrictions shall be met throughout the curing period.

3.6 Construction Tolerances

.1 The provided tolerance does not relieve the Contractor of the sole responsibility for matching splices to above-grade reinforced-concrete elements, such as piers, pile caps, or pier caps, while maintaining all required concrete cover and lap splice requirements

.2 Plan Location:

.1 The tolerance on the plan location for the top of the drilled pile shall not be more than 50 mm in any direction.

.2 The centre of the shaft is defined as the centroid of the reinforcing cage.

.3 Plumbness:

.1 Permissible tolerance for plumbness shall be 0.5% of the total pile length.

.2 The centres of the top and bottom may be taken as the centroid of the reinforcing cage.

.4 Bottom Area:

.1 The bottom of the pile shall be essentially horizontal within a tolerance of 1 vertical to 12 horizontal (1V:12H) with the area of the bottom bearing not less than 98% of that specified on the Drawings.

.5 Top Area:

.1 Excess concrete at the top of the pile beyond the limits of the pile diameter shall be removed.

.2 The concrete cut-off elevation at the pile top shall be within+25 mm to -75 mm of the elevation specified on the Drawings.

.6 If any of these tolerances are exceeded, immediately notify The City's Engineer.

.7 The cost of re-engineering and corrective construction for piles that do not meet the requirements of the Project specifications shall be borne by the Contractor.

4 MEASUREMENT AND PAYMENT

4.1 Measurement

.1 Measurement of mobilization and pile setup shall be lump sum and shall not be separately measured.

.2 Measurement of drilled concrete pile installation shall be by the metre length of drilled piles acceptably installed and as measured by The City's Engineer to the nearest 0.1 m. The quantity measured shall be the actual length installed from the pile tip to the underside elevation of the abutment seat.

4.2 Payment

.1 Payment of mobilization and pile setup shall be full compensation required to:

.1 Mobilize the drill rig(s) onsite

.2 Setup over all pile locations ready to commence pile drilling

.3 Provide all labour, Construction Equipment, tools, and incidentals necessary to complete the Work

.4 No separate payment shall be made for mobilization and demobilization of the drill rig to and from the project site.

.2 Payment of drilled concrete pile installation shall be on a unit price basis per vertical metre for each specified type and size of drilled pile, and shall be full compensation for:

.1 Preparation and editing of all required submittals.

.2 Drilling pile holes to the elevations and dimensions shown on the Drawings

.3 Supply and installation of concrete and reinforcing steel shown on the Drawings

.4 Supply and installation of casing. Removal of temporary casing as required

.5 Removal and disposal of pile hole tailings

.6 Dewatering and cleaning of pile holes as required

.7 All labour, Construction Equipment, tools, and incidentals necessary to complete the Work

.8 No additional payment shall be made where the pile holes are drilled larger than specified unless directed by The City's Engineer

.3 CSL testing per pile (if required).

.4 All costs associated defective piles including further testing and any associated repair work required shall be considered incidental to the Work, and no separate or additional payment shall be made.

END OF SECTION

1 GENERAL

1.1 Work Included

.1 Provide all labour, Materials, and Construction Equipment required for the supply and placement of bituminous tack coat and hot-mix asphalt (HMA) concrete to the bridge deck and approaches.

1.2 Related Work Specified in Other Sections

.1 Bridge Deck Waterproofing Section 07100

1.3 Reference Standards

.1 Perform the Work of this section in accordance with the latest edition of the following standards available at the Effective Date, except where specified otherwise. Provide one copy onsite of The City of Calgary, Standard Specifications, Roads Construction, in either in hard copy or digital format.

.2 Alberta Transportation (AT):

- .1 Test Method TLT-125, Standard Test Method For Particle Shape, Texture and Uncompacted Void Content of Fine Aggregate

.3 The City of Calgary (The City):

- .1 Standard Specifications, Roads Construction.

1.4 Definitions

.1 All defined words or phrases shall have meaning given the City of Calgary Standard General Conditions, The City of Calgary, Standard Specifications, Roads Construction and the Agreement, unless noted otherwise.

1.5 Source Sampling

.1 Sampling and testing procedures used to determine Material characteristics shall be as outlined in The City of Calgary Roads Construction Specification Section 307.02.03, Sampling and Testing (Superpave), or Section 307.03.03, Sampling and Testing (Marshall), as applicable, unless otherwise specified.

1.6 Submittals

.1 Provide the following submittals at least 20 Business Days prior to commencing Work:

- .1 Viscosity-temperature chart for asphalt cement to be supplied showing either Saybolt Furol viscosity in seconds (s) or kinematic viscosity in centistokes (cSt), temperature range 105 to 175 degrees Celsius (°C)
- .2 Manufacturer's test data and certification that asphalt cement meets requirements of this section
- .3 Mix design per The City of Calgary Roads Construction Specification Section 307.00.00 unless noted otherwise in this section

.4 Aggregate source name(s) and location(s)

.5 The gradation of each aggregate to be used in the mixture using the sieve sizes listed elsewhere in this Agreement

.6 The percentage by mass of each aggregate to be used in the mixture

.7 The mix design gradation of the combined aggregate

.8 Other characteristics of the combined aggregate specified in The City of Calgary Roads Construction Specification Section 307.02.00 for a Superpave design or Section 307.03.00 for a Marshall design

.9 All mix design characteristics, including:

  .1 Graphs used in arriving at the final mix design

  .2 The bulk specific gravity of the combined aggregates

  .3 A graph of theoretical maximum specific gravities

  .4 The asphalt absorption of the combined aggregates

  .5 Tensile strength ratio (both with and without freeze-thaw conditioning [for Superpave])

.10 Identification of each asphalt supplier by name, location, and types and grades of asphalt to be supplied

.11 Percent uncompacted voids (Fine Aggregate Angularity) of loosely compacted minus 2500 portion of the combined aggregate in accordance with Alberta Transportation Test Method TLT-125 for a Marshall design; no minimum value specified

.12 For each asphalt supplied, asphalt specific gravity and recommended mixing and compaction temperatures for the preparation of design specimens

.13 Voids table to include air voids, voids in mineral aggregate (VMA), and voids filled with asphalt (VFA) for various asphalt contents (0.1% increments) and bulk densities (increments of 5 kilograms per cubic metre [kg/m^3])

.14 Mix design submissions using reclaimed asphalt pavement (RAP) shall include:

  .1 The RAP source name(s) and location(s)

  .2 All RAP asphalt content and gradation test results

  .3 The bulk specific gravity of the RAP aggregate

  .4 The percentage by weight of RAP to be used in the mixture

  .5 When required, all RAP rheological test results, the design rheology, and all blending information used

1.7 Quality Control, Quality Assurance, Inspection and Testing

.1 Products, workmanship, and testing shall conform to the standards specified in this Technical Specification.

.2 All products and workmanship shall be inspected by The City's Engineer. To facilitate in this process, the Contractor shall provide representative samples of each of the aggregate components, asphalt cement, and RAP for verification purposes. A sufficient quantity of each component shall be provided to result in a 100-kilogram (kg) sample of combined aggregate at design proportions. The cost of such mix design verification shall be borne by The City.

.3 Products and mixes shall be tested for conformance to the specified requirements by an independent testing agency.

.4 The City's Engineer and independent testing agency shall be notified in writing at least 48 hours prior to the commencement of Work to permit inspection and testing.

.5 The Contractor shall cooperate with The City's Engineer and independent testing agency on the inspection of Materials and sampling.

.6 The Contractor shall not produce any asphalt mix prior to receiving The City's Engineer's written notice that the mix design has been verified. Any mix produced prior to receiving such notice will not be accepted.

.7 The aggregate proportioning (including RAP), target gradation, asphalt content, and air void content for the accepted mix design will then be the Design Mix Formula and shall become the Job Mix Formula for the start of production of the asphalt mix.

.8 The Contractor shall be responsible for producing mixes that conform to the Technical Specifications.

.9 Work shall not be covered before inspection and testing unless authorized by The City's Engineer, in writing.

.10 Defective products or Work that fails to meet the specified requirements as directed by The City's Engineer shall be removed and replaced or repaired at the Contractor's own cost.

1.8 Delivery and Storage

.1 When necessary to blend aggregates from one or more sources to produce required gradation, do not blend in stockpiles.

.2 When dryer drum mixing plant is used, stockpile fine aggregate separately from course aggregate.

.3 Provide approved storage, heating tanks, and pumping facilities for asphalt cement.

1.9 Examination

.1 Examine the Drawings and visit the Project Site to determine existing conditions. No additional compensation shall made for extra work due to existing conditions that such examination should have disclosed.

.2 Examine previously constructed work. Notify The City’s Engineer, in writing, of any conditions that may prevent proper completion of this Work. Commencement of Work implies acceptance by the Contractor of existing conditions.

1.10 Protection

.1 Protect all monuments, benchmarks, stakes, and lines located onsite. Protect existing structures, appurtenances, trees, and shrubs.

.2 Repair or replace items damaged by this Work to The City’s Engineer’s approval, at no extra cost to The City.

1.11 Cooperation

.1 Cooperate with Other Contractors to expedite progress of the Work.

.2 Fully coordinate the Work of this section with the Work of the bridge deck waterproofing section. The HMA concrete must be placed as soon as possible but within 5 Business Days maximum per the manufacturer's recommendations after the protection boards for the waterproofing are placed and immediately after the tack coat is cured.

1.12 Haul Routes

.1 Haul routes shall be approved by the municipal authorities having jurisdiction and in accordance with the Agreement.

.2 Vehicles shall be equipped to prevent spilling or leaking of any part of the load.

2 PRODUCTS

2.1 Material

.1 Asphalt cement shall conform to The City of Calgary Roads Construction Specification Section 307.01.00, per roadway design requirements and the Agreement, unless noted otherwise on structural Drawings.

.2 Aggregates shall conform to The City of Calgary Roads Construction Specification Section 307.02.00, meeting Superpave 12.5 millimetres (mm) (Fine Graded) or Section 307.03.00, meeting Marshall Mix Type “B,” “C” per roadway design requirements, and associated Agreement, unless noted otherwise on structural Drawings.

.3 Tack Coat material shall be anionic emulsified asphalt binder (SS-1) subject to approval.

.4 Joint Sealant shall be Bakor 570-05, Meadows 164, Trem THC 200, or Hydrotech Hot Poured Seal 6160.

2.2 Mix Design

.1 Job Mix design shall be submitted per the Agreement’s design requirements for review by The City’s Engineer 20 Business Days prior to commencing the Work.

.2 Design of mix shall conform to The City of Calgary Roads Construction Specification Section 307.00.00. When Marshall is specified in the Agreement, the Marshall mix shall meet Mix Type "B" or "C" requirements, including other related requirements in this section. When Superpave is specified in the Agreement, the Superpave mix shall meet Superpave 12.5 mm (Fine Graded) requirements, including other requirements in this section.

.3 Physical requirements shall be measured in accordance with the requirements of The City of Calgary Roads Construction Specification Section 307.02.00 or Section 307.03.00 for Superpave or Marshall design requirements, respectively, per the Agreement's design requirements.

.4 The Job Mix shall not be changed without prior approval. Should a change in a Material source be proposed, a new Job Mix formula shall be provided to The City's Engineer for approval.

.5 Plant dust collected during processing shall be returned to the mix in quantities not injurious to mix properties.

.6 All costs incurred in mix design formulation shall be the responsibility of the Contractor. Shipping costs for samples sent to The City's Engineer for verification and approval shall be the responsibility of the Contractor.

3 EXECUTION

3.1 Plant and Mixing Requirements

.1 Batch and Continuous Mixing Plants

.1 Shall Conform to ASTM D995 for batch and continuous mixing plants.

.2 Heat asphalt cement and aggregate to the mixing temperature recommended by the mix designer. Do not heat asphalt cement above the lower of:

.1 What is recommended in writing by the asphalt supplier or

.2 160°C

.3 Before mixing, confirm that dry aggregates have a moisture content not greater than 1% by mass or a lesser moisture content if required to meet mix design requirements.

.4 Make available current asphalt cement viscosity data at the plant. With information relative to viscosity of asphalt being used the mix designer shall recommend the temperature of the completed mix at the plant and paver after considering hauling and placing conditions.

.5 Feed cold aggregates to the plant in proportions that support continuous operations.

.6 Immediately after drying, screen aggregates into hot storage bins in sizes to permit recombining into gradation meeting Job Mix requirements.

.7 Store hot, screened aggregates in a manner to minimize segregation and temperature loss.

.8 Maintain temperature of Materials within ±5°C of specified mix temperature during mixing.

.9 Mixing time:

.1 In batch plants, continue wet mixing as long as necessary to obtain a thoroughly blended mix but not less than 30 seconds (s) or more than 75 s.

.2 In continuous mixing plants, mix as long as necessary to obtain a thoroughly blended mix but not less than 45 s.

.3 Do not alter mixing time unless approved.

.2 Dryer Drum Mixing Plant

.1 Feed aggregates to burner end of dryer drum by means of a multi-bin cold feed unit, and blend to meet Job Mix requirements by adjustments of variable speed feed belts and gates on each bin.

.2 Meter total flow of aggregate by an electronic weigh belt system with an indicator that can be monitored by the plant operator and that is interlocked with an asphalt pump so that proportions of aggregate and asphalt entering the mixer remain constant.

.3 Provide for easy calibration of weighing systems for aggregates without having Material entering the mixer.

.4 Make provision for conveniently sampling the full flow of Materials from the cold feed.

.5 Provide screens or other suitable devices to reject oversize particles or lumps of aggregate from the cold feed prior to entering the drum.

.6 Provide a system interlock that will stop all feed components if either asphalt or aggregate from any bin stops flowing.

.7 Accomplish heating and mixing of asphalt mix in an approved, parallel-flow dryer-mixer in which aggregate and asphalt enter the drum at the burner end and travel parallel to the flame and exhaust gas stream, with the following conditions:

.1 Control heating to prevent fracture of aggregate or excessive oxidation of asphalt.

.2 Equip system with automatic burner controls and provide for continuous temperature sensing of asphalt mixture at discharge, with a printing recorder that can be monitored by the plant operator.

.3 Submit printed record of mix temperatures every 5 Business Days to The City's Engineer.

.8 Maintain a mixing period and temperature to produce a uniform mixture in which particles are thoroughly coated, and moisture content of Material as it leaves the mixer is less than 2%.

.3 Temporary Storage of Hot-Mix

.1 Provide mixture storage of enough capacity to permit continuous operation and designed to prevent segregation.

.2 Do not store asphalt mix in storage bins more than 3 metres (m) deep.

.4 Mixing Tolerances

.1 Permissible variation in aggregate gradation and asphalt cement from Job Mix (percent of total mass) shall conform to City of Calgary Roads Construction Specification Section 307.02.02 or Section 307.03.02, as applicable.

.2 Permissible variation of mix temperature at discharge from plant must remain within the viscosity and temperature curve for the asphalt cement. Contractor shall provide chart from asphalt supplier showing this curve to The City's Engineer.

3.2 Equipment

.1 Pavers shall be mechanical, automatic grade controlled, self-powered pavers capable of spreading mix within specified tolerances, true to line, grade, and crown indicated.

.2 Rollers shall be supplied in a sufficient number of type and weight necessary to obtain the specified density of the compacted mix.

.3 Haul trucks shall be of adequate size, speed, and condition to provide orderly and continuous operation and shall include:

.1 Tightly sealed boxes with tight, metal bottoms to prevent leakage of Material

.2 Covers of sufficient size and weight to completely cover and protect asphalt mix when trucks are fully loaded

.3 Insulation for the entire contact area of each truck box during cool weather or for long hauls

.4 Haul trucks that cannot be weighed in a single operation on scales supplied shall not be accepted.

.5 Hand Tools

.1 Lutes or rakes with covered teeth shall be used for spreading and finishing operations

.2 Tamping irons used for compacting Material along curbs, gutters, and other structures inaccessible to rollers shall have a mass not less than 10 kg and a bearing area not exceeding 400 square centimetres (cm^2)

.3 Mechanical compaction equipment, when approved by the City's Engineer, may be used instead of tamping irons

.4 Straight edges shall be 4.5 m in length, and shall be used to test finished surfaces

3.3 Preparation

.1 The tack coat shall be applied to the top surface of protection boards and the approaches. The tack coat shall be applied uniformly at a rate of 0.5 litre per square metre (L/m^2).

.2 The tack coat shall be applied only when the surface to be treated is dry, when the weather is not foggy or rainy, and when the surface temperature is above 5°C.

.3 Before applying the tack coat, loose dirt or other deleterious material shall be removed from the prepared surface by brooming and other methods. All deck drains and catch basins shall be temporarily plugged.

.4 The tack coat shall be applied by means of a self-propelled pressure bituminous material distributor subject to approval.

.5 Tack coats shall be applied in a single application.

.6 The Contractor shall be responsible for accidents or damage resulting from the use of excessive temperatures and shall replace, at no expense to The City, any Material destroyed.

.7 Adjacent structures and appurtenances shall not be spattered by the tack coat. The Contractor shall remove, at no direct expense to The City, any spattering caused by the operations.

.8 Areas missed by the distributor or inaccessible to the distributor shall be treated using hand-spray prior to tacking the adjacent section.

.9 No traffic (construction vehicles) shall be allowed on the tack coat until the Material is fully cured.

3.4 Delivery

.1 Transport mix to the Project Site in vehicles cleaned of foreign material.

.2 Paint or spray truck beds with soap or detergent solution at least once a Day or as required. Elevate truck bed, and thoroughly drain cleaning solution. No ponding of solution shall be permitted.

.3 Schedule delivery of Material for placing in daylight, unless The City's Engineer approves the use of artificial light.

.4 Deliver Material to paver at a uniform rate and in an amount within the capacity of paving and compacting equipment.

.5 Deliver loads continuously in covered vehicles, and immediately spread and compact Material.

.6 Deliver and place mixes at a temperature within range directed, but generally not less than, 135°C.

.7 Do not use bridge decks to turn around loaded or empty trucks.

.8 Keep vehicle tires clean of deleterious material prior to driving onto protection board.

3.5 Placing

.1 Place asphalt concrete to thicknesses, grades, and lines indicated in the Agreement or as directed by The City's Engineer.

.2 Placing Conditions

 .1 Place asphalt mixtures only when air temperature is above 5°C and rising, and secondary rolling of the asphalt concrete will be completed before the temperature of the mat falls below 55°C.

 .2 When the temperature of the surface on which the asphalt is to be placed falls below 10°C, provide extra rollers as necessary to obtain required compaction before cooling.

 .3 Do not place HMA when pools of standing water exist on surface to be paved, during rain, or when surface is damp or frozen.

 .4 Place asphalt concrete on the bridge in two nominal 40-mm compacted lifts, with a tack coat between each lift. Apply the tack coat uniformly at a rate of 0.5 L/m^2.

 .5 Place strips in such lengths as to enable the complete surface width to be completed in 1 Day's operation.

 .6 Spread and strike off mixture with self-propelled mechanical finisher as follows:

  .1 Construct longitudinal joints and edges true to line markings. Lines for the paver to follow shall be parallel to centreline of proposed pavement and approved. Position and operate the paver to follow the established line closely.

  .2 When using pavers in echelon, have the first paver follow marks or lines, and the second paver follow the edge of the Material placed by the first paver. Work pavers as close together as possible. In no case permit them to be more than 30 m apart.

  .3 If segregation occurs, immediately suspend the spreading operation until the cause is determined and corrected.

  .4 Correct irregularities in the alignment left by the paver by trimming directly behind the machine.

  .5 Correct irregularities in the surface of the pavement course directly behind the paver as follows:

   .1 Remove excess Material forming high spots by shovel or lute.

   .2 Fill and smooth indented areas with hot mix.

   .3 Do not broadcast Material over such areas.

 .7 Do not throw surplus Material onto freshly screeded surfaces.

 .8 Verify that no displacement of protection boards or rubberized membranes occurs during the paving operation.

.3 Unloading

.1 Have trucks dump part of their load into the paver and then move up the deck away from the paver.

.2 The paver shall not push the truck.

.3 Any hot mix material spilled in front of the paver shall be removed immediately so that it is not ground into the waterproofing membrane or protection board.

.4 Placing by Hand Spreading

.1 Wood or steel forms may be used if they are approved and rigidly supported to provide correct grade and cross-section. Use measuring blocks and intermediate strips to aid in obtaining the required cross-section.

.2 Distribute Material uniformly. Do not broadcast Material.

.3 During spreading operations, thoroughly loosen and uniformly distribute Material by lutes or covered rakes. Reject Material that has formed into lumps and does not break down readily.

.4 Following placing and before rolling, check surface with templates and straight edges, and correct irregularities.

.5 Provide heating equipment to keep hand tools free from asphalt. Avoid high temperatures that may burn Material. Do not use tools at a greater temperature than the temperature of the mix being placed.

3.6 Compacting

.1 Vibratory rollers shall be operated in static mode.

.2 The minimum average Marshall density of the first lift shall be 95%, with no individual test less than 93%. The remainder of the first lift shall have a minimum Marshall density of 95%. The minimum average Marshall density of the second lift (top lift) shall be 97%, with no individual test less than 95%.

.3 Steel and Pneumatic Rollers:

.1 Steel and pneumatic-tired rollers shall be kept slightly moistened by water.

.2 Steel rollers shall be equipped with scrapers.

.3 Pneumatic tire rollers shall be equipped with coco mats.

.4 Excessive use of water will not be permitted.

.5 The speed of steel tire rollers shall not exceed 5 kilometres per hour (km/h). The speed of pneumatic tire rollers shall not exceed 8 km/h.

.6 Rollers shall be operated with the drive wheels nearest the paving machine.

.4 Longitudinal joints shall be rolled directly behind the paving operation.

.5 After the longitudinal joints and edges have been compacted, rolling shall start longitudinally at the edge and gradually progress toward the centre of the mat.

.6 The roller shall not be driven onto or off the mat over the longitudinal edge of the mat.

.7 Breakdown rolling

.1 All of the first lift shall cool to 110°C before commencing with breakdown rolling.

.2 The Contractor shall complete one pass with the static steel roller only.

.3 The remaining rolling shall be done with pneumatic-tired rollers with overlapping passes.

.4 The Contractor shall not allow the hot mix design to soften the waterproofing such that the protective boards will squirm under the roller and crack the hot mix around the perimeter of the board.

.5 The second lift shall be rolled in the usual manner as specified.

.6 Rollers shall be operated to prevent pick-up of the HMA on the tires.

.8 Rollers shall not be turned around on the deck. The roller must run off the deck to stop and turn.

.9 The line of rolling shall not suddenly be changed or the direction of rolling suddenly reversed. Any pronounced change or direction shall be made on stable Material.

.10 Rollers shall not be permitted to stand on the mat.

.11 The finished surface of the mat shall be free from waves, hairline cracks, roller marks, and other unevenness. The finished surface shall be free from depressions exceeding 6 mm as measured in any direction with a 4.5-m straight edge.

.12 If the finished surface of the mat does not comply with these requirements, the Contractor shall remove and replace Deficient areas at no cost to The City. The replacement of the mat shall be performed with a paving machine and shall comply with the specified riding quality.

3.7 Joints

.1 General

.1 Trim old pavements to vertical face to provide true surface and cross-section against which new pavement may be laid. Remove loose particles.

.2 Paint joint face with a thin coat of hot asphalt cement, or preheat joint face with an approved heater, prior to placing of fresh mixture.

.3 Overlap previously laid strip with spreader by 100 mm.

.4 Remove surplus Material from the surface of the previously laid strip. Do not dispose Material on the surface of a freshly laid strip.

.5 Construct joints between asphalt concrete pavement (ACP) and Portland cement concrete (PCC) pavement as indicated.

.6 Paint contact surfaces of existing structures, such as manholes, curbs, or gutters, with bituminous material prior to placing adjacent pavement.

.7 Where possible, skew lateral joints at 30 degrees (°) or more from the perpendicular to the direction of travel. Rake joints in new asphalt to a 30° slope.

.2 Transverse Joints

.1 Construct and thoroughly compact transverse joints to provide a smooth riding surface.

.2 Stagger joint locations in adjacent lanes by a minimum of 2 m.

.3 Offset transverse joint in succeeding lifts by at least 600 mm.

.3 Longitudinal Joints

.1 Before rolling, carefully remove, gather, and discard coarse aggregate in Material overlapping joints with a lute or rake.

.2 Roll longitudinal joints directly behind the paving operation.

.3 When rolling, shift the roller over onto the previously placed lane so that not more than 150 mm of the roller rides on the edge of the newly laid lane, and then operate the roller to pinch and press fines gradually across the joint. Continue rolling until a thoroughly compacted, neat joint is obtained.

.4 Longitudinal joints shall not be located within travel lanes, offset longitudinal joints in succeeding lifts by at least 150 mm.

4 MEASUREMENT AND PAYMENT

4.1 Measurement

.1 The quantity measured for payment of this section shall be on a unit price basis per square metre or a lump sum basis, as per the Agreement.

.2 For unit price payment, the quantity to be paid for shall be based on the total computed area of the bridge deck, as shown on the Drawings or reviewed and accepted by The City's Design Professional. The quantity shall be measured to the nearest 0.1 square metre (m^2).

4.2 Payment

.1 Payment for the Work of this section shall be on an as-tendered basis for the applicable asphaltic concrete mix type specified.

.2 Payment shall be full compensation for the following:

.1 Preparation of the asphalt mix designs and Job Mix Formula

.2 Protection of the environment and bridge components

.3 Surface profiling

.4 Supply and processing of aggregate

.5 Supply and application of tack coat

.6 Supply of asphalt cement

.7 Processing, hauling, placing, and compacting the mix

.8 Sampling and testing

.9 Construction of ACP joints

.10 All labour, Construction Equipment, tools, and incidentals necessary to complete the Work

END OF SECTION

1 GENERAL

1.1 Work Included

.1 This section outlines the requirements for the design, supply, fabrication, storage, delivery, installation, and all associated Work and incidentals necessary to install the noise barrier system in accordance with the requirements of the Agreement.

.2 The Contractor shall supply all Materials.

.3 A complete job is called for; therefore, any labour, Construction Equipment, tools, or other items not specifically mentioned, but necessary to complete the Work, shall be considered incidental to the Work, and no separate or additional payment shall be made.

.4 Unless stated otherwise in the Agreement, the Contractor shall cover the cost of engineering, Quality Control (QC), Quality Assurance (QA), and Project closure documentation, including As-Built Drawings.

.5 The Contractor shall provide a maintenance manual that includes repair and replacement procedures.

.6 Unless stated otherwise in the Agreement, geotechnical investigations will be undertaken by The City and made available for the Contractor's use.

1.2 Related Work Specified in Other Sections

.1	Drilled Concrete Piles	Section 02466
.2	Concrete Reinforcement	Section 03200
.3	Cast-In-Place Concrete	Section 03300
.4	Metal Fabrication	Section 05500
.5	Precast Concrete Supply, Fabrication, and Installation	Section 03302
.6	Other sections specific to the Project	

1.3 Reference Standards

.1 Perform the Work of this section in accordance with the latest edition of the following standards available at the Effective Date, except where specified otherwise. Provide one copy onsite of CAN/CSA S6 and CSA A23.1 in either in hard copy or digital format.

.2 Alberta Transportation (AT):

  .1 Alberta Transportation Product List for Concrete Sealers

.3 ASTM International (ASTM):

  .1 ASTM C140/C140M-18a, Standard Test Methods for Sampling and Testing Concrete Masonry Units and Related Units

  .2 ASTM C457/C457M-16, Standard Test Method for Microscopical Determination of Parameters of the Air-Void System in Hardened Concrete

.3 ASTM E413, Classification for Rating Sound Insulation

.4 CSA Group (CSA):

.1 CAN/CSA S6, Canadian Highway Bridge Design Code

.2 CSA A23.1/A23.2, Concrete materials and methods of concrete construction/ Test methods and standard practices for concrete

.3 CSA A165 Series, Standards on Concrete Masonry Units (consists of A165.1, A165.2, and A165.3).

.4 CSA A23.3, Design of concrete structures

.5 CSA A23.4, Precast concrete - Materials and construction

.6 CSA A3000, Cementitious materials compendium (consists of A3001, A3002, A3003, A3004, and A3005)

.7 CSA G30.18, R2014, Carbon steel bars for concrete reinforcement

.5 Masonry Standards Joint Committee (MSJC):

.1 TMS 402/602 Building Code Requirements and Specification for Masonry Structures

.6 The City of Calgary:

.1 Design Guidelines for Bridges and Structures

1.4 Definitions

.1 Unless a word is defined within this subsection, capitalized words used herein reference the definition provided within The City of Calgary Standard General Conditions.

.2 “Designer” means an Engineer or team of Engineers retained by the Contractor (either directly or through the Supplier) to perform design of the noise barrier wall system. The Designer shall be experienced in the design of noise barrier wall system, shall be employed by a company that is prequalified with the City of Calgary under category Other New Transportation Structures and shall take professional responsibility for the design of all components of the noise barrier wall system, including connections between all elements necessary as part of the wall.

.3 “Engineer of Record (EOR)” means a team of Engineers engaged by The City to perform design for the overall Project, assigned among Geotechnical, Structural, and Civil disciplines. Design by the EOR related to the noise barrier wall system may include geometric and site design, utility facility relocation, design of external drainage systems, and determination of noise barrier wall design parameters. The EOR shall also review the noise barrier wall system design. The EOR shall not be responsible for the design of the noise barrier wall system itself.

1.5 Design

.1 A site-specific design shall be performed for each individual application. This includes the design of the noise barrier and foundations.

.2 All design drawings and construction specifications shall be authenticated by the Designer.

.3 The design shall conform to CAN/CSA S6, The City of Calgary Design Guidelines for Bridges and Structures, and all other relevant reference standards.

.4 The design life of the noise barriers shall be 50 years, with a minimum 20-year service life for superstructure components.

.5 Shimming:

  .1 The design shall include shimming details that shall be shown on the Drawings.

  .2 Do not use alternative shimming methods, unless approved in writing by The City.

  .3 The maximum combined shim thickness shall not exceed 20 millimetres (mm).

.6 The design shall provide details on stepping the pile foundation, which are subject to approval by The City.

.7 Noise Barrier Wall Profile:

  .1 The noise barrier wall profile shall be as specified in the Agreement, and any verifications or adjustments are subject to approval by The City.

  .2 The top of the barrier profile shall be designed and installed level.

  .3 To accommodate sloping ground, the barrier shall be evenly stepped with all panels installed level.

  .4 The maximum step height between adjacent panels is 300 mm.

  .5 If stepping is required, the minimum height of the noise barrier, as specified in the Agreement, shall be maintained.

.8 The Sound Transmission Class (STC) of the nose barrier product specimen shall be 20 or greater, as determined from the measured sound transmission loss in accordance with ASTM E413.

.9 Engineer of Record:

  .1 The Engineer employed by the Contractor to design the site-specific noise barrier system shall be the EOR.

  .2 The EOR shall be responsible for the construction inspection and review, and shall submit a report with each progress invoice to The City.

  .3 Reports shall indicate construction progress and shall include documentation to verify that, as a minimum, one inspection of pile installation and one inspection of wall fabrication and construction per 100 lineal metres (m) of installed noise barrier was completed and that the construction conforms to the design.

  .4 The EOR shall supervise any corrective action required to correct Deficiencies in construction.

.5 The EOR shall file a letter confirming construction compliance with the requirements of their design and the Agreement (standard form to be provided by The City).

1.6 Submittals

.1 Concrete mix designs shall be submitted for review and approval per Section 03300, Cast-In-Place Concrete.

.2 Any proposed changes to the concrete mix design during fabrication shall be subject to review and approval by The City prior to the Contractor making the change.

.3 The design Drawings, details, and construction specifications shall be submitted to The City for review. The Contractor shall allow a minimum of 10 Business Days for The City to review and return comments.

.4 Include the following details on the design Drawings:

- .1 Reinforcing
- .2 Dimensions
- .3 Joints
- .4 Foundations
- .5 Construction tolerances
- .6 Horizontal and vertical geometry
- .7 Shimming
- .8 Height stepping
- .9 Drainage
- .10 Utility crossing
- .11 Other site-specific features
- .12 Specify all Materials, products, and accessories, as well as construction procedures.

.5 Construction shall not proceed until all comments have been resolved to the satisfaction of The City, unless approved otherwise.

.6 Shop Drawings shall be submitted for review and acceptance.

.7 Maintenance Manual:

- .1 Upon completion of the Work and prior to issuance of the Construction Completion Certificate, the Contractor shall provide a maintenance manual that includes repair and replacement procedures for the noise wall system.

1.7 Qualifications

.1 Should the Contractor propose a precast concrete system, it shall employ a fully certified precast supplier.

.2 Precast suppliers shall be certified in accordance with the Canadian Precast Concrete Quality Assurance (CPCQA) Certification Program or CSA Precast Certification Program.

.3 Noise barrier systems shall be installed only by installers prequalified under The City's Noise Barrier (Sound Attenuation) construction category. Installers may also have to be certified by the respective product supplier.

1.8 Quality Control, Quality Assurance, and Inspection and Testing

.1 Quality Control

.1 The Contractor is responsible for the quality of Materials and products provided for incorporation into the Work.

.2 QA/QC for all aspects of the Work shall be included in the Quality Management Plan (QMP) and submitted for review and acceptance prior to starting the Work.

.2 Quality Assurance

.1 The City may undertake, through an independent CSA-certified testing firm, random sampling, inspection, and testing for the purpose of determining the compliance with the Technical Specifications and the Agreement.

.2 The Contractor shall notify The City of casting times and allow ample time for notification, inspection, and corrective work. The Contractor shall provide a minimum of 2 Days' notice when requesting an inspection.

.3 The Contractor shall provide access to all portions of Work, and manufacture and fabrication plants, and cooperate with The City's representatives.

.4 In case of ambiguity whether the product, system, or Work conforms to the applicable standard, The City reserves the right to have such product or system tested or re-inspected to ascertain the conformance. The cost of such testing will be borne by The City in the event of conformance and by the Contractor in the event of nonconformance with the Agreement.

.5 The City may perform a QA audit at the batching or precast plant.

.3 Inspection and Testing

.1 The frequency of concrete testing shall conform to Section 03300, Cast-In-Place Concrete, and shall be included within the Contractor's QMP.

.2 All testing of concrete shall be the responsibility of the Contractor and shall be performed by an independent, certified testing firm.

1.9 Nonconformance

.1 Noise barriers that are constructed not meeting the requirements of the accepted noise barrier mock-up or not meeting the Project Technical Specifications shall be considered nonconforming work.

.2 Nonconforming noise barrier materials are Materials that are placed out of position or are damaged or not conforming to size, length, and Material specifications.

.3 The Contractor shall report any nonconformances immediately upon identifying them, and repair or correct them to the satisfaction of The City at no cost to The City.

.4 If removal of nonconforming materials is required, the Contractor shall remove the amount of Work performed since the last successful test or installation check, unless otherwise approved by The City in writing.

2 PRODUCTS

2.1 Materials

.1 Concrete:

.1 Concrete shall meet the minimum requirement of Mix Type B-1, as specified in Section 03300, Cast-In-Place Concrete.

.2 Concrete Materials shall conform to the requirements of Section 03300, Cast-In-Place Concrete.

.3 Cold weather concrete shall conform to CSA A23.1.

.2 Concrete for drilled concrete piles shall meet the minimum requirements of Mix Type C, as specified in Section 03300, Cast-In-Place Concrete.

.3 Cement for pile concrete shall be consistent with geotechnical report recommendations.

.4 Reinforcing steel shall conform to the requirements of Section 03200, Concrete Reinforcement.

.5 Masonry units shall conform to the CSA A165 series.

.6 Silane sealer shall conform to the latest Alberta Transportation Product List for Concrete Sealers – Type 2a.

.7 Pigmented sealer shall conform to the latest Alberta Transportation Product List for Concrete Sealers – Type 3. Colour shall be as specified in the Agreement and approved by The City.

.8 All internal hardware and miscellaneous Materials shall conform to the requirements of CSA A23.1.

.9 Lifting hooks and devices for precast elements shall conform to the requirements of CSA A23.4, Clause 15.5.

.10 Wood noise barriers shall not be used.

.11 Wooden or brick shims shall not be used.

2.2 Acceptable Noise Barrier Systems

.1 Acceptable noise barrier systems include the following:

.1 CCI AB Fence: Site-specific design per June 1, 2024, Letter of Approval

.2 StoneTree Concrete Fence Walls: Site-specific design per May 1, 2024, Letter of Approval.

.3 Stonecrete Noise Wall System: Site-specific design per June 1, 2024, Letter of Approval

.4 Concrete Cedar Fence System (DDS Consulting): Site-specific design per June 1, 2024, Letter of Approval

.5 Verti-crete Noise Wall System: Site-specific design per June 1, 2024, Letter of Approval

.6 Lafarge Precast Noise Wall System: Site-specific design per June 1, 2024 Letter of Approval

.7 DDS Precast Noise Wall System: Site-specific design per June 1, 2024, Letter of Approval

.8 Atlantic Industries Limited Tuf Barrier Noise Wall System: Site-specific design per June 1, 2024, Letter of Approval

.9 Atlantic Industries Limited Silent Protector Barrier Noise Wall System: Site-specific design per June 1, 2024, Letter of Approval

.2 An alternative to these systems may be accepted subject to the satisfactory submission of the product information, and review and acceptance of the system by The City, Public Spaces Delivery, Bridge Engineering section.

.3 Additional testing may be required to confirm performance of alternative systems, the costs of which shall be borne by the Contractor.

2.3 Durability Requirements

.1 Noise barriers shall have a uniform appearance, and be free of laitance, efflorescence, and staining.

.2 Concrete masonry units shall have maximum absorption rate of 5%, per ASTM C140.

.3 The required concrete cover to reinforcement shall be within the limits and tolerances specified on the Drawings, and shall conform to CAN/CSA S6, and The City of Calgary Design Guidelines for Bridges and Transportation Structures.

3 EXECUTION

3.1 Mock-up

.1 A mock-up of a full noise barrier section, consisting of two complete panels including finishing, shall be prepared for The City and EOR’s review and acceptance.

.2 Full production of Materials shall not commence until approval of the section, in respect to finishes, colour, dimensions, tolerances, and workmanship, has been given.

.3 The approved section shall form the standard of acceptance for the remainder of the Project and will be permitted to form a part of the permanent Work.

3.2 Aesthetic Requirements

.1 The aesthetic pattern shall be a stacked stone appearance, unless otherwise specified in the Agreement. Other aesthetic requirements for the noise barriers, such as finish, texture, colour, and special features, shall be as specified in the Agreement, and are subject to approval by The City.

.2 The exposed surface of the noise barrier shall be uniform, and free of staining, discoloration, or other aesthetic defects.

3.3 Survey

.1 Unless specified in the Agreement, The City will provide the survey layout for the horizontal alignment of the noise barrier only.

.2 The Contractor is responsible to provide survey for individual piles, and other survey as may be required to complete the Work. The Contractor shall complete a post-installation survey for all piles and submit the information to the City at construction completion.

3.4 Delivery, Handling, and Storage

.1 Delivery, handling, and storage shall be in accordance with CSA A23.4.

.2 All Materials shall be protected from weather and damage while in transit or at the construction site.

3.5 Erection

.1 Erection shall be in accordance with CSA A23.4.

.2 Precast members shall not be handled for shipment until 75% of the design strength is achieved. Proof of strength shall be a compressive strength of a cube (core) on a field-cured plank at the Contractor's expense.

.3 Damage during Installation:

- .1 The Contractor shall install the noise barrier and component pieces to avoid damage.
- .2 In the event that any portion of the noise barrier or component pieces is broken, damaged, or defaced, the Contractor shall replace the broken, damaged, or defaced elements as directed by The City at no additional cost to The City, including any costs associated with removing or dismantling the noise barrier and component pieces, and reconstructing or reinstalling the noise barrier and component pieces.

.4 The Contractor shall install the noise barrier and component pieces to avoid any visible gaps or movement (that is, rocking) between the panels, between the panels and the posts, and between the panels and the finished grade.

- .1 Gaps Smaller than 15 mm:
  - .1 For gaps smaller than 15 mm in the finished wall, the Contractor shall provide a repair procedure for The City's review and acceptance.

.2 The repair procedure shall address both the function and the aesthetic aspects of the finished wall, and the remedial work shall be at no additional cost to The City.

.2 Gaps Greater than 15 mm:

.1 For gaps that are 15 mm or greater in the finished wall, the Contractor shall remove or dismantle the noise barrier and component pieces and reconstruct or reinstall the noise barrier and component pieces as directed by The City to eliminate the visible gaps to the satisfaction of The City.

.2 This remedial work shall be performed at no additional cost to The City.

.5 The installed top-of-wall profile of the noise barrier shall meet or exceed the required elevation of the design top-of-wall profile. No additional payment will be made for exceeding the required elevation of the design top of wall.

.6 Methods of concrete construction shall conform to CSA A23.1, and the MSJC TMS 402/602 Specification (Table A and Table B).

Table A – Summary of MSJC Cold-Weather Masonry Protection Requirements

Temperature[a]	Special Requirements
-4 to 5°C	• Protect wall surface with plastic sheet for 24 hours after construction.
-7 to -4°C	• Protect wall surface with insulating blanket for 24 hours after construction. • Extend insulation period to 48 hours after construction for grouted masonry.
-7°C and below	• Maintain newly constructed masonry above 0°C for at least 24 hours after construction using an acceptable heat source. • Extend heating period to 48 hours after construction for grouted masonry.

Notes:

[a] Minimum daily temperature for grouted masonry or average daily temperature for ungrouted masonry. Average daily temperature is the average of the daily high and low temperatures: (high + low)/2.

Table B – Summary of MSJC Cold-Weather Masonry Construction Requirements

Ambient Temperature[a]	Special Requirements
0 to 5°C	• Do not lay masonry units having a temperature below -7°C or with frozen moisture, ice, or snow on their surface. • Remove visible ice and snow from foundations and masonry by heating to melt the ice. • Do not heat water or sand above 60°C. • Provide mortar between 5 and 49°C by heating sand or mixing water.
-4 to 0°C	Everything in the first row, plus: • Keep mortar temperature above freezing until it is placed. • Heat aggregate and water to provide grout between 21 and 49°C. Keep grout above 21°C until it's placed. • Heat AAC units to 5°C before using thin-bed mortar.
-7 to -4°C	Everything in the first two rows, plus: • Heat masonry surfaces under construction to 5°C. • Provide wind break when wind speed is above 24 km/h. • Heat masonry to a minimum of 5°C prior to grouting.
-7°C and below	Everything in the first three rows, plus: • Provide heated enclosure at grouting locations. • Keep exterior wall surfaces above freezing.

Notes:

[a] Minimum daily temperature for grouted masonry or average daily temperature for ungrouted masonry. Average daily temperature is the average of the daily high and low temperatures: (high + low)/2.

°C = degree(s) Celsius

AAC = autoclaved aerated concrete

km/h = kilometre(s) per hour

.7 The Contractor shall install the noise barrier and the landscaping so that the piles and pile caps are not exposed above the final grade, and no gap or void exists between the bottom of the noise barrier and the finished ground.

.8 The Contractor shall install the noise barrier to maintain the existing drainage, or provide new effective drainage patterns, to the satisfaction of The City.

.9 The Contractor shall be responsible for removing any hazards created by the construction, including:

  .1 Covering all excavated pile shafts, footing trenches, and other objects that may pose a hazard.

  .2 Clearly marking and capping dowels, and any projecting or sharp elements.

  .3 Protecting concrete units from damage or adverse impacts.

  .4 Cleaning and restoring the site as specified in the Agreement.

4 MEASUREMENT AND PAYMENT

4.1 Measurement

.1 The quantity measured for payment of this Section shall be on a unit price basis per square metre (m^2), in accordance with the Agreement

.2 The quantity will be measured in m^2 of face area of wall from finished ground to the design top of wall profile, measured to the nearest 0.1 m^2.

.3 Areas extending above the design top of wall profile or below finished ground will not be measured for payment, and are considered incidental to the Work.

4.2 Payment

.1 Payment for the Work of this section shall be in accordance with the Agreement for the applicable noise barrier type specified, and associated works which shall be fully compensated and are considered incidental to the Work including but not limited to the following:

- .1 All labour, equipment, and Material necessary to complete the Work, including survey of the individual piles and other elements
- .2 Supply of engineering design
- .3 QA/QC
- .4 Construction of the walls, posts, post caps, and post foundations
- .5 Connection of noise barriers to adjoining fences, including repair to any fencing that is damaged or disturbed as a result of noise barrier installation

END OF SECTION

1 GENERAL

1.1 Work Included

.1 This section covers the supply, fabrication, storage, handling, and placement of uncoated, hot-dip galvanized, stainless, and epoxy-coated reinforcing steel, for cast-in-place (CIP) or precast concrete, including all tie wire, support chairs, bolsters, bar supports, and spacers and other incidentals required to complete the Work.

.2 Reinforcing bars shall be supplied and installed in the lengths and shapes indicated on the Drawings or as stipulated in the reference standards, upon approval of The City's Engineer.

.3 Use of epoxy-coated reinforcing is not acceptable unless approved, and requires approval on a Project-specific basis.

1.2 Related Work Specified in Other Sections

.1	Cast-in-Place Concrete	Section 03300
.2	High-Performance Concrete	Section 03301
.3	Precast Concrete Supply, Fabrication, and Installation	Section 03302
.4	Drilled Concrete Piles	Section 02466
.5	Other Technical Specifications relevant to the Work	

1.3 Reference Standards

.1 Perform the Work of this section in accordance with the latest edition of the following standards available at the Effective Date, except where specified otherwise. Provide one copy onsite of CSA A23.1, CSA A23.2, and CAN/CSA S6 in either in hard copy or digital format.

.2 Alberta Transportation:

- .1 Standard Specifications for Bridge Construction

.3 American Galvanizers Association:

- .1 Quality Assurance Manual

.4 ASTM International (ASTM):

- .1 ASTM A143, Standard Practice for Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement
- .2 ASTM A262, Standard Practices for Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steels
- .3 ASTM A276, Standard Specification for Stainless Steel Bars and Shapes
- .4 ASTM A497, Standard Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete

.5 ASTM A767/A767M, Standard Specification for Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement

.6 ASTM A775/A775M, Standard Specification for Epoxy-Coated Steel Reinforcing Bars

.7 ASTM A780/A780M, Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings

.8 ASTM A955, Standard Specification for Deformed and Plain Stainless Steel Bars for Concrete Reinforcement

.9 ASTM A1064/A1064M, Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete

.10 ASTM A1084, Standard Test Method for Detecting Detrimental Phases in Lean Duplex Austenitic/Ferritic Stainless Steels

.11 ASTM D3963/D3963M, Standard Specification for Fabrication and Jobsite Handling of Epoxy- Coated Steel Reinforcing Bars

.5 CSA Group (CSA):

.1 CAN/CSA S6, Canadian Highway Bridge Design Code

.2 CSA A23.1 Concrete materials and methods of concrete construction/

.3 CSA A23.2, Test methods and standard practices for concrete

.4 CSA A23.3, Design of concrete structures

.5 CSA G30.18M, Billet-Steel Bars for Concrete Reinforcement

.6 CSA G40.20/G40.21, General Requirements for Rolled or Welded Structural Quality Steel/Structural Quality Steel

.6 International Organization for Standardization and International Electrotechnical Commission (ISO/IEC):

.1 ISO/IEC 17025, General requirements for the competence of testing and calibration laboratories

.7 Reinforcing Steel Institute of Canada (RSIC):

.1 Reinforcing Steel Manual of Standard Practice

1.4 Definitions

.1 All defined words or phrases shall have meaning given the City of Calgary Standard General Conditions and the Agreement, unless noted otherwise.

1.5 Submittals

.1 Shop Drawings shall be submitted by the Contractor to The City's Engineer for review at least 20 Business Days prior to the scheduled start of fabrication. Shop Drawings shall be submitted sufficiently in advance of the start of the affected Work to allow time for review by The City's Engineer and correction by the Contractor without delaying the Work.

.2 The Contractor shall submit Shop Drawings for review by The City's Engineer in accordance with the Agreement. The Shop Drawings shall be legible and of adequate quality to be reproduced and scanned. Review of Shop Drawings by The City's Engineer shall not relieve the Contractor from the responsibility for errors and omissions. The Contractor remains responsible for the Work per its obligations under the Agreement.

.3 Fabrication and construction shall only be allowed with Materials having mill certificates properly correlated to the Materials used on the Project and that have been reviewed and accepted by The City's Engineer. Mill test reports shall be submitted for review at least 20 Business Days prior to the scheduled start of fabrication. Test reports for all Materials shall be written in English.

.4 The Contractor shall submit an original Certificate of Compliance from the galvanizing applicator, confirming that the hot-dip galvanizing process and the amount and quality of coating meet or exceed the requirements specified in the Agreement.

.5 The Contractor shall submit proof that the applicator of the epoxy coating is certified by the manufacturer and that the application is certified under the Concrete Reinforcing Steel Institute (CRSI) Voluntary Certification Program for Fusion-Bonded Epoxy Coating Applicator Plants.

.6 The Contractor shall have all steel, including couplers, originating outside of Canada or the United States (U.S.) verified by a certified laboratory in Canada, as follows:

  .1 This laboratory shall be certified by an organization accredited by the Standards Council of Canada to comply with the requirements of ISO/IEC 17025 for the specific tests, or type of tests, required by the Material standard specified on the mill test report.

  .2 The Material shall be tested to the specified Material standards, including a determination of boron content, which is not permitted to exceed 0.0008%.

  .3 Preparation and collection of samples for testing shall be directed and witnessed by, or completed by, personnel employed by the testing lab.

.7 A verification letter, signed and sealed by an Engineer in the field of metallurgy and bearing the signature of an authorized officer of the testing laboratory, shall be provided by the laboratory and shall include references to the following:

  .1 Appropriate mill test report(s)

  .2 Material specification number(s)

  .3 Testing standards

  .4 Date of testing

  .5 Statements indicating Material compliance with the requirements of the Agreement.

1.6 Quality Control, Quality Assurance, Inspection and Testing

.1 Quality Control

.1 The Contractor shall be wholly responsible for the quality of Materials and products provided for incorporation in the Work and for the quality of the Work.

.2 The Contractor shall provide a Quality Management Plan (QMP) to The City's Engineer for review at the beginning the of the Project.

.3 The Contractor shall perform inspections and testing necessary to verify that the Work conforms to the requirements of the Agreement, and shall provide copies of such test reports for The City's Engineer's review before proceeding with construction. The standard tests include:

.1 Mill test reports of reinforcement supplied, indicating physical and chemical analysis

.2 Test results (elongation, strength)

.3 Reports from fabrication and galvanizing of reinforcing steel

.4 Test results for bar support chairs, bolsters, and spacers

.4 Work shall conform to the standards, as referenced in the Agreement and in the Technical Specifications. All nonconforming work shall be replaced and repaired at the Contractor's expense at the discretion of The City's Engineer.

.2 Quality Assurance

.1 The City will undertake, through an independent CSA-certified testing firm, random sampling, inspection, and testing to determine compliance with the Technical Specifications and the Agreement.

.2 The Contractor shall provide access to all portions of the Work, storage, or loading areas, and manufacturing and fabrication plants, and cooperate with The City's representatives.

.3 The Contractor shall allow ample time for notification, inspection, and corrective action, if required, and obtain The City's Engineer's approval before scheduling concrete placement.

.4 Concrete reinforcement shall be inspected in place. The Contractor shall notify The City's Engineer when reinforcing installation is complete and before forms are closed, a minimum of 24 hours in advance of any concrete placement.

.5 If, in the opinion of The City's Engineer, any reinforcing steel provided for the Work exhibits flaws in manufacturing, galvanizing, or epoxy coating, or if The City's Engineer determines field contamination of stainless steel, such Material shall be immediately removed from the site and replaced with acceptable reinforcing steel at the Contractor's expense.

.6 In case of ambiguity about whether the Work conforms to the applicable standards and the Agreement, The City's Engineer reserves the right to have such Work tested or re-inspected to ascertain conformance. The cost of such testing shall be borne by The City in the event of conformance and by the Contractor in the event of nonconformance. Any nonconforming Work shall be rejected at The City's Engineer's discretion, and replaced and repaired at the Contractor's own expense.

2 PRODUCTS

2.1 Materials

.1 Reinforcing steel shall conform to CSA G30.18:

.1 Grade 400W shall be used for plain, galvanized, and epoxy-coated reinforcement.

.2 Metals shall be free from defects impairing strength, durability, and appearance of the best commercial quality for the purpose specified.

.3 All Materials shall be new.

.4 All Materials shall have a total maximum boron content of 0.0008%.

.5 All exposed fastenings shall be of the same Material, colour, and finish as the metal to which applied, unless otherwise noted.

.2 Galvanized reinforcing shall also conform to ASTM A767M. Coating shall conform to Class II (610 grams per square metre [g/m^2]). Supplementary requirement S1 shall apply.

.3 Chromating of galvanized coating may be omitted.

.4 Stainless steel reinforcement shall conform to ASTM A276 and ASTM A955M, including annexes, with a minimum Grade 420.

.5 Stainless steel reinforcement:

.1 Stainless steel reinforcement shall be one of the designations defined by the Unified Numbering System (UNS) that is on the approved product list of Alberta Transportation's latest edition of Standard Specifications for Bridge Construction, Section 5 Reinforcing Steel.

.2 Proof of compliance with relevant test standards, such as ASTM A262, Practice E for Austenitic grades; and ASTM A1084, Method C for Duplex grades, shall be supplied for the appropriate steel type.

.3 Only one type of stainless steel shall be used throughout the Project.

.6 Epoxy-coated reinforcing shall conform to ASTM A775/A775M. Coating shall be Scotchkote 213, fusion-bonded epoxy coating, with a thickness of 300 + 85 micrometres (µm), as manufactured by the 3M Company or approved equivalent.

.7 Wire mesh, if specified, shall be supplied in flat sheets only and shall conform to ASTM A1064 and ASTM A497M.

2.2 Accessory Materials

.1 Tie Wire:

.1 Shall be a minimum 1.6-millimetre (mm) annealed type or a patented system approved by The City's Engineer.

.2 Plastic-coated tie wires shall be used for galvanized, stainless steel, or epoxy-coated reinforcing.

.3 Stainless steel tie wires are acceptable to be used for stainless steel and uncoated reinforcement.

.2 Chairs, Bolsters, Bar Supports, and Spacers:

.1 Shall be adequately sized for strength and support of reinforcing steel during construction.

.2 Metal chairs shall be galvanized for galvanized reinforcing and shall conform to CSA G40.20/G40.21.

.3 Chairs and spacers for stainless steel reinforcing shall be of stainless steel material in conformance with ASTM A276.

.4 Precast concrete or plastic supports shall be used for all exposed faces.

.5 Where adjacent to exposed concrete surfaces and for epoxy-coated reinforcement, supports shall be plastic. Masonry bricks, pebbles, metal, or wood pieces are not acceptable.

.3 Precast Mortar and Concrete Blocks:

.1 Shall be acceptable for support of the bottom layer of bars in slabs on-grade

.2 Shall have compressive strength higher than the required compressive strength of the concrete structure designed.

2.3 Storage and Handling

.1 Ship all bars in bundles appropriately tagged and identified with the lot number, manufacturer, steel type, grade, bar mark, and designation.

.2 Deliver, handle, and store concrete reinforcement to prevent damage, contamination with dirt or other materials, and distortion.

.3 Use padded bundling bands and multiple supports to prevent bar abrasion or contamination for galvanized, stainless steel, and epoxy-coated bars.

.4 Cover and protect reinforcing steel at all times during transportation and storage.

.5 Store reinforcing steel of differing material types separately on platforms, skids, or other suitable means to keep the Material off the ground surface.

.6 Store epoxy-coated bars away from long-term, direct sunlight. Cover as required.

.7 Verify the surface finish is continuous, adherent, as smooth and evenly distributed as possible, and free from defects detrimental to the stated end-use of the reinforcement and coated article.

.8 Verify coating adhesion can withstand normal handling consistent with the nature and normal use of reinforcing bars.

.9 Prevent bar-to-bar abrasion and excessive sagging of bundles by using spreaders and non-metallic slings.

3 EXECUTION

3.1 Fabrication

.1 Fabricate reinforcing steel in accordance with latest edition of CSA S6, CSA A23.1, and the Drawings.

.2 The galvanized coating applicator shall follow the procedures contained in the Quality Assurance Manual of the American Galvanizers Association. Safeguard against hydrogen embrittlement in conformance with ASTM A143.

.3 The applicator for epoxy-coating of reinforcing steel shall be certified under the CRSI Voluntary Certification Program for Fusion-Bonded Epoxy Coating Applicator Plants.

.4 Locate reinforcing splices not indicated on the Drawings at points of minimum stress. Obtain The City’s Engineer's written approval for lap splice locations. Unless otherwise noted, provide tension lap splices, Class B, in accordance with CSA S6.

.5 All bars shall be cold bent at a fabricator’s shop. Minimum fabrication temperature to conform to CSA A23.1. Heating of bars to facilitate bending will not be permitted.

.6 Cut bars by shearing or with fluid-cooled saws. Torch cutting of bars shall not be permitted.

.7 Fabricate stainless steel reinforcing bars so that their surfaces do not get contaminated with non-stainless steel ferrous deposits, dirt, or oil, and are not damaged by straightening or bending.

.8 Pins around which galvanized and epoxy-coated reinforcing bars are bent shall have a minimum diameter as follows:

  .1 For 10M to 30M inclusive, 8 bar diameters

  .2 For 35M or greater, 10 bar diameters

.9 Fabricate to the Drawings and to site-confirmed dimensions within the tolerances specified in the RSIC Reinforcing Steel Manual of Standard Practice unless otherwise specified.

.10 Reinforcing steel that is to be hot-dip galvanized shall be galvanized after fabrication.

.11 Welding of reinforcing steel is not permitted without written approval of The City’s Engineer.

.12 Repair of Galvanized Coatings:

.1 Repair all surfaces of sheared ends of bars, as well as cracking and other visible damage or deterioration of the hot-dip galvanizing as a result of handling or installation operations, or any other causes, with ZINGA or an approved equal formulation, in accordance with ASTM A780M.

.2 All field-applied galvanized coatings shall be applied in accordance with the manufacturer's recommendations and as directed by The City’s Engineer.

.3 Repairs to the reinforcing bars shall be done prior to placing the bars in forms.

.13 Coat all epoxy-coated reinforcing bars in the fabrication process with a primer or conversion coating to improve adhesion to epoxy.

.14 Inspect epoxy coating visually for continuity after cure; and verify coating is free from holes, voids, contaminants, cracks, and damaged areas.

.15 Coat all sheared ends, mechanical splices, welded splices, and damaged areas of epoxy coated bars as a result of handling or installation operations, or any other causes, with an approved repair material. Do not carry out repairs when the surroundings are less than 5 degrees Celsius (°C) or when moisture is present on the bar.

.16 Allow for additional quantity of regular, stainless steel, galvanized, and epoxy-coated reinforcing as determined in the Agreement.

3.2 Installation

.1 Place reinforcing steel in accordance with CSA A23.1. Conform to ASTM A767/A767M - Standard Specification for Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement Appendix X1 for installation and inspection of galvanized reinforcing.

.2 Verify that reinforcing steel is free from loose rust, scale, dirt, oil, paint, or other deleterious material.

.3 Adequately support reinforcing and secure against displacement within the tolerances permitted.

.4 Tie bars at all intersections except when the bar spacing is less than 250 mm in each direction; alternate intersections may be tied at these locations.

.5 Splicing of bars, unless shown on plans, shall not be allowed, unless approved by The City’s Engineer in writing. For lapped splices, place the bars in contact and wire them together in such a manner as to maintain a clearance of not less than the required minimum clear distance to other bars, and the required distance to the concrete surface.

.6 Separate contact points between galvanized reinforcing steel to stainless steel or black reinforcing steel by a nonconductive material, such as rubberized pads, rubber hose rings, or polyethylene tape.

.7 Maintain distances from forms by means of spacers, chairs, or stays. Metal chairs shall not be used to support reinforcement on surfaces that are to be exposed or are to be finished; where possible, this reinforcement shall be supported entirely from above. Obtain approval of The City's Engineer for use of spacers at exposed concrete surfaces.

.8 Preferably, spacers for separating layers of reinforcing shall be precast concrete blocks.

.9 Cut back any metal chairs protruding through the surface of hardened concrete, where approved, at least 25 mm and the holes filled in accordance with Section 03300, Cast-in-Place Concrete or Section 03301, High-Performance Concrete, as applicable, included in the Agreement.

.10 Provide concrete cover to steel reinforcement of thickness indicated on the Drawings.

.11 Do not damage epoxy reinforcing steel by dropping, dragging, skidding, or supporting on abrasive materials. The Contractor shall inspect epoxy-coated reinforcement before and after placing.

.12 Obtain written approval from The City's Engineer prior to cutting of reinforcing to accommodate openings or embedded items. Allow for additional splice material that may be required to reinforce these cut bars as directed by The City's Engineer.

.13 Use plastic-sleeved concrete vibrators while placing concrete around epoxy-coated reinforcing.

3.3 Cleaning and Repair

.1 Verify all loose scale, loose rust, and other deleterious matter from surfaces of reinforcing is removed in a manner acceptable to The City's Engineer.

.2 Clean, repair, or replace stainless steel reinforcing bars with any of the following defects at the Contractor's expense:

- .1 Any single area of iron contamination greater than 100 mm
- .2 More than 10 discrete points of iron contamination on bar deformations within any 1000 mm of bar length
- .3 More than 20 discrete points of iron contamination on bar deformations
- .4 More than 5 discrete points of iron contamination that are not located on bar deformations

A discrete point is defined as an area of contamination less than or equal to 5 square millimetres (mm^2). If any area of contamination is larger than 5 mm^2, the area shall be divided by 5 to determine the number of discrete points.

4 MEASUREMENT AND PAYMENT

4.1 Measurement

.1 The quantity of reinforcing steel measured for payment shall be the mass of reinforcing steel acceptably supplied and placed, measured to the nearest kilogram (kg).

.2 The quantity to be paid for shall be based on the total computed mass for the size and length of bars as shown on the Drawings or reviewed and accepted by The City's Engineer.

.3 The mass for all reinforcing steel shall be calculated per Table A.

Table A – Reinforcing Steel Mass

Metric Bar Designation	10M	15M	20M	25M	30M	35M	45M	55M
Mass (kg/m)	0.785	1.570	2.355	3.925	5.495	7.850	11.775	19.625

Notes:

kg/m = kilogram(s) per metre

4.2 Payment

.1 Payment for the Work of this section shall be on a unit price bid for the type of reinforcing steel specified, and shall be full compensation for the following:

.1 Supply and fabrication of reinforcing steel

.2 Delivery to the Project site

.3 Placement of reinforcing steel as shown on the Drawings

.4 All labour, equipment, tools, and incidentals necessary to complete the Work.

.2 All costs associated with the handling, storage, and protection of reinforcing steel shall be considered incidental to the Work; and no separate or additional payment shall be made.

.3 All costs associated with the supply and installation of tie wire, chairs, or other Materials used for supporting, placing, and fastening the reinforcing steel in place shall be considered incidental to the Work; and no separate or additional payment shall be made.

END OF SECTION

1 GENERAL

1.1 Work Included

.1 This section outlines cast-in-place (CIP) concrete work, including:

  .1 Concrete work, such as piles, grade beams, foundation walls, and piers, abutments

  .2 Concrete superstructure, such as decks, elevated slabs, and diaphragms

  .3 Retaining walls and coping

  .4 Concrete tunnels

  .5 Track slabs

  .6 Overhead sign structural bases

  .7 Sidewalks

  .8 Stormwater structures

.2 Companion Section 03301 outlines high-performance concrete (HPC) requirements and supersedes this section wherever noted. Where not specifically stated in Section 03301, the provisions of this section are applicable also to HPC.

.3 Install Materials specified to be supplied under other sections of these Technical Specifications and in the Agreement, including fabricated components, anchor bolts, bearing plates, sleeves, and other inserts to be built into concrete.

1.2 Related Work Specified in Other Sections

.1	Drilled Concrete Piles	Section 02466
.2	Concrete Formwork and Falsework (if provided)	Section 03100
.3	Concrete Reinforcement	Section 03200
.4	High Performance Concrete	Section 03301
.5	Precast Concrete Supply, Fabrication and Installation	Section 03302
.6	Mechanically Stabilized Earth Retaining Walls	Section 03483
.7	Grout (if provided)	Section 04000
.8	Metal Fabrications	Section 05500
.9	Other sections specific to the Project	

1.3 Reference Standards

.1 Perform the Work of this section in accordance with the latest edition of the following standards available at the Effective Date, except where specified otherwise. Provide one copy onsite of CSA A23.1, CSA A23.2, and CAN/CSA S6 in either in hard copy or digital format.

.2 Alberta Transportation (AT):

.1 AT, Approved Concrete Patching Materials for Bridges

.2 AT, Approved Product List for Bridge Concrete Sealers

.3 American Concrete Institute (ACI):

.1 ACI, Manual of Concrete Practice, where noted

.4 ASTM International (ASTM):

.1 ASTM C260, Standard Specification for Air-Entraining Admixtures for Concrete

.2 ASTM C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete

.3 ASTM C494, Standard Specification for Chemical Admixtures for Concrete

.4 ASTM C881, Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete

.5 ASTM C-1202, Standard Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration

.5 Concrete Alberta:

.1 Certification of Concrete Production Facilities Audit Checklist.

.6 CSA Group (CSA):

.1 CAN/CSA S6, Canadian Highway Bridge Design Code

.2 CSA A23.1, Concrete materials and methods of concrete construction

.3 CSA A23.2, Test methods and standard practices for concrete

.4 CSA A283, Qualification code for concrete testing laboratories

.5 CSA-A3000, Cementitious materials compendium

.6 CSA-A3001, Cementitious materials used in concrete

.7 CSA A3004-C8, Physical test methods for cementitious materials for use in concrete and masonry

.8 CSA G30.18, Carbon steel bars for concrete reinforcement

.9 CSA S269.1, Falsework and formwork

Note: When the Materials properties or performance listed in these Technical Specifications are more stringent than the minimum limits of CSA A23.1, the requirements of these Technical Specifications govern.

1.4 Definitions

.1 All defined words or phrases shall have meaning given the City of Calgary Standard General Conditions and the Agreement, unless noted otherwise.

.2 **Mass Pour** means any pour where the minimum dimension is 1.0 metre (m) or greater.

.3 **Satisfactory Control** means concrete from three consecutive loads is within the specified requirements as stated in Table A without field adjustments.

1.5 Supply Provisions

.1 All ingredients shall be selected based on the performance parameters included in the Technical Specifications.

.2 The Contractor shall design all specified concrete mixes and implement a program of testing as specified herein to demonstrate the concrete material meets specifications.

1.6 Submittals

.1 Submit the proposed mix designs, including quantities, for all concrete mix types to The City's Engineer for review 20 Business Days prior to their initial use.

  .1 The City will not accept submissions with incomplete information. Include in the mix design submission all requirements of the Technical Specifications, including mix components, quantities, and identification of sources of supply and admixtures.

.2 Submit copies of mill certificate test reports of cement, fly ash, and silica fume.

.3 Submit coarse and fine concrete aggregate test results for compliance with the requirements of CSA A23.1.

.4 Submit alkali aggregate reaction test results for the aggregate used in the concrete mixes. Test results older than 1 year shall be verified by retesting.

.5 Submit technical data sheets for all proposed pre-mixed grout.

.6 Submit data on all concrete accessories specified or proposed.

.7 Submit data on all concrete admixtures, including the compatibility of the following:

  .1 Water-reducing admixture

  .2 Superplasticizer

  .3 Air entraining agent

  .4 Cement

  .5 Fly ash

  .6 Silica fume, where used.

.8 Concrete suppliers shall submit certification of concrete production facilities in accordance with the Concrete Alberta Certification of Concrete Production Facilities Audit Checklist.

.9 Submit a pour procedure to The City's Engineer for review a minimum of 5 Business Days before the concrete is to be poured, including hot and cold weather concreting methods, in accordance with CSA A23.1.

.10 Not less than 10 Business Days prior to starting the Work, submit to The City's Engineer for review a concrete placement plan describing the method and equipment proposed for the handling, placing, finishing, curing, and protection of the concrete. In addition, the concrete placement plan shall include a description of the following:

.1 The Construction Equipment for transporting, distributing, and vibrating the concrete, and complete details for the support of such equipment.

.2 A list of key personnel who will be working on placing and finishing of the concrete, with a brief resumé of their experience.

.3 The standby plant(s) and equipment available in case of breakdown. A standby plant must be identified and approved by The City's Engineer prior to starting the Work.

.11 Review of the concrete placement plan by The City's Engineer will not relieve the Contractor of the responsibility for satisfying performance of the final product.

1.7 Quality Control, Quality Assurance, and Inspection and Testing

.1 Quality Control

.1 Submit a Quality Management Plan (QMP) to The City's Engineer for review and acceptance before any concrete work commences.

.2 Maintain responsibility of coordination of forming, placing reinforcing steel, placing other required Materials and accessories, and placing concrete.

.3 A full-time qualified superintendent representing the Contractor shall be in attendance to inspect and check all phases of the Work.

.4 Maintain responsibility for the quality of Materials and products provided for incorporation into the Work and for the quality of the Work. The burden of proof is on the Contractor for the quality of the Work.

.5 The absence of quality control (QC) documentation may result in work being deemed incomplete or Deficient and may result in corrective work, costs of which shall be borne by the Contractor.

.6 Maintain responsibility for the concrete mix designs, quality, and documentation in accordance with the Technical Specifications. The review of the mix design does not constitute acceptance of the final product.

.2 Quality Assurance

.1 The City may undertake, through an independent Canadian Council of Independent Laboratories (CCIL) certified testing firm , random sampling, inspection, and testing to determine compliance with the Technical Specifications and the Agreement. This shall in no way relieve the Contractor of their requirement to carry out QC.

.2 Mix Designs:

.1 Submit mix design(s) to The City's independent testing firm for review.

.2 The testing firm shall review the mix designs and confirm whether they are suitable for the intended purpose and are expected to perform to the specified standards.

.3 This review shall in no way relieve the Contractor of the requirement to verify product performance.

.3 Batch Plant Audit:

.1 The City's independent testing firm may perform a quality assurance (QA) audit at the batching plant during the concrete pours.

.2 Provide access to all portions of the Work, including manufacturing and fabrication plants, and cooperate with The City's representatives.

.3 The Contractor may be asked to provide casual labour to the testing firm's field personnel to obtain and handle sample Materials.

.4 Allow ample time for notification, inspection, and corrective work, if required, before scheduling concrete placement.

.5 Notify The City, The City's Engineer, and The City's independent testing firm a minimum 24 hours in advance of concrete placement.

.6 Provide a suitable testing station in a location suitable to the City's independent testing firm and convenient to the point of sampling. The testing station may be required to be moved from time to time during placement.

.7 Make space available for storage and curing of test samples, as follows:

.1 Provide properly designed, temperature-controlled storage boxes for test cylinders, as specified in CSA A23.2 3C, for a period of at least 24 hours, and further protection from adverse weather and mishandling until removed from the Project Site.

.2 Provide a maximum and minimum thermometer for each storage box.

.3 Storage facilities shall be provided, installed, checked, and approved by The City's Engineer before any concrete may be placed.

.8 In case of ambiguity whether the Work conforms to the applicable standard, The City's Engineer reserves the right to have such Work tested or re-inspected to ascertain conformance. The cost of such testing will be borne by The City in the event of conformance and by the Contractor in the event of nonconformance with the Agreement.

.9 Upon request, provide concrete batch records for the concrete used in the Work.

.3 Inspection and Testing

.1 Perform inspections and testing necessary to verify that the Work conforms to the requirements of the Agreement.

.2 Conduct QC testing onsite, including air content, slump, and compressive strength, in accordance with the Contractor's QMP and meeting the requirements of CSA A23.1, as follows:

.1 Testing shall be performed by an independent Canadian Council of Independent Laboratories (CCIL) certified testing firm.

.2 All concrete samples shall be taken from the point of discharge to the forms. If a concrete pump is used, test samples shall be taken from the discharge end.

.3 All test results shall be made available to The City's Engineer, upon request.

.4 All costs of this testing shall be borne by the Contractor.

.3 Provide copies of inspection and test reports to the Subcontractor performing the work.

.4 The Contractor's QMP shall include the frequency of tests for slump, air content, temperature, and compressive strength for each structural element. At a minimum, the following is required, unless otherwise specified:

.1 Conduct tests for slump, air content, and temperatures on a minimum of the first three concrete loads until Satisfactory Control is established.

.2 After Satisfactory Control has been established, conduct testing per the Contractor's QMP.

.3 If testing indicates that a load does not meet the requirements, resume testing on each load until Satisfactory Control is re-established.

.4 Additionally, conduct air, slump, and temperature tests whenever compressive test cylinders are cast.

.5 Produce and test enough early strength cylinders to support the Contractor's QC program and to validate concrete strengths for stripping formwork and applying loads. Costs for all QC tests shall be borne by the Contractor.

.6 For Mass Pours, verify that both the gradient temperature within the concrete and the maximum temperature in the concrete meet the requirements of CSA A23.1, Section 7.6.3, Mass concrete, and Table table20.

.7 Conduct QC testing of temperature for Mass Pours as follows:

.1 Provide a plan showing the location of thermocouples to The City's Engineer for review.

.2 Install thermocouples to monitor temperatures during Mass Pours.

.3 Take temperature readings, at a minimum:

.1 Every 4 hours for the first 12 hours

.2 Every 12 hours for the following 72 hours

.4 Provide temperature data to The City's Engineer and The City for review.

.5 Outline corrective action for concrete not within temperature requirements in the Contractor's QMP.

.8 Concrete test results shall include the following information:

.1 Name of the Project

.2 Date of sampling

.3 Mix design designation number, specified strength, and slump and air content

.4 Name of supplier, and truck and ticket number

.5 Time batched, and time placed

.6 Identification of sampling and testing technician

.7 Cement and admixture types used

.8 Exact location in the structure of the concrete sampled

.9 Ambient air and concrete temperatures

.10 Nominal aggregate size

.11 Water added, and personnel authorizing additional water

.9 Submit responses to all site review reports confirming that all reported Deficiencies were corrected or stating what action was taken.

1.8 Acceptability

.1 Failure to comply with the requirements of the Technical Specifications will result in the structure being considered potentially Deficient.

.2 To conform to the concrete strength requirements of the Technical Specifications, the results of tests performed on laboratory-cured cylinders for each class of concrete shall meet the following:

.1 The average of all tests shall exceed the specified strength.

.2 The average of any three consecutive tests shall be equal to, or greater than, the specified strength.

.3 No individual strength test shall be more than 3.5 megapascals (MPa) less than the specified strength.

.3 If any of the foregoing criteria are not met, The City's Engineer shall have the right to require one or more of the following, the costs of which shall be borne by the Contractor:

.1 Changes in the mix proportions for the remainder of the Work (changes shall be reviewed and approved by The City's Engineer).

.2 Testing of in situ concrete.

.3 Removal and replacement of all nonconforming concrete.

The Contractor shall not proceed with placing concrete for subsequent structural elements until demonstrating through testing of trial mixes that the revised mix design will produce the specified physical properties.

.4 Additional courses of action that The City's Engineer may choose to verify quality of the product include:

.1 Ordering an independent testing firm to obtain cores, x-rays, or similar non-destructive tests where evidence points to a potentially Deficient structure.

.2 Ordering a load test, analysis, or both, as defined by CSA A23.3, if the non-destructive tests are impractical or inconclusive.

.5 If, after the completion of the testing procedure, The City's Engineer is not satisfied with the indicated quality of the concrete in the structure, the Contractor may be required to strengthen or replace those portions that The City's Engineer deems to be unsatisfactory. Alternatively, the penalties described in the Technical Specifications may be assessed at the discretion of The City's Engineer.

2 PRODUCTS

2.1 General

.1 Materials shall be obtained from the same source of supply or manufacturer for the duration of the Project.

.2 All exposed concrete shall be consistent in colour.

.3 Concrete shall come from concrete production facilities that have Construction Equipment in good operating condition and with proper capability to produce quality concrete.

2.2 Cementing Materials

.1 Portland cement concrete shall be Type GU, general use cement conforming to CSA A3001.

.2 High-sulphate-resistant hydraulic cement shall be Type HS cement conforming to CSA A3001. Alternatively:

.1 Type HSb, blended high-sulphate-resistant hydraulic cement, can be used.

.2 Cementing material combinations with equivalent performance may be used upon approval by the City's Engineer.

.3 The supplier shall provide data demonstrating that Type GU cement and fly ash blend is effective in reducing concrete expansion due to sulphate attack in accordance with CSA 23.1, Clauses 4.2.1.2, 4.2.1.3, and 4.2.1.4. The maximum expansion due to sulphate attack should not be greater than 0.05% at 6 months when tested in accordance with the CSA A3004-C8 test method.

.3 The maximum alkali content of cement, expressed as sodium oxide equivalent, shall be 0.6% by mass

2.3 Supplementary Cementing Materials

.1 Silica fume shall be Type SF pozzolan conforming to CSA A3001.

.2 Fly ash shall be a Type F pozzolan conforming to CSA A3001, with the following additional requirements:

  .1 Maximum Calcium Oxide (CaO) content shall be 12%

2.4 Aggregates

.1 All aggregate tests shall be conducted by an approved, independent, third-party laboratory certified in accordance with CSA A283 to Category II.

.2 Following completion of all tests, the laboratory shall declare that the aggregate is fully acceptable for the intended use and that it will provide good long-term performance.

.3 All test results and evaluations shall bear the seal of an Engineer retained by the third-party laboratory.

.4 The analyses of the aggregates shall be current. Sampling and testing shall be done not more than 1 year prior to concrete production unless otherwise approved by The City’s Engineer. Additional analyses of more recent sampling shall be provided periodically if so directed.

.5 All costs associated with the specified aggregate tests shall be borne by the Contractor.

.6 The Contractor shall submit the current results of the aggregate tests for each source of aggregate to be used. The aggregate shall meet the requirements of CSA A23.1, Table 12 – Limits for deleterious substances and physical properties of aggregates.

.7 Testing for organic impurities per CSA A23.2-7A shall not produce results darker than standard Organic Plate Number (No.) 3 colour. Aggregates producing a colour darker than the standard colour will be rejected; provisions 4.2.3.3.2(a) and (b) of CSA A23.1 shall not apply.

.8 Fine aggregates shall be graded to limits specified in Table 10 of CSA A23.1 and shall conform to the requirements for the specified exposure class.

.9 If the fine aggregate consists of a blend from more than one source, the fine aggregate sieve analysis shall show the gradation of the blended fine aggregates. Similarly, in the case of blended coarse aggregates, the coarse aggregate sieve analysis shall indicate the gradation of the blended coarse aggregates.

.10 For all concrete mix types, the coarse aggregate shall conform to the requirements identified in CSA A23.1 for the specified exposure class. The aggregate shall meet the Group I gradation requirements listed in Table 11 of CSA A23.1.

.11 Petrographic analysis of coarse aggregate conducted in accordance with CSA A23.2-15A shall provide a maximum Petrographic Number of 125.

.12 Alkali-Aggregate Reactivity:

.1 Aggregates are not to react with alkaline in the cement to an extent that results in excessive expansion or cracking of concrete.

.2 Evaluation of the potential for alkali-aggregate reactivity and the selection of the preventative measures shall be performed in accordance with CSA A23.2-27A.

.3 In the absence of test results, the aggregate shall be considered highly reactive.

.13 The source of the aggregate and the method of manufacture or production, including the type of equipment used, shall not be altered for the duration of the Project following the acceptance of the aggregate.

.14 Nominal size of coarse aggregate shall be as specified in Table A.

2.5 Water

.1 Water for use in concrete production, surface cleaning, saturation, and curing shall be clean and free from injurious amounts of oil, acid, alkali, soluble chlorides, organic matter, sediment, or any other deleterious substances per CSA A23.1.

2.6 Admixtures

.1 All admixtures shall be of uniform consistency and quality within each container and within the delivery batches.

.2 Air-entraining admixtures shall conform to the requirements of ASTM C260.

.3 Water-reducing admixtures shall conform to the requirements of ASTM C494, Type A. Type D retarding water reducer shall be used only when approved by The City’s Engineer in writing.

.4 Superplasticizers (high-range water reducers) shall conform to the requirements of ASTM C494, Type F.

.5 Set accelerating admixtures shall not be permitted.

.6 Set retarding admixtures and hydration stabilizing admixtures shall not be permitted, unless approved by The City’s Engineer in writing.

.7 Calcium chloride or admixtures containing chloride ions shall not be used in concrete.

.8 No chemical admixtures or additives other than those specified herein shall be added to the concrete mix or applied to the surface of concrete without approval by The City’s Engineer in writing.

2.7 Concrete Accessories

.1 If approved by The City’s Engineer prior to commencement of the Work, concrete accessories (as listed herein) may be used.

.2 All concrete accessories shall be compatible with any sealers or waterproofing used.

.3 All concrete accessories left in place shall have approved corrosion protection.

.4 Liquid membrane-forming curing compound shall conform to ASTM C309. Moist cure elements whenever possible to maximize durability of concrete.

.5 Membrane curing compound shall be Sealtight 1220, white, pigmented curing compound by Meadows or approved equivalent.

.6 Monomolecular film (evaporation reducer) shall be Confilm by Master Builders Technologies, or approved equivalent. Application shall be in accordance with the manufacturer's recommendations.

.7 Silane sealer shall be a Type 1c penetrating sealer currently listed on the AT Approved Product List for Bridge Concrete Sealers.

.8 Pigmented sealer shall be a Type 3 pigmented sealer currently listed on the AT Approved Product List for Bridge Concrete Sealers. Colour shall be determined by The City's Engineer.

.9 Concrete plugs to fit cone holes formed by compatible form ties shall match the colour and texture of the surrounding concrete. Product information shall be submitted to The City's Engineer for review before use on the Project.

.10 Ducts shall be DB-2 ducts as supplied by IPEX or approved equal, complete with all required accessories, fittings, sleeves, couplers, and expansion units as required or specified.

.11 Joint sealant shall be Sikaflex 1a or approved equivalent.

.12 Cushioning foam shall be Evazote EV30 by Zotefoams Inc. or other pre-approved ethyl vinyl acetate (EVA) foam with compressive strength of 35 kilopascals (kPa) at 25% set.

2.8 Crack Repair

.1 For horizontal cracks:

  .1 Low-viscosity (100 centipoises [cps] or less) epoxy sealer

  .2 Epoxy sealer shall be Sikadur 55 SLV or Dural, 333, or approved equal.

  .3 Modified Methacrylate (MMA) or High Molecular Weight-Methacrylate (HMWMA) upon approval by The City's Engineer.

.2 For nonhorizontal cracks:

  .1 Epoxy sealer for pressure injection shall have a viscosity less than 500 cps and meet ASTM C881 Type IV, Grade 1, Class B or C.

  .2 Epoxy sealer system shall be Sikadur 35 Hi-Mod LV in combination with Sikadur 31 Hi-Mod Gel Crack Filler or Sikadur Capseal or an approved equal system.

2.9 Concrete Patching Material

.1 Horizontal concrete patching material shall be a Type NH "Normal Horizontal" material currently listed on the AT Approved Concrete Patching Materials for Bridges list.

.2 Nonhorizontal concrete patching material shall be a Type OH-V “Overhead or Vertical” material currently listed on the AT Approved Concrete Patching Materials for Bridges list.

2.10 Concrete Mixes – Design and Trial Batch Testing

.1 The Contractor, through approved suppliers, shall undertake the concrete mix designs and pay for all costs associated with the development, testing, and submissions of the mix designs and results of performance testing.

.2 Trial batches are required for all new mix designs. The results from the trial batch testing are valid for up to 2 years.

.3 All testing of the concrete shall be the responsibility of the Contractor and shall be performed by an independent Canadian Council of Independent Laboratories (CCIL) certified testing firm.

.4 The Contractor shall submit mix designs and results of performance testing to The City’s Engineer for review. Mix design documentation shall include all components of the mix and quantities of the Materials used. All testing, review, and consent to the selection of the concrete mix designs must be in place at least 20 Business Days prior to concrete placement.

.5 Failure to demonstrate the specified concrete performance will result in delays for which no claims can be made against The City.

.6 The design and QC testing of concrete mixes shall include assessment of compatibility of the Contractor’s proposed Materials, including cement and admixtures, adequate workability of the mixes, as well as the slump and air retention properties of the proposed mixtures. Test results older than 2 years shall be verified by retesting.

.7 In lieu of trial batch testing, the Contractor may submit a mix design from previous works, complete with laboratory and QA/QC field test results, for review and approval by The City’s Engineer. All performance criteria of the Technical Specifications shall apply. Test results older than 2 years shall be verified by retesting

.8 Required air content retention shall be a minimum of 70% of initially measured air content after 1 hour of mixing.

.9 One adjustment of air onsite may be allowed, provided that the adjustment is done under the supervision of qualified personnel.

.10 Concrete mixes that will be placed by pump shall be designed for pumping.

.11 Slump retention shall be 75% after 45 minutes.

.12 Slump measured immediately prior to placing or pumping of concrete shall conform to values specified in Table A and as follows:

  .1 Only one redose of superplasticizer will be allowed after batching.

.13 The Contractor shall prevent segregation of concrete. No segregated concrete shall be placed in the Work.

.14 Additional water shall not be added to the batch after initial mixing.

.15 In no case will batch adjustment relieve the Contractor of the responsibility for the concrete's durability, strength, or acceptability. The City's Engineer reserves the right to reject any batch in the case of confirmed unacceptability and to require immediate removal of any concrete from this batch from the Work.

.16 Chloride ion penetrability shall be assessed using ASTM-C1202, which shall be done on samples cast from the trial batches of concrete at the age of 28 Days and 56 Days. Acceptable levels of chloride ion penetrability for concrete for mix Type B, and C shall be less than 1500 coulombs at fifty-six (56) days.

.17 The City's Engineer reserves the right to request additional testing to measure the tendency for cracking for concrete mixes with high cementitious content (greater than 400 kilograms [kg]) or low water to cementitious ratio (less than 0.35 kg).

.18 CIP concrete mix properties shall be as shown in Table A.

Table A – Mix Properties

<table>
<tr><th>Typical Structural Element Application[a]</th><th>Mix Type</th><th>Minimum Strength (MPa)</th><th>Cement Type</th><th>Maximum w/cm[d]</th><th>Maximum Fly Ash (%)</th><th>Maximum Coarse Aggregate Size</th><th>Minimum Slump (mm)</th><th>Maximum Slump (mm)[b]</th><th>Air Content (%)</th></tr>
<tr><td>Bridge: Deck, Curbs, Median, Approach Slab Substructures[c]</td><td>HPC1</td><td rowspan="4" colspan="8">Refer to Section 03301</td></tr>
<tr><td>Retaining Walls[c] and Coping[c], Walls Above Grade[c]
Sidewalks[c], Expansion Joints, Overlays, Precast LRT Platforms, and MSE Wall</td><td>HPC2</td></tr>
<tr><td>Precast Girders</td><td>HPC3</td></tr>
<tr><td>Precast Deck Panels</td><td>HPC4</td></tr>
<tr><td>Concrete Elements Not in Splash Zone, including Retaining Walls and Coping, Substructures, Track Slab, Walls Above Grade</td><td>B-1</td><td>35</td><td>GU</td><td>0.4</td><td>25</td><td>20</td><td>60</td><td>100</td><td>5-8</td></tr>
<tr><td>Barriers, Concrete Deck with Stainless Steel Reinforcement</td><td>B-2</td><td>35</td><td>GU</td><td>0.35 to 0.38</td><td>20</td><td>20</td><td>-</td><td>180</td><td>5-8</td></tr>
<tr><td>Abutment Footings, Walls Below Grade, Piles and Pile Caps</td><td>C</td><td>35</td><td>HS or HSb</td><td>0.4</td><td>30</td><td>20</td><td>60</td><td>100</td><td>5-8</td></tr>
<tr><td>Slope Protection[c]</td><td>D</td><td>35</td><td>GU</td><td>0.4</td><td>25</td><td>20</td><td>50</td><td>80</td><td>5-8</td></tr>
<tr><td>Other Concrete</td><td>E</td><td>25</td><td>GU</td><td>0.5</td><td>30</td><td>20</td><td>50</td><td>80</td><td>4-7</td></tr>
</table>

Notes:

a. For specific application, refer to Project Drawings and Technical Specifications

b. Slump maximum after addition of superplasticizer

c. In Splash Zone

d. Maximum water to cementing material ratio

- = not applicable

% = percent

LRT = light rail transit

mm = millimetre(s)

MSE = mechanically stabilized earth

2.11 Storage and Handling of Materials

.1 Cement and fly ash shall be stored in a suitable weather-tight building that will protect these Materials from dampness. Cement and fly ash shall be free from lumps at all times during use in the Work. Cement and fly ash stored for a length of time resulting in the hardening or formation of lumps cannot be used in the Work.

.2 All aggregates shall be handled to prevent segregation and to obtain uniformity of Materials, as follows:

  .1 The separated aggregates and the aggregates secured from different sources shall be piled in separate stockpiles.

  .2 The site of the stockpiles shall be cleaned of all foreign materials and shall be reasonably level and firm.

  .3 If the aggregates are placed directly on the ground, Material shall not be removed from the stockpile within 150 mm of the ground level. This Material is to remain undisturbed to avoid contaminating the aggregate with the ground material.

2.12 Ready-Mix Concrete

.1 If through material testing it is demonstrated that the concrete provider is not able to achieve consistent quality of the concrete, The City’s Engineer may order the Contractor not to use that supplier’s concrete in the Work.

.2 The Contractor shall arrange for an acceptable concrete supply without additional compensation or extension of time.

3 EXECUTION

3.1 General

.1 Perform CIP concrete work, including fabrication, placement, finishing, and curing in accordance with requirements of CSA A23.1, and the accepted concrete placement plan, unless indicated otherwise in the Technical Specifications.

.2 Produce all concrete for a particular structure in the same batching plant.

.3 All aggregates for concrete produced for a structure shall be supplied from the same source.

.4 Selection of the equipment shall be based on site-specific requirements and constraints.

3.2 Placing Concrete

.1 Notify The City’s Engineer and The City’s independent testing firm a minimum of 24 hours prior to commencement of any concrete placement. Allow time for corrective work for areas of unusual formwork and congested reinforcement.

.2 Notify The City’s Geotechnical Engineer to inspect and verify soil conditions and bearing pressures of all foundations prior to placing concrete for mud slabs or foundations.

.3 Do not place concrete against frozen ground, frozen concrete, or frosted forms.

.4 Place concrete in accordance with CSA A23.1 and as specified herein.

.5 Place all hardware and other items to be cast into concrete securely and in a manner to prevent undue hardship in placing concrete.

.6 Do not disturb reinforcement, inserts, embedded parts, formed expansions and contraction joints, and other critical items during concrete placement.

.7 Revise, reseat, and correct improperly positioned reinforcing hardware and other embedded items immediately before concrete placement.

.8 Verify and record the temperature of the concrete during placement:

  .1 The concrete temperature during discharge shall be between 10 and 25 degrees Celsius (°C).

.9 Verify and record the temperature of the concrete throughout curing at two different locations (at centre of concrete mass and at surface) using thermocouples, as follows:

  .1 The maximum temperatures during hydration shall not exceed 70°C.

  .2 The total temperature gradients shall not exceed that specified by CSA A23.1 Table 20.

  .3 The temperature rise, or drop, shall not exceed maximum heating or cooling rate of 2°C per hour.

  .4 For larger pours, more thermocouples may be required. Submit a diagram shall showing all locations to be monitored.

.10 Employ corrective measures upon identification of noncompliance to the concrete temperature requirements per the approved QMP.

.11 Comply with hot and cold weather concrete fabrication, placement, and curing requirements per CSA A23.1, except as noted in the Technical Specifications.

.12 Immediately prior to placing concrete, thoroughly wet the forms and any previously placed concrete down with clean potable water.

.13 Maintain specified concrete cover around reinforcing.

.14 Do not place concrete older than 90 minutes from batch time.

.15 Do not add water onsite.

.16 Where concrete is placed on an inclined surface, begin the placing operation at the lower end of the slope and progress upward unless otherwise permitted by The City's Engineer.

.17 Place concrete in accordance with the lines and levels indicated on the Drawings.

.18 Place concrete in approximate horizontal layers such that each lift can be vibrated into the previous lift.

.19 Place concrete directly into its final position in forms. Do not spread concrete with vibrators.

.20 Mechanical Vibrators:

.1 Compact concrete thoroughly using mechanical vibrators.

.2 Work concrete around reinforcement, embedded items, and into all areas and corners of forms.

.3 Use rubber or plastic-tipped mechanical vibrators for concrete placements containing epoxy-coated reinforcement.

.21 Place concrete as a continuous operation, stopping only at construction joints.

.22 Allow a minimum of 3 Days between adjacent concrete placements.

.23 Maintain accurate records of concrete placement. Record date, location of placement, quantity, air temperature, and test samples taken.

.24 Do not to proceed with backfill against newly placed concrete until the concrete achieves a minimum compressive strength equal to or greater than 75% of specified 28-Day compressive strength.

3.3 Curing

.1 All concrete shall receive moist curing or use an approved curing method to prevent moisture losses.

.2 Exposure class shall be as specified. Curing period and regime shall be as defined in CSA A23.1 Tables 2 and 19.

.3 Concrete shall not be placed until all Materials required for the curing phase are onsite and ready for use.

.4 Formed surfaces shall be cured using one of the following methods, which shall be submitted to and approved by The City's Engineer:

.1 Formed surfaces may be protected by watertight formwork left in place for the curing period.

.2 Formed surfaces may be stripped after the concrete has attained sufficient strength to avoid damaging the concrete surface, but not less than 24 hours after the end of concrete placement. Apply continual moist curing to formed concrete surfaces within 2 hours of breaking forms away from the concrete surfaces. Keep concrete continuously and thoroughly wet for the curing period.

.3 Only if approved by The City's Engineer, a membrane-forming curing compound that will prevent exceeding the specified moisture loss, as per CSA A23.1, may be applied at the rate recommended by the manufacturer, as follows:

.1 Submit test results indicating moisture loss is not exceeded.

.2 Do not use curing compounds on surfaces where bond is required for additional concrete or on surfaces that are to receive sealers incompatible with the curing compound.

.3 The formwork shall be left in place for a minimum of 24 hours, and the curing compound shall be applied within 2 hours of formwork removal.

.5 Deck slabs, approach spans, and barriers shall be cured as specified in Section 03301, High Performance Concrete.

.6 If approved for use by the City's Engineer, membrane-curing compound requirements include:

.1 Apply the specified membrane-curing compound at a rate specified by the manufacturer. Apply the total rate in two passes in perpendicular directions by spray or roller method.

.2 Where membrane-curing compound is used on surfaces to receive sealers, topping, hardener, or other type of bonded finish, completely remove the membrane-curing compound by waterblast or sandblast methods.

.3 Where silane sealer is specified, provide a waterblast to break up the membrane-curing compound sufficiently to absorb the silane sealer into the concrete surface.

.7 During hot weather, the curing process shall begin immediately after finishing.

.8 During cold weather, adequate care shall be taken to prevent any heating and hoarding efforts from drying out the concrete.

3.4 Surfacing and Finishing

.1 Refer to Section 03301, High Performance Concrete, for deck finishing and curing.

.2 Clean and fill form-ties or other accessory recesses with nonshrink grout or other approved Material.

.3 Do not leave concrete forms or accessories in place unless approved.

.4 All approved accessories left in place shall have approved corrosion protection and concrete covers, as specified in CSA/CAN S6.

.5 Surface finishes are classified as follows:

.1 Class 1: Ordinary surface finish

.2 Class 2: Rubbed finish

.3 Class 3: Floated surface finish

.4 Class 4: Trowel finish

.5 Class 5: Broomed finish

.6 Apply surface finishes to concrete elements as described herein, unless otherwise specified on the Drawings.

.7 Class 1 - Ordinary surface finish shall be required for all formed surfaces, except for surfaces receiving a concrete sealer, with the following requirements:

.1 Immediately following the removal of forms, remove all fins and irregular projections from all surfaces except from those that are not to be exposed.

.2 On all surfaces, thoroughly clean the cavities produced by form ties and all other holes, honeycomb spots, broken corners or edges, and other defects.

.3 After saturating with water for a period of not less than 3 hours, carefully point and true the defects with a mortar of cement and fine aggregate mixed in the same proportions as the concrete being finished.

.4 Do not use mortar that is more than 1 hour old for pointing.

.5 Cure mortar patches as specified under Subsection 3.3, Curing.

.6 Carefully leave all construction and expansion joints in the completed Work tooled and free from mortar and concrete.

.7 Leave joint filler exposed for its full length with clean and true edges.

.8 Provide final surfaces that are true and uniform. Apply a Class 2 - Rubbed finish to all surfaces that cannot be repaired to the satisfaction of The City's Engineer.

.8 Class 2 - Rubbed finish shall be required for any surface that receive a concrete sealer, with the following requirements:

.1 After removal of forms, start rubbing the concrete as soon as conditions permit.

.2 Immediately before starting this work, keep the concrete thoroughly saturated with water for a minimum period of 3 hours.

.3 If mortar is used in pointing of defects, allow enough time to elapse for mortar to thoroughly set before wetting down.

.4 Rub surfaces to be finished with a medium-coarse carborundum stone, using a small amount of mortar on its face.

.5 Use a mortar composed of cement and fine sand mixed in the same proportions as the concrete being finished. Continue rubbing until all form marks, projections, and irregularities have been removed; all voids have been filled; and a uniform surface has been obtained. Leave the paste produced by this rubbing in place at this time.

.6 After all concrete above the surface being treated has been cast, rub the surface with a fine carborundum stone and water. Continue this rubbing until the entire surface is of a smooth texture and uniform colour.

.7 After the final rubbing is completed and the surface has dried, rub the surface with burlap to remove loose powder.

.8 Provide a final surface that is free from all unsound patches, paste powder, and objectionable marks.

.9 Class 3 - Floated surface finish shall be required for all unexposed top surfaces, with the following requirements:

.1 After the concrete has been compacted, carefully rod and strike off with a strike board to conform to the cross-section and grade shown on the Drawings.

.2 Make proper allowance for camber if required.

.3 Operating either longitudinally or transversely, move the strike board forward with a combined longitudinal and transverse motion, the manipulation being such that neither end is raised from the side forms during the process.

.4 Keep a slight excess of concrete in front of the cutting edge at all times.

.5 After striking off and consolidating, make the surface uniform by longitudinal or transverse floating, or both.

.6 After floating has been completed and the excess water removed, but while the concrete is still plastic, test the surface for trueness with a straight edge.

.7 Immediately fill any depression found with fresh mixed concrete; and strike off, consolidate, and refinish the Material.

.8 Cut down and refinish high areas.

.9 Provide a final surface that conforms to the required grade and contour such that the deviation is not greater than 6 mm under a 3-m straight edge.

.10 Class 4 - Trowel finish shall be required for all exposed top surfaces that do not receive a broomed finish, including concrete gutters, with the following requirements:

.1 After the concrete has been deposited in place, compact the concrete and strike off the surface using a strike board.

.2 Make the surface uniform, dense, and free from voids by wood trowel floating.

.3 When the concrete has hardened sufficiently, the surface shall not vary by more than 3 mm under a 3-m straight edge.

.4 After the concrete has hardened sufficiently, trowel the surface to a smooth, dense finish using a steel trowel.

.11 Class 5 - Broomed finish shall be required for all sidewalk surfaces and approach slabs, with the following requirements:

.1 After the concrete has been deposited in place, compact the concrete, and strike off the surface using a strike board.

.2 Make the surface uniform, dense, and free from voids by wood trowel floating.

.3 When the concrete has hardened sufficiently, the surface shall not vary by more than 3 mm under a 3-m straight edge.

.4 After the concrete has hardened sufficiently, give the surface a broomed finish. Stroke the broom square across the slab with adjacent strokes slightly overlapped to produce regular corrugations between 3-5 mm in depth.

.5 Lay out sidewalk surfaces in blocks with an approved grooving tool as shown on the Drawings or as directed by The City's Engineer.

.6 Use an edging tool along all edges of the sidewalks.

3.5 Defective Concrete

.1 Immediately after removing forms, inspect all concrete surfaces.

.2 Report any imperfect joints, voids, stone pockets, or other defective areas as specified to The City's Engineer at once.

.3 Repair all defects before the concrete is thoroughly dry, as follows:

  .1 Chip defective areas to a depth of not less than 25 mm with the edges perpendicular to the surface.

  .2 Wet the repair, and a space at least 150 mm wide entirely surrounding the repair, to a saturated surface dry condition to prevent absorption of water from the repair material.

  .3 Make the repair of the same Material and of the same proportions used for the concrete, except that the coarse aggregate shall be omitted and cement added to match the colour of the surrounding concrete.

  .4 Use as little mixing water as necessary to satisfy the requirements for handling and placing.

  .5 Retemper the mortar without the addition of water by allowing it to stand for a period of 1 hour; during which time, mix the mortar with a trowel to prevent setting.

  .6 Thoroughly compact the repair material into place.

  .7 Screed off excess material to leave the repair slightly higher than the surrounding surface.

  .8 Leave the repair undisturbed for a period of 1 to 2 hours to permit initial shrinkage before being finally finished.

  .9 Finish and cure the repair to match the adjoining surface and to meet the requirements noted in the Technical Specifications.

.4 Report any shapes and lines outside the tolerances specified within the Agreement, and repair or correct as directed by The City's Engineer at no cost to the City. Any concrete tolerances not specified within the Agreement shall conform to CSA A23.1.

3.6 Carbon Monoxide Equipment

.1 Do not place concrete for slabs if carbon-monoxide-producing equipment has been in operation in the temporary enclosure during the 12 hours preceding the start of concreting.

.2 Provide positive ventilation during the 12 hours preceding the start of concrete placement.

.3 Unless directly used for concrete placing, do not operate carbon-monoxide-producing equipment in the temporary enclosure during or within 24 hours after completing the finishing of any slab section.

3.7 Crack Repair

.1 Where a measured crack width in the concrete member exceeds 0.3 mm, a crack repair procedure outlining products, repair methods, and curing shall be submitted to The City's Engineer for approval before repair work proceeds.

4 MEASUREMENT AND PAYMENT

4.1 Measurement

.1 The quantity of concrete measured for payment will be based on the total computed volume within the neat lines as shown on the Drawings, measured to the nearest 0.01 cubic meters (m^3), and reviewed and accepted by The City's Engineer.

4.2 Payment

.1 Payment for the Work of this section shall be on a unit price bid for the class of concrete specified, less any applicable payment adjustments as outlined in Subsection 4.3, Payment Adjustments, and will be full compensation for falsework and formwork, batch testing, delivery, placement, curing, concrete surface finishing, testing and inspection, and all labour, Materials, Construction Equipment, tools, and incidentals necessary to complete the Work as shown on the Drawings and to the satisfaction of The City's Engineer.

.2 All costs associated with concreting in cold weather, when required, will be considered incidental to the Work, and no separate or additional payment will be made.

.3 The City reserves the right to reject concrete that does not meet the specified requirements. The City may, at its sole discretion, accept concrete that does not meet the specified requirements at a reduced price. Payment adjustment may be made in accordance with Subsection 4.3, Payment Adjustments.

4.3 Payment Adjustments

.1 Payment adjustments shall be made for nonconformance to the specified strength and durability characteristics.

.2 Pay adjustments are applied independently, resulting in multiple penalties if the concrete is Deficient in more than one consideration.

.3 The volume of concrete used to adjust the Agreement amount shall be based on whole truckloads of concrete and shall include all truckloads placed after the last compliant truckload tested up to the next compliant truckload tested.

.4 Low Compressive Strength:

  .1 When structural and durability considerations do not govern, but concrete fails to meet contractual obligations of low compressive strength, the penalty may be assessed at the discretion of The City's Engineer, in accordance with Table B.

Table B – Payment Adjustment for Low-Strength Concrete

Criteria	Deduction
3.5 to 4.5 MPa less than specified	$120.00/m^3
> 4.5 MPa less than specified	$180.00/m^3, or remove and replace

Notes:

> = greater than

.5 Low Air Content:

.1 When the air content is tested with the prescribed procedure and falls outside the specified limits, a durability penalty shall be assessed in accordance with Table C.

Table C – Payment Adjustment for Air Void Spacing Factor

Criteria	Deduction
Between 0.230 mm and 0.260 mm	50% deduction
> 0.260 mm	90 % deduction or remove and replace

Notes:

> = greater than

.6 Cracking:

.1 No payment adjustment will be made based on cracked concrete.

.2 However, the Contractor shall repair all cracks in accordance with the Technical Specifications, regardless of the nature of their cause.

END OF SECTION

1 GENERAL

1.1 Work Included

.1 This section outlines the requirements for all high-performance concrete (HPC) for use in various elements of bridge and other concrete structures.

.2 HPC specified in this section shall meet a combination of performance and uniformity requirements that are more stringent than those for normal structural concrete. Some of these performance characteristics are:

- .1 Durability (longer service life)
- .2 Dimensional stability
- .3 Ease of placement without affecting strength
- .4 Early age strength
- .5 Load carrying capacity

.3 These characteristics shall be obtained by using a specified water-cementitious material ratio (w/cm); supplementing the cementitious component with silica fume and other pozzolans; and using enhanced concrete mixing and placing procedures, as well as diligent curing procedures.

.4 Concrete performance shall be measured by conformance to the plastic concrete properties (Table A), performance characteristics (Table B), and durability properties described in Clause 1.8.

.5 HPC shall be used for structural components exposed to severe field conditions, such as temperature fluctuations, cycles of freezing and thawing, presence of de-icing chemicals, and heavy traffic loading.

.6 Typically, the elements cast with HPC shall include the following structural components:

- .1 Bridge decks supported by concrete or steel girders
- .2 Top portion of cast-in-place (CIP) superstructure
- .3 Sidewalks, traffic barriers, medians, and curbs within the bridge decks
- .4 Precast girders
- .5 Precast light rail transit (LRT) platform planks
- .6 Bridge substructure, earth-retaining structures, and exposed elements of structural foundations within the traffic splash zone

.7 Specific elements to be constructed using HPC are as indicated in the Agreement for the Project.

.8 This section incorporates requirements pertinent to concrete exposure Class C-XL, as defined in the CSA Group (CSA) Standard A23.1, and methods of concrete construction. Those elements of concrete construction not specifically addressed in this section shall conform to other sections of the Technical Specifications, Reference Standards, and the Agreement.

.9 Companion Section 03300, Cast-In-Place Concrete, outlines the requirements for CIP Concrete. Where not specifically stated in this Section, the provisions of Section 03300 are applicable also to HPC.

.10 When the Material properties or performance listed in this section are more stringent than the minimum limits of CSA A23.1, the requirements of this section govern.

1.2 Related Work Specified in Other Sections

.1	Concrete Formwork and Falsework (if provided)	Section 03100
.2	Concrete Reinforcement	Section 03200
.3	Cast-In-Place Concrete	Section 03300
.4	Precast Concrete Supply, Fabrication, and Installation	Section 03302
.5	Pre-stressed and Post-Tensioned Concrete (if provided)	
.6	Metal Fabrications	Section 05500
.7	Mechanically Stabilized Earth Retaining Walls	Section 03483
.8	Other sections specific to the Project	

1.3 Reference Standards

.1 Perform the Work of this section in accordance with the latest edition of the following standards available at the Effective Date, except where specified otherwise. Provide one copy onsite of CSA A23.1, CSA A23.2 and CAN/CSA S6 in either in hard copy or digital format.

.2 Alberta Transportation (AT):

- .1 AT, Approved Concrete Patching Materials for Bridges
- .2 AT, Approved Product List for Bridge Concrete Sealers

.3 ASTM International (ASTM):

- .1 ASTM C260/C260M REV A, Standard Specification for Air-Entraining Admixtures for Concrete
- .2 ASTM C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
- .3 ASTM C457/C457M, Standard Test Method for Microscopical Determination of Parameters of the Air-Void System in Hardened Concrete
- .4 ASTM C494, Standard Specification for Chemical Admixtures for Concrete
- .5 ASTM C666/C666M, Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing
- .6 ASTM C672/C672M, Standard Test Method for Scaling Resistance of Concrete Surfaces Exposed to Deicing Chemicals
- .7 ASTM C881, Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete

.8 ASTM C1581/C1581M REV A, Standard Test Method for Determining Age at Cracking and Induced Tensile Stress Characteristics of Mortar and Concrete under Restrained Shrinkage

.9 ASTM C1202, Standard Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration

.4 Concrete Alberta:

.1 Certification of Concrete Production Facilities Audit Checklist

.5 CSA Group (CSA):

.1 CAN/CSA-S6, Canadian Highway Bridge Design Code

.2 CSA A23.1, Concrete materials and methods of concrete construction

.3 CSA A23.2, Test methods and standard practices for concrete

.4 CSA A23.3, Design of concrete structures

.5 CSA A283, Qualification Code for Concrete Testing Laboratories

.6 CSA A3000, Cementitious materials compendium

.7 CSA A3001, Cementitious materials used in concrete

.8 CSA S269.1, Falsework and formwork

1.4 Definitions

.1 All defined words or phrases shall have meaning given the City of Calgary Standard General Conditions and the Agreement, unless noted otherwise.

.2 **Mass Pour** means any pour where the minimum dimension is 1.0 metre (m) or greater.

.3 **Satisfactory Control** means concrete from three consecutive loads are within the specified requirements as defined in Table A without field adjustments.

1.5 Supply Provisions

.1 All ingredients shall be selected based on the performance parameters included in the Technical Specification.

.2 The Contractor shall design all specified concrete mixes and implement a program of testing as specified herein to demonstrate that the long-term durability of the concrete material will be achieved.

1.6 Submittals

.1 Submit the proposed mix designs, including quantities, for all concrete mix types to The City's Engineer for review 20 Business Days prior to their initial use. The review of the mix design does not constitute acceptance of the final product, the requirements for which are included elsewhere in these Technical Specifications.

.1 The City will not accept submissions with incomplete information. Include in the mix design submission all requirements of the Technical Specifications, including mix components, quantities, identification of sources of supply, and admixtures.

.2 Submit copies of mill certificate test reports of cement, fly ash, and silica fume.

.3 Submit coarse and fine concrete aggregate test results showing compliance with the requirements of CSA A23.1.

.4 Submit alkali aggregate reaction test results for the aggregate used in the concrete mixes. Test results older than 1 year shall be verified by retesting.

.5 Submit technical data sheets for all proposed pre-mixed grout.

.6 Submit data on all concrete accessories specified or proposed.

.7 Submit data on all concrete admixtures, including the compatibility of the following:

.1 Water-reducing admixture

.2 Superplasticizer

.3 Air entraining agent

.4 Cement

.5 Fly ash

.6 Silica fume, where used

.8 Concrete suppliers shall submit certification of concrete production facilities in accordance with the Concrete Alberta Certification of Concrete Production Facilities Audit Checklist.

.9 Submit a pour procedure to The City's Engineer for review a minimum of 5 Business Days before the concrete is to be poured, including hot and cold weather concreting methods in accordance with CSA A23.1.

.10 The Contractor shall submit a detailed procedure for curing concrete including:

.1 Protection against moisture loss due to temperature and wind

.2 Equipment and Materials used

.3 Detailed schedule of concrete placement, curing, formwork removal, and temperature maintenance

.11 Not less than 10 Business Days prior to starting the Work, submit to The City's Engineer for review a concrete placement plan describing the method and equipment proposed for the handling, placing, finishing, curing, and protection of the concrete. The plan shall include a description of the following:

.1 The Construction Equipment for transporting, distributing, and vibrating the concrete and complete details for the support of such equipment.

.2 The concrete deck finishing machine and the guide rails for the support of such equipment.

.3 Work platforms and finishing bridges.

.4 A list of key personnel who will be working on placing and finishing of the concrete, with a brief resumé of their experience.

.5 The standby plant(s) and equipment available in case of breakdown. A standby plant must be identified and approved by The City's Engineer prior to starting the Work.

.12 Review of the concrete placement plan by The City's Engineer shall not relieve the Contractor of the responsibility for satisfactory performance of the final product.

1.7 Quality Control, Quality Assurance, and Inspection and Testing

.1 Quality Control

.1 Submit a Quality Management Plan (QMP) to The City's Engineer for review and acceptance before any concrete work commences.

.2 Maintain responsibility for coordination of forming, placing reinforcing steel, placing other required Materials and accessories, and placing concrete.

.3 A full-time qualified superintendent representing the Contractor shall be in attendance to inspect and check all phases of the Work.

.4 Maintain responsibility for the quality of Materials and products provided for incorporation in the Work and for the quality of the Work. The burden of proof is on the Contractor for the quality of the Work.

.5 The absence of quality control (QC) documentation may result in Work being deemed incomplete or Deficient and may result in corrective work, costs of which shall be borne by the Contractor.

.6 Maintain responsibility for the concrete mix designs, quality, and documentation in accordance with the Technical Specifications. The review of the mix design does not constitute acceptance of the final product.

.2 Quality Assurance

.1 The City may undertake, through an independent Canadian Council of Independent Laboratories (CCIL)-certified testing firm, random sampling, inspection, and testing to determine compliance with the Technical Specifications and the Agreement. This shall in no way relieve the Contractor of their requirement to carry out QC.

.2 Mix Designs:

.1 Submit mix design(s) to The City's independent testing firm for review.

.2 The testing firm shall review the mix designs and confirm whether they are suitable for the intended purpose and are expected to perform to the specified standards.

.3 This review shall in no way relieve the Contractor of their requirement to assure product performance.

.3 Batching Plant Audit:

.1 The City's independent testing firm may perform a quality assurance (QA) audit at the batching plant during concrete pours.

.2 Provide access to all portions of the Work, including manufacturing and fabrication plants, and cooperate with The City's representatives.

.3 The Contractor may be asked to provide casual labour to the testing firm's field personnel to obtain and handle sample Materials.

.4 Allow ample time for notification, inspection, and corrective work, if required, before scheduling concrete placement.

.5 Notify The City, The City's Engineer, and The City's independent testing firm a minimum of 24 hours in advance of concrete placement.

.6 Provide a suitable testing station in a location suitable to The City's independent testing firm and convenient to the point of sampling. The testing station may be required to be moved from time to time during placement.

.7 Make space available for storage and curing of test samples, as follows:

.1 Provide properly designed, temperature-controlled storage boxes for test cylinders, as specified in CSA A23.2-3C, for a period of at least 24 hours and further protection from adverse weather and mishandling until removed from the Project Site.

.2 Provide a maximum and minimum thermometer for each storage box.

.3 Storage facilities shall be provided, installed, checked, and approved before any concrete may be placed.

.8 In case of ambiguity whether the Work conforms to the applicable standard, The City's Engineer reserves the right to have such Work tested or re-inspected to ascertain conformance. The cost of such testing will be borne by The City in the event of conformance and by the Contractor in the event of nonconformance with the Agreement.

.9 Upon request, provide concrete batch records for the concrete used in the Work.

.3 Inspection and Testing

.1 Perform inspections and testing necessary to verify that the Work conforms to the requirements of the Agreement.

.2 Conduct QC testing onsite, including air content, slump, and compressive strength, with the frequency of testing per the Contractor's QMP and meeting the requirements of CSA A23.1, as follows:

.1 Testing shall be performed by a Canadian Council of Independent Laboratories (CCIL) certified testing firm.

.2 All concrete samples shall be taken from the point of discharge to the forms. If a concrete pump is used, test samples shall be taken from the discharge end.

.3 All test results shall be made available to The City's Engineer, upon request.

.4 All costs of this testing shall be borne by the Contractor.

.3 Provide copies of inspection and test reports to the Subcontractor performing the Work.

.4 The Contractor's QMP shall include the frequency of tests for slump, air content, temperature, and compressive strength for each structural element. At a minimum, testing frequency shall be as follows, unless otherwise specified:

.1 Conduct tests for slump, air content, and temperature on a minimum of the first three concrete loads until Satisfactory Control is established.

.2 After Satisfactory Control has been established, conduct testing per the Contractor's QMP. A minimum of one test for every 20 m^3 of concrete placed shall be conducted.

.3 If testing indicates that a load does not meet the requirements, resume testing on each load until Satisfactory Control is re-established.

.4 Additionally, conduct air, slump, and temperature tests whenever compressive test cylinders are cast.

.5 Produce and test enough early strength cylinders to support the Contractor's QC program and to validate concrete strengths for stripping formwork and applying loads. Costs for all QC tests shall be borne by the Contractor.

.6 For Mass Pours, verify that both the gradient temperature within the concrete and the maximum temperature in the concrete meet the requirements of CSA A23.1, Section 7.6.3, Mass concrete, and Table 20.

.7 For bridge decks, record the concrete temperature at two different locations per each 150 square metres (m^2) of deck surface to verify that both the gradient temperature within the concrete and the maximum temperature in the concrete meet the specifications of CSA A23.1.

.8 Conduct QC testing of temperature for Mass Pours as follows:

.1 Provide a plan showing the location of thermocouples to The City's Engineer for review.

.2 Install thermocouples to monitor temperatures during mass pours.

.3 Temperature readings shall be taken at a minimum:

.1 Every 4 hours for the first 12 hours

.2 Every 12 hours for the following 3 Days

.4 Provide temperature data to The City's Engineer and The City for review.

.5 Outline corrective action for concrete not within temperature requirements in the Contractor's QMP.

.9 Concrete test results shall include the following information:

.1 Name of the Project

.2 Date of sampling

.3 Mix design designation number, and specified strength, slump, and air content

.4 Name of supplier, and truck and ticket number

.5 Time batched, and time placed

.6 Identification of sampling and testing technician

.7 Cement type and admixtures used

.8 Exact location in the structure of the concrete sampled

.9 Ambient air and concrete temperatures

.10 Nominal aggregate size

.11 Water added, and personnel authorizing additional water

.10 Submit responses to all site review reports confirming that all reported Deficiencies were corrected, or stating what action was taken.

1.8 Durability Requirements

.1 Requirements for concrete mix proportions and plastic concrete properties are summarized in Table A.

.2 The air content shall be within the range specified for the class of HPC (Table A).

.3 Hardened concrete shall have an average air void spacing factor per lot of no more than 230 micrometres (μm), with no individual test result greater than 260 μm as determined in accordance with ASTM C457.

.1 The spacing factor may depart from these requirements if its durability factor after 300 rapid freezing and thawing cycles performed in conformance with procedure A of ASTM C666 is greater than 90%.

.2 The City's Engineer shall verify the air void system conforms to the Technical Specifications.

.4 Plastic mix air content and the air void system in the hardened concrete shall conform to the Technical Specifications regardless of the method of concrete placement.

.5 Pumped concrete shall be designed to retain required properties at the point of discharge to the forms.

.6 Rapid chloride permeability of concrete at 28 Days determined in accordance with ASTM C1202 shall conform to limits specified in Table B.

.1 The Engineer may accept results of verification tests performed on cores retrieved from the hardened concrete.

.2 Coring of in situ concrete may be done only upon The City's Engineer's written approval.

.7 The required concrete cover to reinforcement shall be within the limits and tolerances specified in the Agreement.

.8 The success and effectiveness of HPC depends not only on Material property requirements specified herein, but also on an effective QC program, and good workmanship in manufacturing, placing, and curing the concrete. The City Engineer's approval of the Contractor's procedure for concrete placement and curing procedures is required.

.9 Curing shall conform to the requirements in these Technical Specifications.

.10 Cracking of In-place Concrete:

.1 Crack widths greater than 0.3 millimetre (mm) shall be repaired. As specified in Section 3.8.

1.9 Acceptability

.1 Failure to comply with the requirements of these Technical Specifications will result in the structure being considered potentially Deficient.

.2 To conform to the concrete strength requirements of the Technical Specifications, the results of tests performed on laboratory-cured cylinders for each type of concrete shall meet the following:

.1 The average of all tests shall exceed the specified strength.

.2 The average of any three consecutive tests shall be equal to, or greater than, the specified strength.

.3 No individual strength test shall be more than 3.5 megapascals (MPa) less than the specified strength.

.3 If any of the foregoing criteria are not met, The City's Engineer shall have the right to require one or more of the following, the costs of which shall be borne by the Contractor:

.1 Changes in the mix proportions for the remainder of the Work (changes shall be reviewed and approved by The City's Engineer).

.2 Testing of in situ concrete.

.3 Removal and replacement of all nonconforming concrete. .

The Contractor shall not proceed with placing concrete for subsequent structural elements until demonstrating through testing of trial mixes that the revised mix design will produce the specified physical properties.

.4 Additional courses of action that The City's Engineer may choose to verify quality of product include:

.1 Ordering an independent testing firm to obtain cores, x-rays, or similar nondestructive tests where evidence points to a potentially Deficient structure

.2 Ordering a load test or analysis, as defined by CSA A23.3, if the nondestructive tests are impractical or inconclusive

.5 If, after the completion of the testing procedure, The City's Engineer is not satisfied with the indicated quality of the concrete in the structure, the Contractor may be required to strengthen or replace those portions The City's Engineer deems to be unsatisfactory. Alternatively, the penalties described in the Technical Specifications may be assessed at the discretion of The City's Engineer.

2 PRODUCTS

2.1 General

.1 Materials shall be obtained from the same source of supply or manufacturer for the duration of the Project.

.2 All exposed concrete shall be consistent in colour.

.3 Concrete shall come from concrete production facilities that have Construction Equipment in good operating condition and with proper capability to produce quality concrete.

2.2 Cementing Materials

.1 Cementing materials for use in HPC shall conform to CSA A3001, and shall be one of the following:

.1 Type GU, General use cement

.2 Type GU-10SF

.3 Type MH, Moderate heat of hydration cement, upon prior approval by The City, where size of the concrete elements requires restrictions relative to heat of hydration.

.2 The maximum alkali content of cement, expressed as sodium oxide equivalent, shall be 0.6% by mass.

.3 Type HS cement shall not be used in HPC

.4 Type HE High early-strength cement shall not be used in place of Type GU cement.

2.3 Supplementary Cementing Materials

.1 Silica fume shall be a Type SF pozzolan conforming to CSA A3001.

.2 Fly ash shall be a Type F pozzolan conforming to CSA A3001, with the following additional requirements:

.1 Calcium oxide content of Type CI fly ash shall not exceed 12%.

2.4 Aggregates

.1 All aggregate tests shall be conducted by an approved, independent, third-party laboratory certified in accordance with CSA A283 to Category II.

.2 Following completion of all tests, the laboratory shall declare that the aggregate is fully acceptable for the intended use and that it will provide good long-term performance.

.3 All test results and evaluations shall bear the seal of an Engineer retained by the third-party laboratory.

.4 The analyses of the aggregates shall be current. Sampling and testing shall be done not more than 1 year prior to concrete production unless otherwise approved by the Engineer. Additional analyses of more recent sampling shall be provided periodically if so directed.

.5 All costs associated with the specified aggregate tests shall be borne by the Contractor.

.6 The Contractor shall submit the current results of the aggregate tests for each source of aggregate to be used. The aggregate shall meet the requirements of CSA A23.1, Table 12 – Limits for deleterious substances and physical properties of aggregates.

.7 Testing for organic impurities per CSA A23.2-7A shall not produce results darker than standard colour (Organic Plate Number [No.] 3). Aggregates producing a colour darker than the standard colour will be rejected; provisions 4.2.3.3.2(a) and (b) of CSA A23.1 shall not apply.

.8 Fine aggregates shall be graded to limits specified in Table 10 of CSA A23.1 and shall conform to the requirements for the specified exposure class.

.9 If the fine aggregate consists of a blend from more than one source, the fine aggregate sieve analysis shall show the gradation of the blended fine aggregates. Similarly, in the case of blended coarse aggregates, the coarse aggregate sieve analysis shall indicate the gradation of the blended coarse aggregates.

.10 For all concrete mix types, the coarse aggregate shall conform to the requirements identified in CSA A23.1 for the specified exposure class. The aggregate shall meet the Group I gradation requirements listed in Table 11 of CSA A23.1.

.11 Petrographic analysis of coarse aggregate conducted in accordance with CSA A23.2-15A shall provide a maximum Petrographic Number of 125.

.12 Alkali-Aggregate Reactivity:

  .1 Aggregates shall not react with alkaline in the cement to an extent that results in excessive expansion or cracking of concrete.

  .2 Evaluation of the potential for alkali-aggregate reactivity and the selection of the preventative measures shall be performed in accordance with CSA A23.2-27A.

  .3 In the absence of test results, the aggregate shall be considered highly reactive.

.13 The source of the aggregate and the method of manufacture or production, including the type of equipment used, shall not be altered for the duration of the Project following the acceptance of the aggregate.

.14 Nominal size of coarse aggregate shall be as specified in Table A.

2.5 Water

.1 Water for use in concrete production, surface cleaning, saturation, and curing shall be clean and free from injurious amounts of oil, acid, alkali, organic matter, soluble chlorides, sediment, or any other deleterious substances per CSA A23.1.

2.6 Admixtures

.1 All admixtures shall be of uniform consistency and quality within each container and within the delivery batches.

.2 Air-entraining admixtures shall conform to the requirements of ASTM C260

.3 Water-reducing admixtures shall conform to the requirements of ASTM C494, Type A. Type D retarding water reducer shall be used only when approved by The City’s Engineer in writing.

.4 Superplasticizers (high-range water reducers) shall conform to the requirements of ASTM C494, Type F.

.5 Set retarding admixtures and hydration stabilizing admixtures shall not be permitted, unless approved by The City’s Engineer in writing.

.6 Set accelerating admixtures shall not be permitted.

.7 Calcium chloride or admixtures containing chloride ions shall not be used in concrete.

.8 No chemical admixtures or additives other than those specified herein shall be added to the concrete mix or applied to the surface of concrete unless approved by The City’s Engineer in writing.

2.7 Concrete Accessories

.1 If approved by The City’s Engineer prior to commencement of the Work, concrete accessories (as listed herein) may be used.

.2 All concrete accessories shall be compatible with any sealers or waterproofing membranes used.

.3 All concrete accessories left in place shall have approved corrosion protection.

.4 Use of curing compound in lieu of wet curing shall not be permitted, unless approved in writing by The City’s Engineer.

.5 Liquid membrane-forming curing compound shall conform to ASTM C309.

.6 Membrane curing compound shall be Sealtight 1220, Type 2 white pigmented curing compound by W.R. Meadows or approved equal.

.7 Molecular film (evaporation reducer) shall be Confilm by Master Builders, or approved equal. Application shall be in accordance with the manufacturer's recommendations.

.8 Fibres shall be synthetic fibres or approved equal in the amount specified in the proposed mix design.

.9 All steel accessories shall be corrosion-protected using methods approved by The City's Engineer. Dissimilar metals shall be separated by approved methods.

.10 Concrete plugs to fit cone holes formed by compatible form ties shall match the colour and texture of the surrounding concrete. Product information shall be submitted to The City's Engineer for review by before use on the Project.

.11 Ducts shall be DB-2 ducts as supplied by IPEX or approved equal, complete with all required accessories, fittings, sleeves, couplers, and expansion units as required or specified.

.12 Joint sealant shall be Sikaflex 1a or approved equal.

.13 Cushioning foam shall be Evazote EV30 by Zotefoams Inc. or other pre-approved ethyl vinyl acetate (EVA) foam with compressive strength of 35 kilopascals (kPa) at 25% set.

2.8 Concrete Sealers

.1 Silane sealer shall be a Type 1c penetrating sealer currently listed on the AT Approved Product List for Bridge Concrete Sealers.

.2 Pigmented sealer shall be a Type 3 pigmented sealer currently listed on the AT Approved Product List for Bridge Concrete Sealers. Colour shall be determined by The City's Engineer.

2.9 Crack Repair

.1 For horizontal cracks:

  .1 Low-viscosity (100 centipoises [cps] or less) epoxy sealer

  .2 Epoxy sealer shall be Sikadur 55 SLV or Dural, 333, or approved equal.

  .3 Modified Methacrylate (MMA) or High Molecular Weight Methacrylate (HMWMA) approved by The City's Engineer shall be used for horizontal cracks.

.2 For nonhorizontal cracks:

  .1 Epoxy sealer for pressure injection shall have a viscosity less than 500 cps and meet ASTM C881 Type IV, Grade 1, Class B or C.

  .2 Epoxy sealer system shall be Sikadur 35 Hi-Mod LV in combination with Sikadur 31 Hi-Mod Gel Crack Filler or Sikadur Capseal, or an approved equal system.

2.10 Concrete Patching Material

.1 Horizontal concrete patching material shall be a Type NH “Normal Horizontal” material currently listed on the AT Approved Concrete Patching Materials for Bridges list.

.2 Non-horizontal concrete patching material shall be a Type OH-V “Overhead or Vertical” material currently listed on the AT Approved Concrete Patching Materials for Bridges list.

2.11 Concrete Mixes – Design and Trial Batch Testing

.1 The Contractor, through approved suppliers, shall undertake the concrete mix designs and pay for all costs associated with the development, testing, and submissions of the mix designs and results of performance testing.

.2 Trial batches shall be required for all new mix designs. The results from the trial batch testing are valid for up to 2 years.

.3 All testing of the concrete shall be the responsibility of the Contractor and shall be performed by an independent, Canadian Council of Independent Laboratories (CCIL) certified testing firm.

.4 The Contractor shall submit mix designs and results of performance testing to The City’s Engineer for review. Mix design documentation shall include all components of the mix and quantities of the Materials used. All testing, review, and consent to selection of the HPC mix designs must be in place at least 20 Business Days prior to concrete placement.

.5 Failure to demonstrate the specified concrete performance shall result in delays for which no claims can be made against The City.

.6 The design and QC testing of concrete mixes shall include assessment of compatibility of the Contractor’s proposed Materials, including cement and admixtures, adequate workability of the mixes, as well as the slump and air retention properties of the proposed mixtures. Test results older than 2 year shall be verified by retesting.

.7 In lieu of trial batch testing, the Contractor may submit a mix design from previous works, complete with laboratory and QA/QC field test results, for review and approval by The City’s Engineer. All performance criteria of this Technical Specification shall apply. Test results older than 2 years shall be verified by retesting.

.8 Required air content retention shall be a minimum of 70% of initially measured air content after 1 hour of mixing.

.9 One adjustment of air onsite may be allowed, provided that the adjustment is done under the supervision of qualified personnel.

.10 Concrete mixes that will be placed by pump shall be designed for pumping.

.11 Slump retention shall be 75% after 45 minutes.

.12 Superplasticizer:

    .1 Superplasticizer shall be used in HPC.

.2 Slump measured immediately prior to placing or pumping of concrete shall conform to values specified in Table A.

.3 Only one re-dose of superplasticizer will be allowed after batching.

.4 The Contractor shall prevent segregation of concrete.

.5 No segregated concrete shall be placed in the Work.

.13 Additional water shall not be added to the batch after initial mixing.

.14 In no case will batch adjustment relieve the Contractor of the responsibility for the concrete's durability, strength, or acceptability. The City's Engineer reserves the right to reject any batch in the case of confirmed unacceptability and to require immediate removal of any concrete from this batch from the Work.

.15 Chloride ion penetrability shall be assessed using ASTM C1202, which shall be done on 28-Day-old samples cast from the concrete trial batches. Acceptable level of chloride penetrability for HPC shall be as shown in Table B.

.16 For all HPC, trial batches shall include 42-Day cracking potential tests, which shall be done on at least three trial mixes, in accordance with ASTM C1581.

.17 Salt Scaling Potential:

.1 Trial batch testing shall include tests for salt scaling potential. Salt scale testing shall be carried out as per ASTM C672 with the following modifications:

.1 Proportioning – the patching product shall be prepackaged by the supplier.

.2 Specimen – shall have a 50 mm depth and the dike is to be placed on the under or formed side of the specimen. To ensure all form oil is removed, the formed surface shall be prepared by light sandblasting, such that approximately 15 grams of material is removed. Three specimens shall be formed for testing.

.3 Mixing and Testing – machine mix and test according to the applicable provisions of CSA CAN3-A5.

.4 Curing – a period of 28 days, the first 14 days in moist storage and the last 14 days under controlled chamber at 50% RH and 23° C (±1°C).

.5 Salt Solution – the de-icing salt shall consist of sodium chloride and water, having a concentration such that each 100 ml of solution contains 3 grams of sodium chloride.

.6 Mass Loss – Prior to the final visual examination and rating and after each of the 10 cycles, remove the salt solution together with all the flaked off concrete from the surface and place into a watertight container.

This procedure is best accomplished by tilting the slab into a 500 mm diameter funnel and washing the surface of the specimen with the salt solution. The washing should continue until all loose particles are removed from the concrete. The solution shall then be strained through a filter, and the residue dried out in an oven at 105°C to a constant mass. The residue shall be cumulatively weighted after each 10 cycles. The residue shall be defined as the loss of mass and expressed in kilograms per square metre of exposed slab area. The loss of mass shall be calculated to the nearest 0.001 kg/m2.

.7 Report – measure and report cumulative weight after every 10 cycles as kg/m2.

.2 The surface mass loss during 30 cycles of freezing and thawing shall be less than 0.4 kilogram per square metre (kg/m^2) for the mix to be considered acceptable.

.18 HPC required mix properties shall be as shown in Table A. HPC specified performance characteristics shall be as shown in Table B.

Table A – Mix Properties

Mix Type	Typical Structure Element Application[a]	Supplementary Cementing Materials	Coarse Aggregate Maximum (mm)	Cement Content (kg/m)[b,c]	w/cm[d]	Air Content (%)	Maximum Slump (mm)[e]
HPC1	Bridge: Deck, Curbs, Approach Slabs, Medians, Substructures[f] Substructures[f], Foundations[f], Retaining Walls[f], Sidewalks	Silica Fume, 7.5-10%[g] Fly Ash up to 20%[h]	20	Per Mix Design	0.35-0.37	5-8	180 100[i]
HPC2	MSE Retaining Walls, Retaining Walls[f] and coping[f], Walls above Grade[f], Expansion Joints, Deck Overlays, Precast LRT Platform Panels	Silica Fume, 7.5-10%[g] Fly Ash up to 20%[h]	14	Per Mix Design	0.35-0.37	5-8	180
HPC3	Precast Girders	Silica Fume 10%	14	Per Mix Design	0.28-0.33	5-8	260
HPC4	Precast Deck Panels	Silica Fume, 7.5-10%[g] Fly Ash up to 20%[h]	14	Per Mix Design	0.35-0.37	5-8	260

Notes:

a. For specific application, refer to Drawings and Technical Specifications.

b. Type GU.

c. The amount of cement shall be provided as required to achieve the durability and strength performance specifications; however, the Contractor is made aware of the increased cracking tendency of HPC with high cement content. A lower dosage of cement within the specified range is encouraged.

d. water to cementing materials ratio.

e. After superplasticizer added at the batching plant.

f. Within splash zone.

g. By weight of cement.

h. Class F.

i. Sidewalk concrete only.

% = percent

kg/m = kilogram(s) per metre

MSE = mechanically stabilized earth

Table B – Performance Characteristics

Mix Type	28-Day Compressive Strength Minimum (MPa)	Chloride Ion Penetrability (Coulombs)	Maximum Air Void Spacing (μm)
HPC1	45	Maximum 1,000[b]	230
HPC2	45	Maximum 1,000[b]	230
HPC3	70	Maximum 1,000[b]	230
HPC4	45	Maximum 1,000[b]	230

Notes:

b Maximum limit 28 Days after casting.

2.12 Storage and Handling of Materials

.1 Cement and fly ash shall be stored in a suitable weather-tight building that will protect these Materials from dampness. Cement and fly ash shall be free from lumps at all times during use in the Work. Cement and fly ash stored for a length of time resulting in the hardening or formation of lumps cannot be used in the Work.

.2 All aggregates shall be handled to prevent segregation and to obtain uniformity of Materials, as follows:

.1 The separated aggregates and the aggregates secured from different sources shall be piled in separate stockpiles.

.2 The site of the stockpiles shall be cleaned of all foreign materials and shall be reasonably level and firm.

.3 If the aggregates are placed directly on the ground, Material shall not be removed from the stockpile within 150 mm of the ground level. This Material is to remain undisturbed to avoid contaminating the aggregate with the ground material.

2.13 Ready-Mix Concrete

.1 In case of doubt as to the consistent quality of concrete provided by the proposed supplier, The City’s Engineer may order the Contractor not to use that supplier’s concrete in the Work.

.2 The Contractor shall arrange for an acceptable concrete supply without additional compensation or extension of time.

3 EXECUTION

3.1 General

.1 Perform concrete work, including fabrication, placement, finishing, and curing, in accordance with requirements of CSA A23.1, and the accepted concrete placement plan, unless indicated otherwise in the Technical Specifications.

.2 All HPC for a particular structure shall be produced in the same batching plant.

.3 All aggregates for concrete produced for a structure shall be supplied from the same source.

.4 Selection of the equipment shall be based on site-specific requirements and constrains.

3.2 Placing Concrete

.1 The Contractor is advised of the potential impact placement procedures have on the durability performance of the concrete, especially regarding concrete cracking. Special environmental conditions, procedures, monitoring, and products may be required to produce the quality of in-place HPC expected on this Project.

.2 Placement of HPC shall not commence if:

.1 The anticipated air temperature during the pour is expected to exceed 20 degrees Celsius (°C) for placement of HPC on bridge decks or 22°C for placement of HPC other than on bridge decks.

.2 The anticipated air temperature during the concrete pour is expected to drop below 5°C on the Day of concrete placement or during the subsequent 7 Days,

.1 This requirement may be waived if a combination of an enclosure, heating, and insulated forms are used to maintain a minimum ambient air temperature of 10°C, subject to approval by The City's Engineer.

.3 Windy conditions are present or expected during the pour, whereby combined effects of air temperature, relative humidity (RH), concrete temperature, and wind could result in a surface moisture evaporation rate more than 1 kg/m^2 per hour as determined by CSA A23.1 Annex D.

.4 Rain is predicted during the concrete pour.

.5 Equipment, Materials, wind breaks, fog spray equipment, water supply, or adequate labour are not available for a continuous concrete pour.

.6 Do not start placing concrete until all Materials required for the curing phase are onsite and ready for use.

.3 Notify The City's Engineer and The City's independent testing firm a minimum of 24 hours prior to commencement of any concrete placement.

.4 Allow time for corrective work for areas of unusual formwork and congested reinforcement.

.5 Notify the geotechnical Engineer to inspect and verify soil conditions and bearing pressures of all foundations prior to placing concrete for mud slabs or foundations.

.6 Do not place concrete against frozen ground, frozen concrete, or frosted forms.

.7 Place all hardware and all other items to be cast into concrete securely and in a manner to facilitate placing concrete.

.8 Do not disturb reinforcement, inserts, embedded parts, formed expansions and contraction joints, and other critical items during concrete placement.

.9 Revise, reseat, and correct improperly positioned reinforcing hardware and other embedded items immediately before concrete placement.

.10 Verify and record the temperature of the concrete during placement:

.1 The concrete temperature during discharge into the forms shall be between 10°C and 20°C.

.11 Verify and record the temperature of the concrete throughout curing using thermocouples, as follows:

.1 Use a minimum of two thermocouples per 100 cubic metres (m^3). Submit a diagram showing all locations to be monitored.

.2 The maximum temperatures during hydration shall not exceed 60°C.

.3 The total temperature gradient shall not exceed that specified in CSA A23.1 Table 20.

.4 The temperature rise, or drop, shall not exceed a maximum heating or cooling rate of 2°C per hour.

.12 Employ corrective measures upon identification of noncompliance to the concrete temperature requirements per the approved QMP.

.13 Comply with hot and cold weather concrete fabrication, placement, and curing requirements per CSA A23.1, except as noted in these Technical Specifications.

.14 Use of Ice and Liquid Nitrogen:

.1 Maintain the mix temperature at or below 18°C by including ice or liquid nitrogen to the mix at the plant.

.2 The use of ice or liquid nitrogen shall be reviewed by The City's Engineer and supervised by The City's independent testing firm.

.3 Take special care to maintain the consistency of the designed w/cm ratio, while adjusting the mix proportions to account for the addition of ice or liquid nitrogen.

.15 Immediately prior to placing concrete, thoroughly wet the forms and any previously placed concrete down with clean, potable water.

.16 Maintain specified concrete cover around reinforcing.

.17 Do not place concrete older than 90 minutes from the batch time.

.18 Do not add water onsite.

.19 Where concrete is placed on an inclined surface, begin the placing operation at the lower end of the slope and progress upward unless otherwise permitted by The City's Engineer.

.20 Place and screed concrete in accordance with the lines and levels indicated on the Drawings.

.21 Place concrete in approximate horizontal layers such that each lift can be vibrated into the previous lift.

.22 Verify that the maximum vertical freefall of concrete does not exceed 1,200 mm. Confine concrete with a suitable vertical drop pipe to prevent segregation.

.23 Place concrete directly into its final position in forms. Do not spread concrete with vibrators.

.24 Mechanical Vibrators:

.1 Compact concrete thoroughly using mechanical vibrators.

.2 Work concrete around reinforcement, embedded items, and into all areas and corners of forms.

.3 Use rubber or plastic-tipped mechanical vibrators for concrete placements containing epoxy-coated reinforcement.

.25 Place concrete as a continuous operation, stopping only at construction joints.

.26 Allow a minimum of 3 Days between adjacent concrete placements.

.27 Maintain accurate records of concrete placement. Record date, location of placement, quantity, air temperature, and test samples taken.

.28 Do not proceed with backfill against newly placed concrete until the concrete achieves a minimum compressive strength equal to or greater than 75% of specified 28-Day compressive strength.

3.3 Additional Requirements for Placing and Finishing Concrete Bridge Decks

.1 To avoid moisture loss due to rising temperatures, place HPC for bridge decks during night-time periods such that concrete reaches initial set before 10 A.M. or earlier, depending on the weather conditions. This requirement applies to hot weather conditions only, as determined by The City's Engineer.

.2 Screed deck concrete using one of the following approved finishing machines or an approved equivalent:

.1 Terex Bidwell Models 2450, 3600, or 4800.

.2 Gomaco Models C450 or C750.

.3 Allen Models 4836B, 6036B, or 6048B.

.3 Install work bridges to meet the requirements of the Technical Specifications.

.4 Place and finish concrete bridge decks receiving a polymer modified asphaltic (PMA) wearing surface (where approved)or a waterproofing membrane using the equipment specified in the Technical Specifications.

.5 Finishing Machine Guide Rails:

.1 Furnish and install finishing machine guide rails to suit the longitudinal and transverse profile of the deck with an allowance for the deflection of the structure as determined by the Contractor and verified by The City's Engineer.

.2 Guide rails shall be adequately supported as recommended by the manufacturer of the finishing machine and shall be completely in place and firmly secured prior to placing of concrete.

.3 The support for these rails shall be fully adjustable (not shimmed) to obtain the correct profile and shall be placed outside the immediate area to be concreted.

.4 Do not treat rails with parting compound to facilitate their removal.

.5 Extend the rails beyond both ends of the scheduled placement length for a distance that permits the finishing machine to reach all areas of the concrete placed.

.6 Verify that the equipment can operate within the geometric constrains of the Project Site.

.7 Provide rail anchorages for horizontal and vertical stability.

.8 Do not ballistically shoot rail anchorages into concrete unless that concrete is to be subsequently overlain.

.9 Submit plans for anchoring rails for review by The City's Engineer.

.10 Inserts shall not be permitted in the finished surface.

.6 After the rails have been set to the proper grade and elevation, and prior to starting the concrete placement, check the clear distance from the bottom of the screed to the top of the prepared concrete surface formwork or reinforcing steel in the presence of The City's Engineer, as follows:

.1 Attach a fill strip to the bottom of the screed during this check as a means of detecting areas where the required concrete thickness might be compromised and to verify that the minimum specified concrete cover to the top reinforcing steel can be achieved.

.2 Set up enough screed rails to allow the clearance check to be made in one continuous run for a complete Day's placement.

.3 Make corrections as directed by The City's Engineer to obtain the specified thickness or concrete cover.

.7 The finishing machine shall be capable of forward and reverse motion under positive control. Make provisions for raising the screeds to clear the screeded surface for travelling in reverse.

.8 Prior to placing any concrete, verify the adjustment and operation of the finishing machine by moving the machine over the full length of the section to be placed and traversing the float completely across all end-bulkheads.

.9 Finishing:

.1 Finish each riding surface in one operation with a mechanical finishing machine spanning the full width of the pour.

.2 Select a method of finishing capable of producing a finished surface meeting the requirements of Clause 3.5, Surface Defects and Tolerances.

.3 Keep hand-finishing to a minimum.

.4 Provide finishing bridges that span the full width of the pour for all hand-finishing operations.

.5 Screeding:

.1 Move the vibratory screed slowly at a uniform rate. Maintain a roll of concrete along the entire front of the screed at all times to guarantee the filling and consolidation of the surface concrete.

.2 Complete screeding in no more than two passes.

.3 Do not allow the screed vibrators to run except when screeding is actually in progress.

.4 Do not walk on or otherwise damage the screeded surface.

.6 Remove cement grout that builds up in areas adjacent to edges that cannot be machine-finished.

.7 Fill holes and cavities caused by the removal of the guide rails with concrete before the remainder of the concrete has reached final set.

.8 Hand-screed and -finish concrete to conform with the machine-finished concrete.

.9 Carefully finish the concrete surface around expansion joint blockouts and deck drains. Exercise care to prevent any concrete from entering these areas.

.10 During the placement and finishing operation, use fogging and an evaporation retarder. Mix and apply the Material in accordance with the manufacturer’s instructions, no later than 10 minutes after the longitudinal floating operation starts.

.11 Longitudinal Bull Floating:

.1 Float the concrete surface produced behind the finishing machine with a wood or magnesium float.

.2 Float the surface the minimum amount necessary to produce a uniform surface, free from open texturing, plucked aggregate, and local projections or depressions.

.12 Deck Sidewalk Finish:

.1 Use evaporation retarder immediately after the deck sidewalk surface has been struck off with a strike board.

.2 Float the surface with a wooden or cork float.

.3 Use an edging tool on edges and control joints.

.4 Remove edging tool marks prior to final finishing.

.5 Apply a light broom finish.

3.4 Limitations of Operation:

.1 If concrete placement is stopped or delayed for a period of 1 hour or more, discontinue further placement.

.2 Placement may resume only after a period of not less than 12 hours.

.3 This requirement may be waived at the discretion of The City's Engineer provided a gap is left in the lane or strip; the gap shall be sufficient in length for the finishing machine to clear the previously placed concrete.

.4 Prepare vertical joints and cold joints between adjacent pours in accordance with CSA A23.1

3.5 Surface Defects and Tolerances:

.1 The finished surface shall conform to the longitudinal and transverse profiles as indicated on the Drawings.

.2 Concrete tolerances not specified within the Agreement shall conform to CSA A23.1.

.3 The surface shall be free from open texturing, plucked aggregate, and local projections.

.4 All surfaces shall be such that when tested with a 3-m-long straight edge placed anywhere, in any direction on the surface, there shall not be a gap greater than 3 mm between the bottom of the straight edge and the surface being tested. Bridge deck sidewalks shall not vary more than 3 mm under a 3.6 m straight edge.

.5 The surface shall be checked as described in these Technical Specifications immediately after final bull floating.

.6 Surfaces that do not meet the required tolerances shall be corrected immediately.

3.6 Curing

.1 Employ special precautions following the placement and screeding of concrete but prior to wet curing to protect HPC surfaces from the drying effects of wind and sun.

.2 Immediately after finishing the concrete, continuously apply fog mist until placement of wet burlap and plastic.

.3 Do not use misting to apply water to the concrete's surface for finishing purposes.

.4 Do not direct the misting device towards the concrete surface.

.5 Apply only a fine coating or sheen with the misting device. Water must not be allowed to drip, flow, or puddle on the concrete surface during fog misting, when placing the burlap, or at any time before the concrete has achieved final set.

.6 Unformed Surfaces:

    .1 Protect concrete against loss of moisture, freezing, rapid temperature changes, rain, flowing water, and mechanical injury by moist curing for a period of not less than 7 Days following its initial set.

    .2 Moist cure the concrete surface by covering it with clean white or light-coloured wet burlap as soon as the concrete has set sufficiently to support the weight of the burlap without excessive marking of the concrete surface. Exercise care so that the burlap is thoroughly presoaked but well-drained.

    .3 Cut burlap into sheets sized for successful handling off the work bridge or space outside the wet concrete. Other means of handling and placing burlap may be required to successfully place and maintain the burlap in place.

.4 Burlap must be applied immediately after finishing of the concrete surface within 2 m to 4 m of the finishing operation. Failure to apply wet burlap within the required time frame shall be cause for rejecting the Work. Remove and replace surface concrete in the rejected area at no additional cost to The City.

.5 Cover the burlap with clear or white vapour-proof polyethylene sheeting to prevent wicking of moisture away from the concrete surface by the fabric.

.6 Keep the burlap continuously wet during the curing period.

.7 Prevent air flow in the space between the moisture vapour barrier and the burlap.

.8 Furnish both the burlap and vapour-proof sheeting in sheets large enough to cover the entire width of the deck.

.9 Lap adjacent sheets at least 300 mm.

.10 Adequately weigh the top sheeting to prevent displacement or billowing.

.11 Maintain the integrity of the vapour sheeting during the curing period and patch any damaged pieces immediately to the satisfaction of The City's Engineer.

.12 Provide adequate equipment before concrete placement begins so that the burlap is always kept wet.

.13 Supply burlap that is clean and free of dust prior to prewetting.

.14 Supply water for curing as specified for the concrete.

.15 Provide moist curing with burlap and water at all times, regardless of ambient temperature. During cold weather, prevent burlap from freezing.

.7 Formed Surfaces:

.1 Formed surfaces may be protected by watertight formwork left in place for the curing period. Moist cure exposed horizontal surfaces of concrete as per Subsection 3.6.6.

.2 Formed surfaces shall be stripped after concrete has attained sufficient strength to avoid damage to the concrete surface, but not less than 2 Days after the end of concrete placement. In case of elements of significant length-to-height ratio, such as retaining walls and traffic barriers, release side forms within 12 hours after concreting.

.3 Moist curing shall commence as per Subsection 3.6.6 as soon as possible after stripping form.

.4 Total curing time (with and without forms) of formed surfaces shall be a minimum of 7 Days.

.8 During hot weather, begin curing process immediately after finishing. Use continuous water or absorptive mats.

.9 During cold weather, take adequate care to prevent heating and hoarding efforts from drying out the concrete.

.10 Where approved by The City's Engineer, a membrane-forming curing compound may be applied at the rate recommended by the manufacturer. Do not use curing compounds on surfaces where bond is required for additional concrete or on surfaces that are to receive sealers incompatible with the curing compound.

3.7 Surfacing and Finishing

.1 Clean and fill form-ties or other accessory recesses with nonshrink grout or other approved Material.

.2 Do not leave concrete accessories in place unless approved.

.3 All approved accessories left in place shall have approved corrosion protection and concrete covers as specified in CSA/CAN-S6.

.4 Apply surface finishes to concrete elements as described in Section 03300 – Cast in Place Concrete, unless otherwise specified on the Drawings.

3.8 Surface Texturing for Vehicle Bridge Decks not Receiving an Asphaltic Wearing Surface

.1 Cut grooves into the new concrete deck surface following the curing period. Do not groove fresh concrete with a rake in place of cutting cured concrete.

.2 Cut grooves perpendicular to traffic flow.

.3 Make saw cuts 2.5 mm wide, a minimum 6 mm deep, and spaced 25 mm on centre.

.4 Do not groove the area within 600 mm of traffic barriers and curbs.

.5 Extend saw cuts within 100 mm of expansion joints and deck drains.

.6 Supply all water for the cutting operation.

.7 Collect all runoff from grooving operations and suspended solids in collection tanks at either end of the bridge off the bridge approaches or deck.

.8 Pass the collected runoff through several settling and filtration processes before it is discharged into the sewer system.

.9 The final effluent shall meet the requirements of local and provincial standards for water quality.

3.9 Defective Concrete

.1 Immediately after removing forms, inspect all concrete surfaces.

.2 Report any imperfect joints, voids, stone pockets, or other defective areas specified to The City's Engineer at once.

.3 Repair all defects before the concrete is thoroughly dry, as follows:

   .1 Chip defective areas to a depth of not less than 25 mm with the edges perpendicular to the surface.

.2 Wet the repair, and a space at least 150 mm wide entirely surrounding the repair, to a saturated surface dry condition to prevent absorption of water from the repair material.

.3 Make the repair of the same Material and of the same proportions used for the concrete, except that the coarse aggregate shall be omitted and cement added to match the colour of the surrounding concrete.

.4 Use as little mixing water as necessary to satisfy the requirements for handling and placing.

.5 Retemper the mortar without the addition of water by allowing it to stand for a period of 1 hour; during which time, mix the mortar with a trowel to prevent setting.

.6 Thoroughly compact the repair material into place.

.7 Screed off excess material to leave the repair slightly higher than the surrounding surface.

.8 Leave the repair undisturbed for a period of 1 to 2 hours to permit initial shrinkage before being finally finished.

.9 Finish and cure the repair to match the adjoining surface and to meet the requirements of the Technical Specifications.

.4 Report any shapes and lines outside the specified tolerances, and repair or correct as directed by The City's Engineer at no cost to The City.

3.10 Carbon Monoxide Equipment

.1 Do not place concrete for slabs if carbon-monoxide-producing equipment has been in operation in the temporary enclosure during the 12 hours preceding the start of concreting.

.2 Provide positive ventilation during the 12 hours preceding the start of concrete placement.

.3 Unless directly used for concrete placing, do not operate carbon-monoxide-producing equipment in the temporary enclosure during or within 24 hours after completing the finishing of any slab section.

3.11 Crack Repair

.1 Use the following procedure where a measured crack width in the bridge deck or horizontal surfaces exceeds 0.3 mm:

.1 Blow out cracks clean and dry with a jet of oil-free compressed air.

.2 Seal cracks by a slow gravity feed of approved Material to maximize the penetration.

.3 Seed surface with coarse sand.

.2 Use the following procedure where a measured crack width in nonhorizontal surfaces exceeds 0.3 mm:

.1 Blow out cracks clean and dry with a jet of oil-free compressed air.

.2 Install injection ports along crack spaced at a maximum of 150 mm apart.

.3 Alternate port locations from one side of the crack to the other for full-depth cracks.

.4 Apply epoxy mortar binder between injection ports to temporarily seal crack surfaces during injection.

.5 Seal cracks by pressure injection of approved Material.

.6 Start injection at the lowest entry port and continue until there is evidence of resin coming from the port above or adjacent to the one being injected.

.7 Attain manufacturer-specified injection pressures prior to discontinuing injections and opening subsequent injection ports.

.8 Complete pressure injection for all remaining ports until the crack is sealed.

.3 Injection ports shall be removable and insert type, complete with caps or mechanical means of closure when under pressure.

.4 Injection port pressure shall be equal to or greater than the maximum operating pressure of the pump.

4 MEASUREMENT AND PAYMENT

4.1 Measurement

.1 The quantity of HPC measured for payment will be based on the total computed volume within the neat lines as shown on the Drawings, measured to the nearest 0.01 cubic meters (m^3), and reviewed and accepted by The City's Engineer.

4.2 Payment

.1 Payment for the Work of this section shall be on a unit price bid for the class of HPC specified, less any applicable payment adjustments as outlined in Subsection 4.3, Payment Adjustments, and will be full compensation for falsework and formwork, batch testing, delivery, placement, curing, concrete surface finishing, testing and inspection, and all labour, Materials, Construction Equipment, tools, and incidentals necessary to complete the Work as shown on the Drawings and to the satisfaction of The City's Engineer.

.2 All costs associated with concreting in cold weather, when required, will be considered incidental to the Work, and no separate or additional payment will be made.

.3 The City reserves the right to reject HPC that does not meet the specified requirements.

.4 The City may, at its sole discretion, accept HPC that does not meet the specified requirements at a reduced price. Payment adjustment may be made in accordance with Subsection 4.3, Pay Adjustment.

4.3 Pay Adjustment

.1 Pay adjustments will be made for nonconformance to the specified HPC strength and concrete characteristics.

.2 Pay adjustments are applied independently, resulting in multiple payment adjustments if the concrete is Deficient in more than one consideration.

.3 The volume of concrete used to adjust the Agreement amount shall be based on whole truckloads of concrete and shall include all truckloads placed after the last compliant truckload tested up to the next compliant truckload tested.

.4 Low Compressive Strength:

.1 When structural and durability considerations do not govern, but concrete fails to meet contractual obligations of strength, the penalty may be assessed at the discretion of The City's Engineer, in accordance with Table C.

Table C – Payment Adjustment for Low-Strength Concrete

Criteria	Deduction
3.5 to 4.5 MPa less than specified	\$450.00/m^3
> 4.5 MPa less than specified	\$600.00/m^3, or remove and replace

Notes:
> = greater than

.5 Low Air Content:

.1 When the air content of HPC is tested with ASTM C457 and falls outside the specified limits, a penalty will be assessed in accordance with Table D.

Table D – Payment Adjustment for Air Void Spacing Factor

Criteria	Deduction
Between 0.230 mm and 0.260 mm	50% deduction
> 0.260 mm	90% deduction or remove and replace

Notes:
> = greater than

.6 Cracking:

.1 No pay adjustment will be made based on cracking.

.2 However, the Contractor shall repair all cracks in accordance with the Technical Specifications, regardless of the nature of their cause.

.7 Penetrability:

.1 When the chloride ion penetrability of HPC is tested with ASTM C1202, using a field-cast and laboratory-cured cylinder, and falls outside the specified limits, a penalty shall be assessed in accordance with Table E.

Table E – Payment Adjustment for Penetrability[a]

Criteria	Deduction
<1,000 coulombs	No deduction
1,001 to 1,200 coulombs	$250.00/$m^3$
>1,201 coulombs	$650.00/$m^3$, or remove and replace at no cost to The City

Notes:

[a] Penetrability requirements may be verified at the discretion of The City's Engineer by other durability indicators.

< = less than

END OF SECTION

PRECAST CONCRETE SUPPLY, FABRICATION AND INSTALLATION

1 GENERAL

1.1 Scope of Work

.1 This section outlines the requirements for the supply, fabrication, storage, delivery, and installation of precast, prestressed, concrete girders and deck panels for use in bridges and other structures.

1.2 Related Work Specified in Other Sections

.1	Concrete Reinforcement	Section 03200
.2	Cast-In-Place Concrete	Section 03300
.3	High-Performance Concrete	Section 03301
.4	Structural Steel Supply, Fabrication, and Erection	Section 05120

1.3 Reference Standards

.1 Perform the Work of this section in accordance with the latest edition of the following standards available at the Effective Date, except where specified otherwise. Provide one copy onsite CSA A23.1, CSA A23.2, and CAN/CSA S6 either in hard copy or digital format.

.2 American Welding Society (AWS):

- .1 AWS D1.5, Bridge Welding Code

.3 ASTM International (ASTM):

- .1 ASTM A29/A29M, Standard Specification for General Requirements for Steel Bars, Carbon and Alloy, Hot-Wrought
- .2 ASTM A108, Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished
- .3 ASTM A123/ A123M, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
- .4 ASTM A416/A416M, Standard Specification for Low-Relaxation, Seven-Wire Steel Strand for Prestressed Concrete
- .5 ASTM A1064 / A1064M - 18a, Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete
- .6 ASTM C260, Standard Specification for Air-Entraining Admixtures for Concrete
- .7 ASTM C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
- .8 ASTM C494, Standard Specification for Chemical Admixtures for Concrete
- .9 ASTM C1433, Standard Specification for Precast Reinforced Concrete Box Sections for Culverts, Storm Drains and Sewers

.10 ASTM D2240, Standard Test Method for Rubber Property - Durometer Hardness

.11 ASTM D412, Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension

.4 CSA Group (CSA):

.1 CAN/CSA S6, Canadian Highway Bridge Design Code

.2 CSA A23.1, Concrete materials and methods of concrete construction

.3 CSA A23.2, Test methods and standard practices for concrete

.4 CSA A23.3, Design of concrete structures

.5 CSA A23.4, Precast concrete - Materials and construction

.6 CSA A283, Qualification Code for Concrete Testing Laboratories

.7 CSA A3000, Cementitious materials compendium (consists of A3001, A3002, A3003, A3004, and A3005)

.8 CSA G30.18, Carbon steel bars for concrete reinforcement, as applicable

.9 CSA G40.20/G40.21, General requirements for rolled or welded structural quality steel / Structural quality steel

.10 CSA W47.1, Certification of companies for fusion welding of steel

.11 CSA W48, Filler metals and allied materials for metal arc welding

.12 CSA W59, Welded Steel Construction

.5 Precast/Prestressed Concrete Institute Concrete Institute (PCI):

.1 PCI MNL-116, Manual for Quality Control for Plants and Production of Precast and Prestressed Concrete Products, latest edition

1.4 Definitions

.1 All defined words or phrases shall have the meaning given in the City of Calgary Standard General Conditions, The City of Calgary Standard Specifications, Roads Construction and the Agreement, unless noted otherwise.

1.5 Qualifications

.1 The Contractor shall be fully certified at the time of tender by the Canadian Precast Concrete Quality Assurance (CPCQA) Certification Program for the applicable product group class.

.2 Precast concrete elements shall be fabricated and erected in accordance with the CSA Standards in appropriate categories according to CSA A23.4 and as specified herein.

.3 Welding companies supplying welded metal fabrication shall be certified to CSA W47.1, Division 1 or 2.

1.6 Submittals

.1 The Contractor shall submit the following to The City's Engineer for approval, allowing a minimum of 10 Business Days for review, unless otherwise noted:

.1 Concrete mix designs, in accordance with Section 03301, High Performance Concrete. If a new concrete mix is proposed to The City, trial batch data shall also be submitted. Proposed changes to the concrete mix design during fabrication shall be subject to review and approval by The City's Engineer prior to the Contractor making the change.

.2 Shop Drawings, showing details for all precast elements, including all elements of all structures, shall be prepared by the Contractor and submitted to The City's Engineer for review and approval prior to fabrication. The Shop Drawings shall be authenticated by an Engineer retained by the Contractor and shall include the following:

.1 Full dimensions of all elements; Shop Drawings showing partial details or details of some elements but not all will not be reviewed. Dimensions shown shall account for dimensional changes during fabrication.

.2 Material properties and reference specs for all components.

.3 Details of temporary attachments, if permitted by The City's Engineer.

.4 Design calculations for items designed by the Contractor's Engineer.

.5 Details of the prestressing strands, including size, grade, debonding materials, stress and strain data, and copies of the manufacturer's certified mill test reports.

.6 Details of conventional reinforcement including sizes, grade, bar bends and isolation required for dissimilar materials.

.7 Jacking procedures, forces, and methods and sequences for stressing and de-stressing the strands.

.8 Details and locations for hold-down devices.

.9 Expected camber and deflection of the members immediately following fabrication and installation, and long-term in service.

.10 Details of the concrete curing system.

.11 Details of temporary supports and lifting devices used during handling and storage operations.

.3 The shop drawings will be reviewed for general conformance with the design by the City's Engineer. This review will not relieve the Contractor of their responsibility for completing the Work in accordance with the Contract requirements. All review comments provided by the City's Engineer shall be addressed and/or incorporated into the revised shop drawings and resubmitted for review and acceptance prior to fabrication commencing.

.4 Copies of documentation following fabrication, including concrete quality control (QC) test results, stressing and destressing data, and temperature graphs during curing.

.5 Fabrication schedule prior to production, updated and submitted monthly at a minimum.

.6 A Transportation Plan authenticated by an Engineer retained by the Contractor, including:

.1 Details of lifting

.2 Transportation route

.3 Support and blocking, including stability during transport

.4 Methods to prevent precast elements from overstressing (including custom trailers and steering dolly, maximum truck speed during transport)

.7 An Erection Plan comprising a schedule and detailed, step-by-step procedure clearly illustrating all construction equipment, methods, and sequences by which the Contractor proposes to unload and erect the precast elements. The Erection Plan shall be submitted a minimum of 15 Business Days prior to erection. The Erection Plan shall include drawings authenticated by the Contractor's Engineer, providing the following information:

.1 Access to Work, including earth berms, work bridges, and rock platforms

.2 Type and capacity of equipment

.3 Sequence of operation, including position of cranes, trucks loaded with panels, and traffic accommodation for all stages of unloading and erection

.4 Detailed crane position on the ground, particularly adjacent to substructure elements, such as piers and abutment backwalls, utilities, or other structures, with details of load distribution on wheels, tracks, and outriggers; if approved by The City's Engineer, details of the crane position on the structure, showing wheel loads and axle spacing of equipment (stationary and moving)

.5 Loads and their position from crane wheels, tracks, and outriggers during all positions of lifting when the crane is on or adjacent to the structure. The Contractor shall be responsible for maintaining the structural integrity of all adjacent structures and utilities impacted by the crane loads. The Contractor shall indicate required allowable bearing for supporting ground and shall be responsible for verifying same. The Contractor is also fully responsible for maintaining the stability of all affected slopes as a result of the operations, including all costs associated with the design and construction of temporary slope stabilization work.

.6 Details of temporary falsework and release procedures, if applicable, including proposed methods to be used to maintain structure stability prior to grouting and placing concrete

.7 Details of temporary girder bracing to maintain stability during erection and installation operations

.8 Details of lifting devices, showing vertical forces and rated capacities of lifting devices

.9 Method and procedures for installation of foam-bearing strips and adhesive on precast deck panels, if applicable

.10 Provisions for control and adjustment of errors for height and positioning of precast elements, in particular precast deck panels

.8 A Field Cast Connections Plan for precast deck panels, detailing the procedure for placing concrete in the girder haunches, shear blockouts, and transverse joints, and including:

.1 Details of all materials and construction equipment, and procedures for mixing, placing, and completely containing the concrete

.2 Plan for completely filling haunches with concrete and confirming they are free of voids

.3 Experience of personnel with related work and list of related projects

.4 Procedures for handling and controlling any leakage

.9 A Grouting Plan for girder post-tensioning ducts, detailing the procedure for placing grout and including:

.1 Details of all materials and equipment, and procedures for mixing, placing, and completely containing the grout

.2 Type and model of grout pump

.3 Plan for completely filling ducts with grout and confirming they are free of voids

.4 Experience of grouting personnel with related work, including list of related projects

.5 Procedures for handling and controlling grout leakage

1.7 Quality Control, Quality Assurance, and Inspection and Testing

.1 The Contractor’s plan for quality control (QC) and quality assurance (QA) shall be included in the Quality Management Plan (QMP) and submitted to The City’s Engineer for review prior to starting fabrication. The QMP shall include QC and QA for all fabrication and field casting. All QC and QA, including testing as part of the Contractor’s QMP, shall be paid for by the Contractor.

.2 Fabrication:

.1 The Contractor shall be responsible for QA/QC, as specified in Section 03301, High Performance Concrete.

.2 Testing requirements for all plant cast concrete, including frequency of tests, shall be in accordance with CSA A23.4. The Contractor shall provide copies of QC tests related to the Project as specified in CSA A23.4.

.3 The Contractor shall provide certified copies of mill test reports of reinforcing steel supplied, showing physical and chemical analysis.

.3 Site Casting:

.1 The Contractor shall be responsible for all QC testing of concrete and grout for field-cast connections.

.2 Testing shall be conducted by an independent, CSA A283 certified laboratory retained by the Contractor.

.3 Concrete for field-cast connections shall be tested in accordance with PCI MNL-116.

.4 Grout for post-tensioning ducts shall be tested in accordance with CSA A23.2-1B, for viscosity, bleeding, expansion, and compressive strength of flowable grout.

.5 Test results shall be forwarded to The City's Engineer within 3 Days following testing. The grout test samples shall be cured in a similar method to that used during construction, as approved by The City's Engineer.

.4 Testing by The City:

.1 In addition to the Contractor's responsibility for QA/QC, The City may conduct additional testing deemed necessary at The City's expense. This testing is independent of the Contractor's QMP and shall not replace the Contractor's QC testing.

.2 The Contractor shall allow The City unhindered access to the concrete, concrete constituent Materials, and precast elements and shall assist The City in carrying out tests. There shall be no charge to The City for Materials taken by The City's Engineer for testing purposes.

1.8 Acceptability

.1 During fabrication, The City's Engineer's inspection and acceptance shall be required for the following items prior to casting:

.1 Form inspection and dimension check

.2 Placement of reinforcing steel, post-tensioning ducts and stressing strand

.3 Placement of hold-down devices and all other internal hardware

.2 Failure to comply with the requirements of these specifications will result in precast members being considered potentially Deficient.

.3 Additional testing, inspection, and evaluation may be required where evidence points to a potentially Deficient precast member. The Contractor shall be responsible for the costs and schedule implications for the corrective actions required.

.4 The Contractor shall pay all costs for additional testing, inspection, and analysis required to demonstrate the adequacy of a precast element that does not meet the requirements of the Agreement. The Contractor shall be responsible for Project costs associated with schedule delays related to demonstrating the adequacy of the element.

1.9 Access

.1 The Contractor shall provide full access to fabrication facilities for the inspection of Material and workmanship.

.2 The Contractor shall allow free access for The City's Engineer to all parts of the Work.

.3 The Contractor shall assist The City's Engineer and provide resources for checking layout and performing inspection duties if requested.

2 PRODUCTS

2.1 Concrete

.1 Concrete shall conform to the requirements of Section 03300, Cast-In-Place Concrete and Section 03301, High-Performance Concrete.

2.2 Reinforcing Steel

.1 Reinforcing steel shall conform to the requirements of Section 03200, Concrete Reinforcement.

2.3 Prestressing Steel

.1 Prestressing steel shall be Grade 1860, uncoated, seven-wire, low-relaxation strand in accordance with ASTM A416M, size as shown on the Drawings. with

.2 Should The City consider it necessary, approval of the prestressing strand (in addition to the requirements of ASTM A416) shall be based on tests carried out by the Contractor at The City's expense in a testing laboratory prior to any fabrication. The Contractor shall supply samples of the strand in such cases at The City's request.

2.4 Post-tensioning Ducts

.1 Ducts shall meet requirements specified in CSA A23.1 and shall be of adequate size and strength to accommodate stressing tendons and shall be capable of transmitting P/T forces from the grout to the surrounding concrete.

2.5 External Forms

.1 Precast concrete elements shall be fabricated in steel forms acceptable to The City's Engineer. The forms shall be designed such that their removal will not cause damage to the precast elements.

.2 Forms shall result in precast elements that conform to the dimensions shown on the Drawings.

2.6 Internal Forms

.1 Forms for internal voids shall conform to the requirements of CSA A23.4, Clause 13.2.

2.7 Prestressing Beds

.1 Prestressing beds shall conform to the requirements of CSA A23.4, Clause 28.2.2.

2.8 Hardware and Miscellaneous Materials

.1 All internal hardware and miscellaneous Materials shall conform to the requirements of CSA A23.4.

.2 Voids and Ducts:

- .1 Voids and ducts shall be placed as shown on the Drawings and must be tied and securely held in the required positions to prevent movement during casting.
- .2 Continuous ducts shall align precisely.
- .3 The ends of the voids shall be sealed. Voids found to be distorted, damaged, or of insufficient strength will be rejected.
- .4 Blow holes caused by air expanding within the voids and rising to the surface shall be repaired when the concrete is in the plastic state.

.3 The Contractor shall mark each precast unit to correspond to the identification mark on Shop Drawings and include the name of the Precast Contractor and date. For girders and deck panels, the marking shall be cast on the bottom of the unit outside of the bearing area such that it is visible post-installation.

2.9 Lifting Hooks

.1 Lifting hooks and devices for precast elements shall conform to the requirements of CSA A23.4, Clause 15.5.

2.10 Stud Shear Connectors

.1 All stud shear connectors shall conform to the chemical requirements of ASTM A108, Grades 1015, 1018, or 1020. In addition, they shall meet the mechanical properties specified in AWS D1.5, Table 7.1 for Type B studs. Certified mill test reports for the Material shall be provided.

2.11 Miscellaneous and Embedded Steel Components

Comply with specification section 05120.

3 EXECUTION

3.1 Fabrication

.1 Precast elements shall be fabricated in accordance with CSA A23.4 and as specified herein.

.2 Forms:

.1 Forms shall be assembled and checked for dimensional controls for each setup.

.2 Form release agents and surface retarders shall be applied in accordance with the manufacturer's recommendations.

.3 The Contractor shall prevent form release agents and surface retarders from coming in contact with reinforcing or prestressing steel, or other embedded hardware.

.3 Reinforcing Steel:

.1 Handling and placing all mild reinforcing steel shall be in accordance with the requirements of Section 03200, Concrete Reinforcement.

.2 Notwithstanding the requirements of Section 03200, Concrete Reinforcement, welding of reinforcing steel shall not be permitted under any circumstances.

.4 Stressing:

.1 An initial load shall be applied to each strand to eliminate slack and provide a reference point for measuring and recording elongation. The final load shall then be applied. The force in each strand shall be measured and recorded by elongation and pressure gauge.

.2 The jack pressure shall not vary from the pressure corresponding to the calculated elongation by more than 5%. If the required elongation is not obtained by stressing to this maximum allowable jack pressure at one end of the precast element, complete the stressing from the other end.

.3 The Contractor shall determine the calculated jack gauge reading, the required gross elongation based on estimated anchorage and seating losses, and the required net elongation for each strand. During stressing operations, the Contractor shall record the actual jack gauge reading, measured gross elongation, and measured anchorage losses, and then calculate the actual net elongation for each strand.

.4 Tensioning force and elongation shall be verified in accordance with Subsection 5.2.2 of the PCI Quality Control Manual MNL-116.

.5 The Contractor shall keep all strands clean and free of damage prior to placement and stressing within the form. Failure of one or more wires within a single strand shall not be permitted, and if wires fail, the strand shall be removed and replaced. Splices of strands shall not be permitted.

.6 Stressing strands shall not be stressed more than 24 hours prior to being encased in concrete.

.7 Stressing tendons shall be carried out by experienced personnel with equipment suitable for single tendon stressing.

.8 Destressing shall not be carried out until the concrete has reached the minimum compressive strength as shown on the Drawings. The cylinders used to determine this strength shall be cured under the same conditions as the concrete of the precast element.

.9 Transfer of the prestressing force shall be carried out by a method approved by The City's Engineer. If the strands are to be cut, the destressing sequence shall be subject to approval by The City's Engineer.

.10 Prestressing strand ends shall be recessed 25 millimetres (mm) deep from the end of the precast element using expanded foam or other means as approved by The City's Engineer. After transfer, the projecting strand shall be cut back flush with the backside of the recess. The recesses shall be cleaned and patched per the Technical Specifications.

3.2 Placing Concrete

.1 The methods of mixing, conveying, spreading, consolidating, finishing, curing, and protecting the concrete shall be established and documented by the Contractor.

.2 Immediately prior to casting concrete, the Contractor shall verify the interior of the forms are clean and free of foreign or deleterious materials.

.3 The temperature of the mixed concrete shall not be less than 10 degrees Celsius (ºC) and not more than 25ºC at the time of placing in the forms.

.4 Concrete shall be deposited carefully and vibrated so that it fills the forms completely and makes complete contact with all reinforcement, prestressing strands, ducts, anchorages, and embedded Materials. Vibrators shall not be used to spread concrete.

.5 Concrete shall be deposited at frequent locations within the forms in a manner and in a location as close as practicable to its final position. The concrete shall be vibrated thoroughly and uniformly into place by methods that do not cause the constituent Materials to segregate. The Contractor shall provide experienced personnel to deposit and vibrate the concrete and shall properly vibrate each batch of concrete in place as it is deposited.

.6 Buckets, chutes, and other equipment used to deposit concrete in the forms shall be positioned as close to the top of the forms as possible to minimize the free fall of the concrete.

.7 Depositing of concrete shall be a single, continuous, complete operation so that each precast element is monolithic without joints. The time from initial mixing of concrete until placing concrete in the forms shall not exceed 1 hour. The elapsed time between placement of the concrete onto previously placed concrete shall not exceed 30 minutes.

3.3 Finishing Concrete

.1 Refer to Spec Section 03300 for finish classes. Exposed surfaces shall be finished in accordance with the Drawings.

.2 The top surfaces of girders shall receive a roughened surface with 6-mm transverse indentations, spaced at 15 mm unless otherwise indicated in the Drawings.

.3 The top surfaces of precast deck panels, including partial depth panels, shall receive a Class 5 broomed finish transverse of the direction of traffic or as otherwise indicated in the Drawings.

.4 The vertical concrete surfaces of the shear blockouts and transverse joints of precast deck panels shall be a rough, clean, exposed, aggregate finish. The Contractor shall apply form retarder, such as BASF MasterFinish HC or equivalent, as approved by The City's Engineer to these areas. After form removal, the areas shall be sand or water blasted sufficiently to produce the exposed aggregate finish.

.5 The Contractor shall clean the prestressing strand end recesses, apply an approved epoxy bonding agent, and grout the recessed pockets.

.6 Immediately after the removal of the forms, all defects in the concrete shall be repaired as directed by The City's Engineer, provided the defects are not extensive enough to cause rejection of the precast element.

.7 Holes made by hold-up or hold-down devices or other fabrication equipment shall be cleaned of all oil and grease, washed with clean water, and then, without delay, patched flush with the surface with the approved grout.

.8 All objectionable fins, projections, offsets, streaks, and other surface imperfections shall be removed to The City's Engineer's satisfaction by approved means.

.9 If, in The City's Engineer's opinion, repairs to the concrete are not satisfactory or will be detrimental to the strength or long-term durability of the precast unit, as directed by The City's Engineer, the unit shall be replaced at the Contractor's own expense.

3.4 Curing Concrete

.1 Concrete shall be either moist cured for a minimum of 7 days from the time of casting or steam cured until the concrete has reached the strength shown on the Drawings. The accelerated curing cycle for the precast concrete shall be as specified for the "damp" moisture category in CSA A23.4, Table 2, Accelerated Curing Cycle.

.2 If steam curing is used, it shall not be applied until after the initial set has taken place, considered to be 4 hours after the completion of concrete placing. The cylinders used to determine the concrete strength shall be cured under the same conditions as the precast unit in question.

.3 From the time of pretensioning to the time of initial set, the ambient air temperature of the precast element shall not vary by more than ±3°C. During steam curing, the rise in ambient air temperature shall not exceed 15°C per hour to a maximum temperature of 70°C.

.4 Thermocouples:

.1 Two thermocouples shall be installed within each precast girder to monitor the temperature if steam curing is used.

.2 The temperature shall be continuously monitored, with readings not exceeding 30 minutes.

.3 The temperature data shall be submitted to The City's Engineer and The City for review.

.4 Corrective action for concrete not within the temperature requirements specified herein shall be outlined in the Contractor's QC Plan.

.5 Once curing has been completed, the temperature of the concrete shall not be allowed to fall at a rate exceeding 20°C per hour.

.5 The precast element, including patched areas, shall be properly cured and stored within the plant a minimum of 3 days.

.6 The Contractor shall monitor the rate of cooling of the element and avoid thermal shock from prematurely subjecting the element to freezing temperatures.

.7 The Contractor shall not subject precast elements to freezing temperatures before reaching 85% of the design strength, as shown on the Drawings.

3.5 Repairing Damaged Concrete

.1 Serious damage, honeycomb, and other casting defects shall be immediately reported to The City's Engineer. Repair procedures shall be submitted for review by The City's Engineer and acceptance by The City prior to commencement of the repair. All repairs shall be completed prior to curing of the unit.

.2 Repairs to defects, including cracks, honeycombs, or spalls, shall be carried out in accordance with the requirements in the Technical Specifications. Unacceptable cracks, honeycombs, or spalls will result in rejection of the affected unit.

.3 All repair procedures shall be developed by an Engineer retained by the Contractor, reviewed by The City's Engineer, and accepted by The City prior to the commencement of the repair.

.4 Cracks in the bearing area of a girder or deck panel are unacceptable with the exception cracks less than 0.1 mm in width and initiated by a stress raiser, such as a formed hole in the deck panel. Unacceptable cracks in the bearing area will result in the rejection of the unit.

.5 Cracks in the anchorage area exceeding 0.3 mm in width are unacceptable and will result in the rejection of the unit.

.6 All cracks in the anchorage area 0.1 mm to 0.3 mm in width shall be repaired by epoxy injection in accordance with the manufacturer's instructions or by other methods as approved by The City's Engineer. Coring shall be carried out to confirm the penetration of the epoxy into the cracks if so requested by The City's Engineer.

.7 Cracks outside of the bearing and anchorage areas that are wider than 0.3 mm or longer than 300 mm are unacceptable and will result in the rejection of the unit.

.8 Honeycombs or spalls in the bearing areas are unacceptable and will result in rejection of the unit.

.9 Major Honeycombs and Spalls:

.1 Major honeycombs and spalls are voids more than 30 mm deep or more than 0.1 square metre (m^2) in area.

.2 Major honeycombs and spalls in the anchorage areas are unacceptable and will result in rejection of the unit.

.3 Major honeycombs and spalls in any area that exposes prestressing strand are unacceptable and will result in rejection of the unit.

.10 Repairs of minor honeycombs and spalls in the anchorage areas may be made prior to or after destressing of the precast element.

.11 Repairs of honeycombs and spalls outside of the bearing or anchorage areas shall be made using cementitious material prior to destressing of the precast element.

3.6 Handling and Storage

.1 Lifting Devices:

.1 Lifting devices shall be of such a nature as to avoid twisting, racking, or other distortions while handling, storing, moving, and erecting the deck panels.

.2 Lifting devices shall be anchored fully to the main body of concrete.

.3 Lifting devices shown on the Drawings are minimum requirements, and the Contractor shall satisfy themselves as to the adequacy of such devices.

.4 Deck panels shall be picked up only by the lifting devices.

.2 During storage and hauling, girders and deck panels shall be maintained in an upright position and shall be supported on the bearing area only. Extreme care shall be exercised during the handling and storage of the precast units to avoid twisting, cracking, or other distortion that may result in damage.

3.7 Mock-Up

.1 The Contractor shall place the first two fabricated precast deck panels beside each other, in accordance with the details shown on the Drawings, to confirm dimensions and fit-up, and check for conflicts.

.2 The mock-up shall be reviewed by The City and The City's Engineer prior to fabrication of the remaining precast deck panels.

3.8 Installation – Bridge Deck Panels

.1 General:

.1 The Contractor shall be responsible for the security and integrity of the panels during all handling operations, including transportation to the Project Site, unloading, and installation. Panels damaged during these operations shall be replaced or repaired to the satisfaction of The City's Engineer before final approval is granted. The decision to repair or replace the damaged panels will be entirely at the discretion of The City.

.2 Panel transportation and erection shall not commence until the Contractor's Transportation Plan and Erection Plan have been reviewed and accepted by The City's Engineer.

.3 The Contractor's project manager, site superintendent, and erection designer may be required to attend a pre-job meeting with The City's Engineer at a location determined by The City prior to commencement of field work.

.4 Before erection begins, the Contractor shall complete a layout by means of chalk lines and markings applied to all girders showing the locations of all shear blockouts and transverse joints of panels in accordance with the layout plan.

.2 Girder Haunch Forming:

.1 The Contractor shall supply and install the foam bearing strips onto the girder top flanges as specified on the Drawings.

.2 The Contractor shall supply and install an approved epoxy adhesive for the strips as specified on the Drawings and in accordance with the manufacturer's recommendations.

.3 The Contractor shall clean all contact surfaces prior to applying the epoxy adhesive and foam bearing strips at the locations and in accordance with the details as indicated on the Drawings.

.4 The Contractor shall place the foam bearing strips correctly and seal them adequately to prevent the leakage of concrete during placement.

.5 If leakage occurs, it shall be the responsibility of the Contractor to carry out required remedial measures at their own cost in accordance with the Contractor's Field Cast Connections Plan as approved by The City.

.3 Handling and Transportation of Panels:

.1 The precast deck panels shall be picked up only by the lifting devices installed by the Contractor. Storage of precast deck panels onsite shall only be allowed with the written approval of The City's Engineer.

.2 When transporting panels, the Contractor shall be responsible for acquiring all of the required permits and verifying that the conditions of all permits are met.

.3 Extreme care shall be exercised during the handling and transportation of the panels to avoid damaging panels. The Contractor shall be responsible for protecting panels at restraint points on the vehicle.

.4 The Contractor shall be responsible for handling, transporting, storing, and erecting panels in a manner that does not induce tensile stresses sufficient to cause cracking. Panels with cracks larger than 0.3 mm may require replacement at the Contractor's expense as determined by The City's Engineer.

.5 No loose timber blocking will be permitted for use in temporary works for any aspect of panel handling and transportation.

.6 It is the Contractor’s responsibility to ascertain the actual weight of the panels. The concrete in the precast, prestressed panels may be denser than regular concrete; and the panels contain a high percentage of reinforcing steel and stressing strands, which also tend to increase the weight of the panels.

.4 Erecting Panels:

.1 It is essential that panels are erected with utmost attention to the positioning, alignment, and elevation, as shown on the Plans.

.2 Before erecting panels, the Contractor shall verify the dimensions of the bearing areas and shear blockouts to the dimensions and layout of the girders. All discrepancies discovered by the Contractor shall be brought immediately to the attention of The City’s Engineer.

.3 The Contractor shall use the levelling bolts on the panels to closely match adjacent panel elevations and achieve the profile as shown on the Drawings. The Contractor shall adjust the levelling bolts to their anticipated final locations prior to erecting the panels in place.

.4 Any adjustment to the position, bearing location, or bearing elevation shall be approved in writing by The City’s Engineer. Any additional cost or schedule impacts shall be borne by the Contractor.

.5 After The City’s Engineer has approved the erected positions of the panels, the Contractor shall cut the levelling bolts 50 mm below the top of the deck panel. All lifting hooks shall be cut off 50 mm below the top surface of the panel, and all lifting hook pockets shall be filled with grout.

.5 Field-Cast Concrete:

.1 Concrete for the haunches, shear blockouts, and joints shall be as specified in the Technical Specifications.

.2 When the daily minimum air temperature or the temperature of the girders or panels in the immediate area falls below 5°C, or when there is a probability of it falling below 5°C within 24 hours of placing concrete, the following provisions for cold weather concreting shall be implemented:

.1 Before placing concrete, adequate preheat shall be provided to raise the temperature of the adjacent areas of the girders and panels to at least 10°C.

.2 Temperature of the concrete during placing shall be between 10 and 20°C.

.3 The concrete shall be enclosed and kept between 15 and 25°C for at least 5 Days. The system of heating shall be designed to prevent concrete from drying out excessively.

.4 Cold weather protection measures shall be maintained at least 12 hours after moisture curing of concrete has been terminated during periods of freezing weather.

.3 The Contractor shall grind the top of all field-cast surfaces to be flush with the adjacent precast concrete following curing.

.4 After all precast concrete panels have been installed, the Contractor and The City's Engineer shall conduct a final inspection to locate damage or Deficiencies. All visible damage or Deficiencies shall be repaired by the Contractor to the satisfaction of The City's Engineer and acceptable to The City before final approval is granted.

3.9 Installation – Bridge Girders

.1 General:

.1 The Contractor shall be responsible for the security and integrity of the girders during all handling operations, including transportation to the Project Site, unloading, and installation. Girders damaged during any of these operations shall be replaced or repaired to the satisfaction of The City's Engineer before final approval is granted. The decision to repair or replace the damaged girders will be entirely at the discretion of The City.

.2 Girder transportation and erection shall not commence until the Contractor's Transportation Plan and Erection Plan have been reviewed and accepted by The City's Engineer

.3 The Contractor's project manager, site superintendent, and erection designer may be required to attend a pre-job meeting with The City's Engineer at a location determined by The City prior to commencement of field work.

.4 Before erection begins, the Contractor shall complete a layout with markings applied to substructure units showing the locations of all bearings and girders in accordance with the layout plan.

.2 Handling and Transportation of Girders:

.1 The precast prestressed concrete girders shall be picked up only by the lifting devices installed by the Contractor. Storage of girders onsite shall only be allowed with the written approval of The City's Engineer.

.2 When transporting girders, the Contractor shall be responsible for acquiring all of the required permits and meeting the conditions of all permits.

.3 Extreme care shall be exercised during the handling and transportation of the girders to avoid damage.

.4 The Contractor shall be responsible for protecting girders at restraint points on the vehicle.

.5 The Contractor shall be responsible for handling, transporting, storing, and erecting girders in a manner that does not induce tensile stresses sufficient to cause cracking. Girders with cracks larger than 0.3 mm may require replacement at the Contractor's expense as determined by The City's Engineer.

.6 No loose timber blocking will be permitted for use in temporary works for any aspect of girder handling and transportation.

.7 It is the Contractor's responsibility to ascertain the actual weight of the girders. The concrete in the girders may be denser than regular concrete, and the girders contain a high percentage of reinforcing steel and stressing strands than regular elements, which also tends to increase the weight of the girders.

.3 Erection of Girders:

.1 The Contractor is responsible to complete girder erection in accordance with the approved Erection Plan and shall be fully responsible for the means and methods throughout transportation, erection, and installation.

.2 The erection of girders shall not impose damage or overstressing to the substructures.

.3 It is essential that the girders are erected with utmost attention to the positioning, alignment, and elevation as shown on the Erection Plan.

.4 Before erecting the girders, the Contractor shall verify the as-built dimensions of the girders and complete a survey of all bearing areas, including distances and elevations, comparing the results to the dimensions shown on the Drawings. All discrepancies discovered by the Contractor shall be brought immediately to the attention of The City's Engineer.

.5 Any adjustment to the position, bearing location, or bearing elevation shall be approved in writing by The City's Engineer. Any additional cost or schedule impacts shall be borne by the Contractor.

3.10 Post-Tensioning

.1 Post-Tensioning Plan:

.1 The Contractor shall submit a Post-Tensioning Plan to The City's Engineer for review a minimum of 15 Business Days prior to stressing operations.

.2 The plan shall be authenticated by an Engineer retained by the Contractor and include the Materials, Construction Equipment, sequences, and stressing calculations with appropriate losses and anticipated elongations. All stressing calculations shall be independently checked, Authenticated and submitted to the City's Engineer for review.

.3 Effective stress is considered as the stress remaining in the strand following tensioning and after all losses are accounted for, including creep and shrinkage, elastic shortening, relaxation, and any other losses applicable to the system. The effective stress and sequence of stressing shall be in accordance with the Drawings or as otherwise approved by The City's Engineer.

.2 All post-tensioning and grouting operations shall be undertaken by qualified personnel only. The crew site supervisor and foremen shall be certified to PTI Level 2 Bonded PT Field Specialist.

.3 All ducts shall be pressure tested by methods acceptable to The City's Engineer prior to placement of any strands within the duct. If leaks are discovered during the test, the Contractor shall locate and seal them before commencing post-tensioning operations.

.4 The Contractor shall confirm the stressing strands are free of rust, dirt, oil, grease, or any other substances that may affect the bond prior to placement of the strands.

.5 Individual wire failures during stressing of the strand shall not be accepted and shall be replaced at the Contractor's expense.

.6 Hydraulic jacks used to stress strands shall be suitable for the application and shall be equipped with a pressure gauge or load cell for measuring the stresses. The Contractor shall verify the stresses by measuring and recording the actual strand elongations.

.7 Any variation in measured stresses and elongations of more than 5% shall be brought to the immediate attention of The City's Engineer prior to further stressing.

.8 The Contractor shall provide The City's Engineer with the following record after completion of post-tensioning operations:

.1 Strand location, size, and type

.2 Date of strand installation and stressing

.3 Details of stressing equipment used

.4 Actual jacking forces and gauge pressures

.5 Assumed and measured elongations

.6 Assumed and measured anchor sets

.7 Jack calibration documentation

3.11 Grout

.1 Post-tensioning ducts shall be completely filled with grout following stressing operations.

.2 Grout for the post-tensioning ducts shall be a high-early, nonshrink, flowable, prebagged product suitable for the application as specified in the Technical Specifications.

.3 All grout material shall be packaged in waterproof containers with the production date and shelf life of the material shown. The grout shall be mixed, placed, and cured in strict accordance with the manufacturer's recommendations.

.4 The method of forming and pouring the grout shall be submitted to The City's Engineer for review and approval prior to the Work being undertaken.

.5 Placement of grout shall be performed by experienced workers competent in this field.

.6 When the daily minimum air temperature or the temperature of the girders in the immediate area of the grouting falls below 5°C, or when there is a probability of it falling below 5°C within 24 hours of grouting, the following provisions for cold weather grouting shall be implemented:

.1 Before grouting, adequate preheat shall be provided to raise the temperature of the adjacent areas of the girders to at least 10°C.

.2 Temperature of the grout during placing shall be between 10 and 20°C.

.3 The grout shall be enclosed and kept between 15 and 25°C for at least 5 days. The system of heating shall be designed to prevent the grout from excessively drying.

.4 +Cold weather protection measures, as approved by The City's Engineer, shall be maintained at least 12 hours after moisture curing of concrete has been terminated during periods of freezing weather.

.7 Grouting of the ducts shall be completed within 3 Days following post-tensioning operations. All ducts shall be clean and free of any foreign or deleterious material and shall be thoroughly blown with compressed air immediately prior to grouting. Flushing the ducts with water will not be permitted.

.8 Grout Equipment:

.1 Equipment for grouting shall be suitable for the application and in accordance with the manufacturer's recommendations.

.2 At a minimum, this shall include a high-speed shear mixer and grout pump capable of producing 1.0 megapascals (MPa) of pressure.

.3 The mixer shall be capable of producing a uniform, thoroughly blended grout free of cement lumps or other unmixed ingredients.

.9 The Contractor shall be responsible for the supply and installation of all grout fitting connections and vent tubes that shall be capable of withstanding the pump pressures during grouting operations. Exit points of the vent tubes shall be positioned at a higher elevation than the highest elevation of the duct.

.10 An expansion test in accordance with Clause 1.7.3.4 shall be completed prior to injecting the grout. The grout shall be sampled from the end of the pump.

.11 Grout Injection:

.1 Injection of grout into the ducts shall be from the lowest to highest point.

.2 Grout shall be pumped into the injection vent and continuously wasted at the exit vent until any residual water or air is removed.

.3 The exit vent shall then be closed while maintaining grout pumping for 15 seconds before closing the injection vent so that the duct is completely filled with grout.

.12 Following closure of the vents, the Contractor shall immediately check and continuously monitor for grout leakage until the grout has set. Any leakage found shall be immediately sealed, and the Contractor shall resume grouting.

3.12 Site Cleanup

.1 The Contractor is to leave the Project Site in a neat, restored, and presentable condition satisfactory to The City's Engineer.

.2 When required, the Contractor is to provide written evidence that regulatory agencies have been satisfied.

.3 All concrete shall be left clean and free of oil, grease, mud, dust, road spray, or other deleterious matter.

3.13 Tolerances

.1 Fabrication and erection tolerances for all precast components shall be in accordance with Clause 12 of CSA A23.4, unless specified herein.

.2 Fabrication

.1 Cross-sectional dimensions throughout the entire length of the precast element shall not vary from those shown on the Drawings by more than 5 mm.

.2 The locations of prestressing steel shall not vary from those shown on the Drawings by more than 3 mm.

.3 The dimensions and locations of the shear blockouts on precast deck panels shall not vary by more than 5 mm from those shown on the Drawings.

.4 The maximum tolerance for plan squareness and sweep shall be 5 mm for precast deck panels. The bottom surface of deck panels at the bearing areas shall be in a true level plane that does not vary by more than 2 mm from a true straight edge placed in any direction across the bearing area.

.5 The maximum tolerance for sweep for precast girders shall be 1 millimetre per metre (mm/m) in length.

.3 Erection

.1 The top surface of the adjacent installed deck panels shall be flush within a tolerance of 3 mm.

.2 The maximum deviation from the centreline of an installed deck panel to the centreline as shown on the Drawings shall be 5 mm.

.3 Girders shall be erected and adjusted as required to match as closely as possible to the lines and grades shown on the Drawings.

.4 Under no circumstances shall the final position of the girders vary by more than 6 mm unless otherwise approved in writing by The City's Engineer. The final position shall be subject to approval by The City's Engineer.

4 MEASUREMENT AND PAYMENT

4.1 Measurement

.1 The quantity measured for payment of this section shall be on a unit price basis or a lump sum basis for the type and size of precast concrete element specified, as per the Agreement.

4.2 Payment

.1 Payment for the Work in this section shall be as tendered for the applicable precast concrete element specified, and will be full compensation for the supply and manufacturing of precast concrete elements; loading and hauling to the project site; unloading; erection; and all labour, material, and equipment necessary to complete the work, including all subsidiary and incidental items thereto.

.2 Payment for this Work shall be issued upon 100% completion of all the Work as described in this section, including submission of all documentation per this section.

END OF SECTION

1 GENERAL

1.1 Work Included

.1 This section outlines the requirements for design, supply, fabrication, and construction of mechanically stabilized earth (MSE) retaining walls. The wall locations are shown on the IFC Drawings.

.2 The Work is defined as follows:

- .1 Design of the MSE wall system by the Contractor’s Engineer.
- .2 Fabrication and delivery of all necessary components, including precast concrete facing panels, precast or cast-in-place (CIP) concrete coping, soil reinforcing materials, and accessories.
- .3 Construction of the MSE wall system and associated components, which may include:
  - .1 Excavation for the wall and concrete levelling pad
  - .2 Facing panel installation
  - .3 Concrete coping
  - .4 Installation of concrete barriers
  - .5 Installation of soil reinforcing materials and accessories
  - .6 Installation of drainage measures
  - .7 Supply, placement, and compaction of backfill
  - .8 Installation of traffic barrier and pedestrian safety railing as noted on the IFC Drawings and as required to complete a fully functional MSE wall system
- .4 Quality control (QC) and quality assurance (QA) during design, fabrication, delivery, and construction of the MSE wall system.

1.2 Related Work Specified in Other Sections

.1	Concrete Reinforcement	03200
.2	Cast-In-Place Concrete	03300
.3	High-Performance Concrete	03301
.4	Precast Concrete	03302
.5	Metal Fabrications	05500
.6	Excavation and Backfill	02315
.7	Other specifications relevant to the Project	

1.3 Reference Standards

.1 Perform the Work of this section in accordance with the latest edition of the following standards available at the Effective Date, except where specified otherwise.

.2 The American Association of State Highway and Transportation Officials (AASHTO):

  .1 AASHTO LRFD Bridge Design Specifications

.3 ASTM International (ASTM):

  .1 ASTM International (ASTM) A123/A123M, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

  .2 ASTM A143/A143M, Standard Practice for Safeguarding Against Embrittlement of Hot Dip Galvanized Structural Steel Products

  .3 ASTM A572/A572M, Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel

  .4 ASTM A780/A780M, Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings

  .5 ASTM A1064/A1064M, Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete

  .6 ASTM D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lbf/ft3 (600 kN-m/m3))

  .7 ASTM D1505, Standard Test Method for Density of Plastics by the Density-Gradient Technique

  .8 ASTM D2240, Standard Test Method for Rubber Property - Durometre Hardness

  .9 ASTM D5262, Standard Test Method for Evaluating the Unconfined Tension Creep and Creep Rupture Behaviour of Geosynthetics

  .10 ASTM D6637/D6637M, Standard Test Method for Determining Tensile Properties of Geogrid by the Single or Multi-Rib Tensile Method

  .11 ASTM D6706, Standard Test Method for Measuring Geosynthetic Pull-out Resistance in Soil

  .12 ASTM D7737/D7737M, Standard Test Method for Individual Geogrid Junction Strength

.4 The City of Calgary:

  .1 Design Guidelines for Bridges and Structures

.5 CSA Group (CSA):

  .1 CAN/CSA S6, Canadian Highway Bridge Design Code (CHBDC)

  .2 CSA A23.3, Design of concrete structures

  .3 CSA A23.4, Precast concrete materials and construction

.4 CSA C22.2 NO. 211.1, Rigid Types EB1 and DB2/ES2 PVC Conduit

.5 CSA G30.18, Carbon steel bars for concrete reinforcement

.6 CSA W59, Welded steel construction

.6 Geosynthetic Institute (GSI) Geosynthetic Research Institute (GRI):

.1 GSI GRI GG 4(a), Standard Practice for Determination of the Long-Term Design Strength of Stiff Geogrids

.2 GSI GRI GG 4(b), Standard Practice for Determination of the Long-Term Design Strength of Flexible Geogrids

.7 U.S. Federal Highway Administration (FHWA):

.1 FHWA Design and Construction of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes – Volumes 1 and 2 (FHWA-NHI-10-024 and 025)

1.4 Definitions

.1 All defined words or phrases shall have meaning given the City of Calgary Standard General Conditions and the Agreement, unless noted otherwise.

.2 "Designer" means an Engineer or team of Engineers retained by the Contractor (either directly or through the Supplier) to perform design of the MSE wall system. The Designer shall have a minimum of 5 years of experience in the design of MSE wall system and shall take professional responsibility for the design of all components of the MSE wall system, including connections between all elements necessary to provide internal stability of the wall.

.3 "Engineer of Record (EOR)" means a team of Engineers engaged by The City to perform design for the overall Project, assigned among Geotechnical, Structural, and Civil disciplines. Design by the EOR related to the MSE wall system may include geometric and site design, Utility Facility relocation, design of external drainage systems, and determination of MSE wall design parameters. The EOR shall also review the bearing stresses, settlement and global stability related to the Contractor's MSE wall system design. The EOR shall not be responsible for the design of the MSE wall system itself.

.4 "Panel Fabricator" means the company responsible for fabricating the precast concrete facing panels. The Panel Fabricator may or may not be an organization independent of the Supplier. The Panel Fabricator shall be retained by the Contractor, either directly or through the Supplier.

.5 "Supplier" means the company responsible for providing all necessary Materials for the MSE wall system and confirming the supplied products meet the specified quality standards. The Supplier shall be retained by the Contractor.

1.5 MSE Wall System Requirements

.1 The retaining walls shall consist of precast concrete facing panels generally sized at 1.5 metres (m) by 1.5 m (unless approved otherwise), mechanically connected to soil-reinforcing elements embedded in an engineered backfill, plus accessories as shown or noted.

.2 Precast panels shall have a maximum dimensional ratio, height-to-width or width-to-height of less than or equal to 1.5. Panels of larger size or aspect ratio shall require approval from The City.

.3 All elements of an MSE wall system shall meet The City of Calgary Design Guidelines for Bridges and Structures and shall be submitted for review by The City.

.4 Aesthetic requirements for the wall, such as finish, texture, colour, and special features, shall be as specified in the Agreement, and are subject to approval by The City.

.5 All components of the MSE wall system, including precast panels, soil reinforcement, connections, inspection wires, hardware and associated Materials, shall be sourced through a single Supplier.

.6 One of the following City-accepted MSE wall systems shall be used. Only one system shall be used for all the MSE walls in a Project:

- .1 Reinforced Earth, by Reinforced Earth Company Ltd., Suite 618, 7015 MacLeod Trail SW, Calgary AB, T2H 2K6, 403-452-4654
- .2 Vist-A-Wall with precast panels by Atlantic Industries Ltd., 220 - 5925 12 Street SE, Calgary AB, T2H 2M3, 403-730-6980
- .3 Nilex Group, 9222 40 Street SE, Calgary, AB, T2C 2P3, 403-543-5454

.7 An alternative to these systems may be accepted, subject to the satisfactory submission of the product information, and review and acceptance of the system by The City.

.8 If the wall system selected by the Contractor requires modification to any component of the Project, the Contractor will be solely responsible for all costs required to complete the change. Proposed changes to the Project shall be submitted to the EOR and The City for review and acceptance 15 Business Days prior to commencement of detailed design.

1.6 Division of Responsibilities

.1 The EOR (City’s Engineer) shall be responsible for:

- .1 Geometric and site design (surface water control, and swales and discharge points), including utility conflict accommodation
- .2 Design of external drainage systems outside the reinforced earth zone, at the interface with the retained soil zone, or both

.3 Determination of design parameters (load cases, geometry, soil properties, requirements for integrating the structure with the MSE wall)

.4 Design of the wall for global stability, including bearing, settlement, sliding, and overturning

.5 Review of bearing stresses and both total and differential settlement (short- and long-term)

.6 Review of Contractor's Shop Drawings to confirm design is consistent with Project design criteria

.7 QA review during the Contractor's design, fabrication, and construction phases

.8 Provision of written confirmation that the MSE wall satisfies structural and civil requirements as defined in the Technical Specifications, and that geotechnical and hydrogeologic conditions observed during construction were consistent with the geotechnical report and specifications

.9 Review and confirmation of Record Drawings

.2 The Designer shall be responsible for:

.1 Design of the MSE wall system, including facing panels, soil reinforcement, connection fittings, and internal drainage systems.Review of design parameters and performance criteria included in the Agreement and geotechnical report, and design of the wall to satisfy the specified requirements.

.2 Confirmation of the global stability design using actual soil properties of the backfill that will be used in the Work; the Designer shall collaborate with the EOR to cover data gaps in analyses between global and internal stability.

.3 Preparation and authentication of Shop Drawings, design notes, and construction specifications for the MSE wall system.

.4 Provision of a letter of assurance that the MSE wall system has been constructed in accordance with the design and specifications

.3 The Supplier shall be responsible for:

.1 Supply of all necessary and compliant components and Materials and submittal of mill certificates confirming that supplied products meet the specified quality standards.

.2 Retaining or employing a qualified Engineer to design the wall and provide direction to the Contractor during construction.

.3 Implementation of adequate QC procedures to verify that fabricated products and assemblies meet specification requirements.

.4 Assignment of a Project field representative to attend the site during construction start-up and weekly during wall construction to monitor the construction for consistency with the design and advise the Contractor regarding construction procedures.

.4 The Contractor shall be responsible for:

.1 Execution of the Work of this section in accordance with the Agreement.

.2 QC during construction; all QC documentation, including mill certificates, lab and field test results, and field inspection reports, shall be forwarded to the EOR during construction.

1.7 Qualifications

.1 The Designer of the MSE wall system shall be a Professional Engineer registered in the Province of Alberta, with a minimum of 5 years of experience in the design of MSE soil-retaining structures; and shall take professional responsibility for the design of all components of the MSE wall system, including connections between all elements necessary to provide internal stability of the wall.

.2 The panel fabricator shall be certified by the Canadian Precast/Prestressed Concrete Institute (CPCI) Certification Program.

.3 The panel fabricator shall be certified in accordance with CSA’s certification procedures and shall meet the requirements of CSA A23.4.

.4 The Contractor building the MSE wall shall employ qualified personnel experienced in constructing MSE walls to perform and supervise the Work.

1.8 Design

.1 General Design Requirements:

.1 Location, layout, geometry control, short- and long-term settlement, global stability, allowable rate of fill placement, and allowable bearing capacity requirements shall be as specified in the Agreement.

.2 Two-stage MSE retaining walls are not permitted.

.3 The design life for all MSE wall systems and components shall be 100 years, unless noted otherwise.

.4 The soil reinforcement length shall be the same from top to bottom of each wall section. The reinforcement length defining the width of the entire reinforced soil mass may vary with wall height along the length of the wall.

.5 Water-carrying appurtenances, such as catch basins, drainage inlets and outlets, and culverts, shall be placed away from, or beyond the ends of, the soil reinforcement zone; and provisions shall be made to mitigate the detrimental effects of potential leakage.

.6 The design shall consider all applicable loads, including the following:

.1 Superimposed dead load (for example, railing, barriers)

.2 Load effects on installations buried within MSE backfill

.3 Loads due to construction staging

.4 Hydrostatic pressure

.5 Effects of other adjacent structures

.7 Concrete levelling pads shall be designed for applicable panel loads during construction. Details of temporary shoring or temporary support measures for panels, if required, shall be outlined.

.8 Obstructions:

.1 Obstructions, such as foundation piles and associated casings, or casings for future pile installations in the soil reinforcement zone, shall be accommodated with appropriate arrangement of soil reinforcing around such obstructions.

.2 For those MSE wall systems that lend themselves to splaying of the soil reinforcement, the splay angle shall not exceed 15 degrees (°) from the perpendicular of the facing panel. For other MSE wall systems, coverage ratios of soil reinforcement shall be specifically developed for the Project.

.9 Unless a traffic barrier is mounted directly on top of the MSE wall, pedestrian railing, bicycle railing, or safety railing shall be mounted on top of MSE wall coping; and the wall shall be designed to resist loads transmitted by the railing system.

.10

.11 Design shall be provided for all elements, including:

.1 Excavation and preparation of original ground

.2 Backfill

.3 Levelling pads

.4 Concrete facing panels

.5 Concrete coping

.6 Weld plates and connections

.7 Soil-reinforcing materials

.8 Geotextile

.9 Accessories (as applicable)

.12 All surcharge loads on walls shall be indicated on the Shop Drawings.

.13 Any soil passive pressure having favourable effects on the stability of the walls shall be ignored.

.14 Walls shall be designed for ultimate limit state (ULS) and serviceability limit state (SLS) using load and resistance factors as given in CAN/CSA S6.

.15 The design shall be able to satisfy all geometry requirements, including horizontal curves, wall batters, corners, and slopes.

.16 Where staged construction is required, and large differential settlement is expected between stages, appropriately located full-height vertical slip joints shall be provided. This is different than the prohibited “two-stage” wall mentioned earlier.

.17 The effect of any existing or planned structures or Utility Facilities as shown on the IFC Drawings in front of, behind, under, or on the wall shall be considered in the design and spatial arrangement of soil reinforcing materials. The Designer shall become familiar with the geotechnical reports referenced in the Agreement and may need to supplement this information with additional geotechnical investigative work.

.2 Traffic Barriers:

.1 MSE walls with traffic running parallel to the top of the wall system shall have rigid traffic barriers meeting requirements of CAN/CSA-S6, Section 12.

.2 Traffic barriers shall be located on top of the MSE walls and supported on a moment slab to resist sliding and overturning, unless otherwise approved.

.3 The Designer shall account for reaction loads from the moment slab in the design and detailing of soil reinforcement.

.3 Drainage:

.1 Geomembrane:

.1 All galvanized steel soil reinforcement within the traffic splash zone (below the road surface and extending to 10 m away from the roadway) shall be protected from exposure to de-icing salt by an impermeable geomembrane placed above the top layer of soil reinforcement.

.2 The membrane shall be sealed to prevent leakage, sloped to drain away from the bridge, and connected to an outlet beyond the MSE soil mass.

.3 A nonwoven geotextile filter fabric layer shall be placed below and above the membrane to prevent puncture.

.2 Weep Drains:

.1 Weep drains consisting of flexible, perforated, 150 mm diameter pipe, complete with filter sock, shall be provided near the front and the back bottom corner of the MSE mass.

.2 Weep drains shall be daylighted or connected for positive drainage.

.3 Downspouts shall be provided for drainage from deck joints and deck wick drains.

.3 Downspouts:

.1 Downspouts shall be rigid polyvinyl chloride (PVC) type DB2 conduit meeting the requirements of CSA C22.2 Number (No.) 211.1.

.2 Coupling shall be solvent bell ends (SBEs).

.3 Downspouts shall have a vertical slip joint with a dished top drain inlet cast into the wall coping.

.4 Downspouts shall not be directed through the MSE mass.

.5 Downspouts shall be recessed full height in a chase formed into the front of panels or by using special wall panels and covered with a 10-gauge or 2.6 mm thick steel plate. The plate shall be shop painted with an Approved coating system. Surface preparation shall be in accordance with the selected coating systems' published product data sheet.

.4 Erosion Control:

.1 Grassed swales with a nondegradable erosion control mat shall be provided behind the top of MSE walls, and shall have a minimum width of 600 mm and a minimum depth of 150 mm.

.2 The swales shall have a bottom liner of impervious geomembrane

.3 Swales and the top of walls shall slope away from bridge abutments.

.4 Geometric Requirements:

.1 An inward batter of 1H:50V (horizontal to vertical, into the soil mass) along the height of the wall shall be provided and shown on design drawings. Wall batter may transition to vertical at corners and tight-radiused curved segments.

.2 Acute corners less than 70° inside panels shall not be allowed.

.3 Special corner units shall be used when the interior angle between adjacent panels is 130° or less. The special corner panels shall be used to maintain the 20 mm nominal design joint gap along the front face of panels on either side of the bend line.

.5 Precast Concrete Facing Panels:

.1 For precast panels, the minimum concrete cover to reinforcing steel shall be 60 mm at all faces, unless otherwise shown on the Drawings.

.2 The minimum thickness of precast panels should be 140 mm, excluding additional thickness required for architectural treatment.

.3 The vertical and horizontal joints between precast components shall be designed to be 20 mm nominal unless otherwise approved.

.4 Joints Between Panels:

.1 Joints between panels shall have a lip and recess (shiplap) configuration.

.2 Butt joints may be used if a precast high-performance concrete (HPC) concrete backing block is designed and installed along the joint to prevent soil infiltration.

.3 Backing blocks shall overlap adjacent panels a minimum of 100 mm and have a minimum thickness of 140 mm.

.4 A minimum 300-mm-wide strip of filter fabric is required behind all panel joints. The fabric shall be adhered in place with adhesive to prevent displacement during placement of backfill.

.5 The wall panels shall be designed to accommodate differential settlements of 100 mm in a 10-metre (m) length.

.6 Preformed holes are permitted in the top facing panels to accommodate dowels for anchorage of the CIP concrete coping. The holes shall be located at least 100 mm above the bottom of the coping section.

.7 MSE wall panels shall be fully supported by compacted backfill without voids on the non-exposed side.

.6 Concrete Wall Coping:

.1 A CIP coping is required at the top of all MSE walls unless a CIP concrete barrier slab is indicated on the IFC Drawings. Precast concrete coping may be used where no barrier or guardrail is required.

.2 Joints in Coping:

.1 Coping joints shall be evenly spaced and be designed to mitigate cracking in the coping.

.2 Reinforcing should be discontinuous at these locations to allow cracking to occur.

.3 Locations of coping joints should correspond with panel joints.

.3 The top of the concrete wall shall be smooth and have no abrupt changes in height and a 3% wash slope towards the facing panels.

1.9 Submittals

.1 Submit items under this section to The City and Engineer of Record (EOR) for approval, allowing a minimum of 15 Business Days for review, unless otherwise noted. Fabrication shall not proceed until all comments have been resolved to the satisfaction of the EOR and The City.

.2 Submit qualifications and experience of the Designer for review prior to submission of Shop Drawings.

.3 Design Notes:

.1 Submit design notes and calculations to the EOR at least 15 Business Days prior to commencement of fabrication. The submission shall include calculations for the design of the facing panels, soil reinforcing, and stability of the MSE wall system, including:

.1 Internal stability

.2 Soil-reinforcement interaction

.3 Pull-out capacity of reinforcement

.4 Rupture of soil reinforcement

.5 Design of facing for panel strength and connection capacity panel stability

.2 Design notes shall be presented in a legible and logical format, and shall be sufficiently detailed to allow a technical review of design concepts and assumptions used in the design. The design package shall be accompanied by properties of all Materials used, together with the appropriate test certificates.

.3 The proposed wall design shall be subject to review by the EOR to verify that overall slope stability requirements are met. The wall supplier shall provide geotechnical parameters used for design of the soil reinforcing to the EOR to aid in this review. Anticipated slope stability requirements, with respect to length of soil reinforcing, shall be indicated on the Drawings.

.4 Shop Drawings:

.1 Submit Shop Drawings of wall components for information only. Shop Drawings shall include overall dimensions of elements, dimensions of any blockouts or inserts, and a schedule of pieces, as well as a reinforcement layout.

.2 Shop Drawings shall be legible and of adequate quality to be reproduced and microfilmed. Each drawing shall have enough blank space for the EOR’s’s review stamp.

.3 As a minimum, Shop Drawings shall contain:

.1 Wall layout plan and elevation, complete with dimensions and elevations and typical wall cross-sections

.2 Precast concrete facing panel reinforcing, connection, and hardware detailing

.3 Design criteria and list of Material properties

.4 Backfill properties

.5 All component and connection details

.6 MSE wall drainage details

.7 Construction procedures and construction sequencing

.5 Design notes and Shop Drawings shall be stamped, signed, and sealed by MSE wall designer.

.6 Review of Design Notes and Shop Drawings by EOR:

.1 The design notes and Shop Drawings will be reviewed by the EOR solely to ascertain conformance with codes and specifications.

.2 Review of the Shop Drawings and wall design calculations by the EOR shall not be construed as relieving the Contractor of the responsibility for the completeness and accuracy of the Work and its conformance with the

Technical Specifications. Responsibility of the final design remains solely with the Contractor.

.3 The EOR's review of the Shop Drawings shall not be construed as relieving the Contractor from the responsibility for errors or omissions in the calculations and Shop Drawings or for the proper completion of the Work in accordance with the Agreement.

.7 Revise the Shop Drawings and calculations as required to the satisfaction of the EOR without any additional cost to The City. No fabrication shall commence until all Shop Drawings have been reviewed and accepted by the EOR.

.8 Incorporate as-built conditions into the Shop Drawings an updated copy as records at the completion of construction.

.9 Submit data on all concrete mix designs proposed for use to the testing firm and to the EOR for approval per Sections 03300, Cast-In-Place Concrete, and Section 03301, High-Performance Concrete.

.10 Submit mix data for proposed grouts. For each grout submitted, identify the type of grout, the intended use, and related information for approval.

.11 Submit copies of mill test reports of reinforcement and steel straps (if applicable) according to Section 03200, Concrete Reinforcement.

.12 Submit results of ladle analysis of all reinforcement to be spliced by welding and submit manufacturer's information and test reports for mechanical splices of all reinforcement to be mechanically spliced.

.13 Submit product data for polymeric bars, if proposed. Include a written methodology to prevent floating of reinforcement during placement of concrete and a written methodology of cutting the reinforcement, if required.

.14 Submit gradation information and Standard Proctor Density curves for all engineered fill and confirm whether any changes in the design of reinforcing strips, filter fabric, or other details have been considered.

.15 Submit samples of the backfill material to be used and provide a written report to the EOR indicating whether the backfill material meets design assumptions and conforms to the Technical Specifications.

.16 If requested by The City or the EOR, the Contractor shall submit a 20-kilogram (kg) representative sample of the backfill proposed for construction to The City's geotechnical testing agency for testing and approval 10 Business Days prior to start of construction.

.17 Submit a maintenance manual that includes repair and replacement procedures.

1.10 Quality Control, Quality Assurance, and Inspection and Testing

.1 Quality Control and Quality Assurance (by the Contractor):

.1 The Contractor is responsible for QA/QC throughout the Work, including the fabrication and construction of the MSE Wall System, to confirm that all components satisfy the Technical Specifications.

.2 QA/QC for concrete shall be in accordance with Sections 03200, Concrete Reinforcement, 03300, Cast In Place Concrete and 03301, High-Performance Concrete, as applicable.

.3 The Contractor's plan for QA/QC shall be included in the Quality Management Plan (QMP) and submitted to the EOR for review prior to starting any fabrication. All QA/QC, including testing, associated methods, means, Materials, Construction Equipment, and labour, as part of the Contractor's QMP, shall be paid for by the Contractor.

.4 The Contractor shall provide a full-time, qualified superintendent representing the Contractor in attendance to inspect all phases of this Work.

.5 Non-performance of a Subcontractor shall not relieve the Contractor of responsibility for quality of the design, submissions, and construction of MSE walls.

.6 The Contractor's QA/QC shall include:

.1 Review and confirmation of steel properties (reinforcing steel, soil reinforcing, steel plate fabrications) and geosynthetic reinforcing

.2 Testing of concrete properties (strength, air content, slump)

.3 Inspection and testing by a testing firm, paid for by the Contractor, of the engineered backfill and base material required for the MSE retaining wall system to confirm that it meets design assumptions

.4 Inspection and testing to confirm the thickness of all coatings, including galvanizing

.5 Contractor's review and circulation of Shop Drawings.

.7 The Contractor shall provide the EOR with certified copies of the panel fabricator's QC tests related to this Project as specified in CSA-A23.4 upon request.

.2 Quality Control and Quality Assurance (by the Supplier and Designer):

.1 A qualified representative from the MSE retaining wall system company shall be onsite to advise the erection crew regarding construction procedures. The representative shall be present for not less than 2 Days during the initial stages of construction and is to attend the site weekly during construction thereafter.

.2 The Designer shall review the fabrication of precast concrete elements and conduct periodic site inspections during installation of the MSE wall system.

.3 Quality Assurance (by the EOR):

.1 The City and the EOR may conduct additional QA inspection and testing of the fabrication or construction activities at their discretion, and the Contractor shall accommodate these requests as much as possible. This QA does not relieve the Contractor from responsibilities for QC.

.2 The Contractor shall notify the EOR and The City's testing firm a minimum of 2 Business Days prior to commencing backfill work.

.4 Inspection and Testing

.1 Testing by the Contractor:

.1 The Contractor will engage a testing agency to perform QC testing.

.2 Additional testing made necessary by Material substitutions and the repair of faulty work shall be paid for by the Contractor.

.3 All test records generated during fabrication as a result of the contractor's QA/QC program shall be submitted to the EOR for review.

.2 Testing by The City:

.1 In addition to the Contractor's responsibility for QA/QC, The City may appoint a testing agency to perform independent QA testing as deemed necessary by The City.

.2 These inspections will be performed by testing agencies appointed by and paid for by The City.

.3 This testing is independent of the Contractor's QMP and shall not replace the Contractor's QC testing.

.3 The Contractor shall submit all test results and inspection reports to the EOR and The City for review.

.4 The Contractor shall allow for inspection of the forms and reinforcement by the Designer (Contractor's Engineer), the EOR, and The City before casting the first panel.

.5 Inspect concrete surfaces immediately after stripping or removing forms. Report immediately to the EOR any shapes and lines outside the specified tolerances.

.6 Remove and replace defective concrete per the submitted and approved repair procedure and to the satisfaction of the EOR.

.7 Engineered Backfill and Granular Base Material:

.1 Engineered backfill and granular base material required for the MSE retaining wall system shall be inspected and tested by a testing firm paid for by the Contractor to confirm that the Material meets design assumptions.

.2 This testing should be part of the Contractor's QC Plan.

.3 All testing data shall be current to within 1 year of the time of supply and shall be submitted to The City and the EOR for review.

.4 The Contractor's testing firm shall prepare the necessary Standard Proctor Density curves for all types of backfill used and will take as many field tests as required to properly ascertain compaction of backfill.

.5 Laboratory testing to ASTM D698 shall be undertaken by the Contractor to confirm the density of the sourced fill material.

.8 If new Materials are introduced to the Project, they shall be tested prior to use. Additional testing shall be at the Contractor's own expense.

.9 The Contractor and Supplier shall provide test data to confirm performance of the MSE retaining wall system. These shall include the following tests:

.1 Tensile strength of the soil reinforcing strips

.2 Full-scale testing of the complete panel-soil reinforcing connection assembly to failure (conducted within 1 year of construction commencement)

.3 Compaction tests of the backfill in place

.4 Tests for the electro-chemical properties of backfill

The EOR may request additional tests to be performed specific to the application.

.10 In the case of geo-grid reinforced MSE walls, the long-term creep (10 years from construction) of the geo-grid shall be limited to 5 mm.

1.11 Acceptability

.1 Failure to comply with the requirements of the Technical Specifications will result in the structure being considered potentially Deficient and may be cause for rejection by The City.

.2 Where evidence points to a potentially Deficient structure, the EOR may order an independent testing firm to obtain cores, x-rays, or similar non-destructive tests to confirm adherence to the Technical Specifications.

.3 The EOR may order a load test or analysis, or both, as defined by CAN/CSA-A23.3, if the non-destructive tests are impractical or inconclusive.

2 PRODUCTS

2.1 Concrete Materials

.1 Concrete components outside the traffic splash zone shall conform to Section 03300 of the Technical Specifications.

.2 Concrete components within the traffic splash zone shall conform to Section 03301 of the Technical Specifications.

.3 The traffic splash zone shall be determined as per the City of Calgary Design Guideline for Bridges and Structures.

.4 Concrete coping shall be consistent with panel concrete in Material and colour.

2.2 Concrete Mixes

.1 Supply concrete as shown in Table A.

Table A. MSE Wall Concrete Elements

Mix Type	Structural Element and Location	Reference Standard Specification
HPC2	Coping, precast MSE panels within splash zone	Section 03301, High-Performance Concrete
Type B-1	Coping, precast MSE panels not within splash zone	Section 03300, Cast-In-Place Concrete
Type E	Levelling pad unless HSb cement required per geotechnical report	Section 03300, Cast-In-Place Concrete

.2 Do not change concrete mix proportions or source Material for concrete without written approval of the EOR.

2.3 Grout Mixes

.1 All grout mixes shall be submitted to the EOR for review and approval prior to use.

.2 Epoxy grout shall be premixed in strict accordance with the manufacturer's instructions to obtain a minimum compressive strength of 70 megapascals (MPa) in 7 Days.

.3 Cement grout shall be mixed with enough water for placement and hydration, capable of developing a minimum compressive strength of 20 MPa in 7 Days and 35 MPa in 28 Days. Grout exposed to freezing conditions shall be air-entrained 4 to 7%.

.4 Dry pack grout shall be mixed with enough water for the mixture to make a sound solid pack, capable of developing a compressive strength of 35 MPa in 28 Days. Non-shrink grout shall be premixed in strict accordance with manufacturer's instructions to obtain a minimum compressive strength of 16 MPa in 24 hours and 50 MPa in 28 Days. Use Sika Grout 212 or approved alternate.

2.4 Concrete Reinforcing Materials

.1 Reinforcing steel shall conform to Section 03200, Concrete Reinforcement.

.2 Reinforcing steel shall be 400W grade and conform to CSA G30.18.

.3 All reinforcing steel shall be galvanized if the wall panels are in the traffic splash zone (above or full wall height below the road surface).

2.5 Metal Fabrications

.1 Welding shall conform to CSA W59.

.2 Galvanizing of steel components shall conform to ASTM A123/A123M.

.3 Pins and pipes used for alignment of panels during construction shall be made of durable Materials, such as galvanized steel or polypropylene, and shall be installed straight and in the locations shown on the fabrication drawings.

2.6 Formwork Materials

.1 Formwork materials shall conform to Section 03300, Cast-In-Place Concrete.

.2 Form oil shall not leave a residue on the concrete panel. All form oil shall be water soluble and be removed by power-washing prior to application of sealers.

2.7 Soil-Reinforcing Materials

.1 All Materials shall be inert or designed to resist expected naturally occurring alkaline and acidic soil conditions.

.2 Geosynthetic Reinforcing:

- .1 Geosynthetic reinforcing shall meet AASHTO LRFD Bridge Design Specifications, Clause 11.10.6.4.3b. The requirements for "…applications involving severe consequences of poor performance or failure…" shall apply.
- .2 Results of product-specific durability studies carried out to determine the product-specific long-term strength reduction factor shall be submitted for the EOR's review and approval. These studies shall be used to estimate the short- and long-term effects of the environment factors on the strength and deformational characteristics of the geosynthetic reinforcement throughout the specified design life.
- .3 Geosynthetic reinforcing materials shall satisfy the requirements of the following tests, with the understanding that the test methods are current at the time of construction:
  - .1 ASTM D5262
  - .2 ASTM D6637
  - .3 ASTM D6706
  - .4 ASTM D7737M
  - .5 GSI GRI GG 4(a)
  - .6 GSI GRI GG 4(b)
- .4 Geosynthetic reinforcing materials shall contain stabilizers or inhibitors to prevent degradation of properties due to ultraviolet (UV) light exposure.
- .5 The nominal long-term reinforcement material design strength (Tal) values for specific products shall be determined by third-party agencies, such as the Highway Innovative Technology Evaluation Centre (HITEC) or AASHTO National Transportation Product

Evaluation Program (NTPEP), and product lines shall be retested at least every 3 years.

.6 Polymeric materials, if approved, shall contain stabilizers or inhibitors to prevent degradation of properties due to UV light exposure.

.3 Steel Soil Reinforcing:

.1 The design life of the corrosion protection system for steel soil reinforcing shall be defined as the time elapsed for the effects of corrosion to reduce the cross-sectional area such that the strength of the reinforcing is reduced to the point where the average stress over the remaining area meets the requirements of the design.

.2 The design life of reinforcing shall not be less than 100 years.

Steel material shall be galvanized per ASTM A123/A123M to a coating thickness of at least 0.087 mm, or as required to meet the design life but not less than 0.087 mm. Any repair of galvanizing shall be done in accordance with ASTM A780..4 The design of galvanized steel soil-reinforcing connection components shall consider potential steel embrittlement due to the galvanizing process and the cold service temperatures.

2.8 Backfill Materials

.1 All backfill placed within the wall volume shall be free from organic or otherwise deleterious substances and shall be within the following gradation limits, as shown in Table B.

.2 The structural backfill shall be crushed aggregate material free of organic matter and other deleterious substances, conforming to the requirements of Table B (next page).

Table B. Backfill Requirements

Designation and Class			
Metric Sieve Size (CGSB 8-GP-2M)	**Crushed Aggregate Material Des 2 Class 20**	**Crushed Aggregate Material Des 2 Class 25**	**Crushed Aggregate Material Des 2 Class 40**
Sieve Size (µm)	**Percent Passing (%)**	**Percent Passing (%)**	**Percent Passing (%)**
125,000	-	-	-
80,000	-	-	-
50,000	-	-	-
40,000	-	-	100
25,000	-	100	70-94
20,000	100	82-97	-
16,000	84-94	70-94	55-85
10,000	63-86	52-79	44-74
5,000	40-67	35-64	32-62
1,250	22-43	18-43	17-43
630	14-34	12-34	12-34
315	9-26	8-26	8-26
160	5-18	5-18	5-18
80	2-10	2-10	2-10
% Fractures by Weight (2 faces)	60+	60+	50+
Plasticity Index	NP - 6	NP - 6	NP - 6
Los Angeles Abrasion Loss % Maximum	50	50	50

Notes:

- = not applicable
% = percent
µm = micrometres(s)
Des = designation
NP = non-plastic

.3 The Contractor shall test backfill material for friction angle by Direct Shear Test or Tri-axial Test.

.4 Any backfill within the retaining wall volume, whether from a natural or an industrial source, shall be tested and meet the following criteria as shown in Tables C1 or C2.

Table C1. Electrochemical Properties of Backfill when using Galvanized Steel Soil Reinforcement

Select Backfill Requirements		Test Method (ASTM)	Test Method (AASHTO)
Resistivity	≥3,000 ohm-cm	G187	T 288
pH	5-10	G51	T 289
Chlorides	≤100 ppm	D4327	T 291
Water-soluble sulphates	≤200 ppm	D4327	T 290
Magnesium sulphate soundness	Loss <30% after four cycles	D5240	T 104
Organic content	≤1.0%	D2974	T 267

Notes:

≤ = less than or equal to
≥ = greater than or equal to
ohm-cm = ohm(s) per centimetre
ppm = part(s) per million

Table C2. Electrochemical Properties of Backfill when using Geo-synthetic Reinforcement

Select Backfill Requirements		Test Method (ASTM)	Test Method (AASHTO)
pH	4.5-9	G51	T 289
Organic content	≤1.0%	D2974	-
Design temperature at the wall site	≤30°C	-	-

.5 Use of Materials outside of the criteria stated or referenced herein requires the written consent of the EOR. The Designer shall provide written confirmation certifying that the backfill material for the wall meets the stated requirements and any additional requirements specified by the EOR. All test results shall be submitted to The City.

.6 In no case shall any backfill within 2000 mm from the back of the facing panels have more than 5% passing the 0.080-mm sieve size.

2.9 Low Fines Crushed Granular Fill (Winter Fill)

.1 The use of winter fill shall not be permitted unless approved by the EOR.

.2 If the projected temperatures at the time of fill placement are below 0°C for 8 hours or more, 40 mm minus, low fines crushed granular fill from natural sources only (no slag) shall be used. In particular, this Material shall be used where compaction is required in winter conditions but is not limited to winter use only.

.3 The gradation of the proposed Material shall be developed by the Designer; however, less than 1% of the fill shall pass the 5,000-μm sieve, and the Material passing shall exhibit two or more fracture faces.

.4 Any changes including the use of winter backfill in the design of the reinforcing strips, filter fabric, or other details shall also be identified and submitted to the EOR for review.

.5 Geotextile fabric shall be placed between all low fines crushed granular fill and all other fill.

.6 Impermeable geomembrane shall be PVC, high-density polyethene (HDPE), or linear low-density polyethene (LLDPE), with a minimum thickness of 0.75 mm, and comply with the minimum physical properties listed in Table D.

Table D. Impervious Geomembrane Specifications and Physical Properties

Physical Property (Specification)	Value
Tear Strength (ASTM D1004)	45 N
Puncture Strength (ASTM D4833)	140 N

2.10 Panel Joint Materials

.1 Bearing Pads:

.1 Bearing pads shall be of appropriate size and stiffness to resist the combined loads of panel self-weight and downdrag forces acting on soil reinforcement connections and to maintain the specified vertical gap between the facing panels.

.2 Bearing pad properties shall meet the required performance criteria through the full range of anticipated service temperatures for the design life of the wall.

.3 Pads shall conform to the following Material standards:

.1 Ethylene propylene diene monomer (EPDM) rubber pads conforming to ASTM D2240, Scale A, having a Shore durometer hardness of 75 ±5.

.2 HDPE pads with a minimum density of 0.946 gram per cubic centimetre (gm/cm3) in accordance with ASTM D1505.

.2 Joint Cover:

.1 Horizontal and vertical panel joints shall be covered by a geotextile.

.2 The geotextile may be either a nonwoven, needle-punched, polyester geotextile; or a woven, monofilament, polypropylene geotextile as approved by the Designer.

.3 Filter fabric used behind joints in facing panels shall be Terrafix 270R or approved equal.

.3 Adhesive:

.1 The adhesive used for securing filter fabric to the back of panel joints shall be per the Designer's recommendations.

.2 Application of excessive thickness of adhesive shall be avoided.

3 EXECUTION

3.1 General

.1 The ground on the exposed side of the wall facing shall slope away from the wall. The surface water on the backfill side shall be drained away from the wall to prevent runoff next to the facing panels and ponding above the reinforced zone.

.2 No drilling or driving of posts (including for signs or guard rails) or any other roadside hardware through the reinforced backfill shall occur after placement of backfill unless approved by The City in writing.

.3 No buried utilities other than specifically approved shall be placed within the reinforced earth zone. The placement of drainage components shall occur only during construction backfilling.

.4 Obstructions:

.1 At vertical or horizontal obstructions, the reinforcement shall not be angled more than 15° from perpendicular to the wall.

.2 No exceptions to this shall be allowed without verifying with the Designer and EOR.

.3 A minimum of 100 mm clear shall be provided between the obstruction and the reinforcement.

.5 The joint between precast MSE walls and CIP elements shall be protected from loss of fines and shall allow for differential settlement between the two types of construction.

.6 Where walls or wall sections intersect with an angle of 130° or less, a special vertical corner element panel shall be used. The corner element panel shall cover the joints of the panels that abut the corner and allow for independent movement of the abutting panels.

.7 For hillside construction, drainage blankets shall be used to collect and divert groundwater from the reinforced soil mass.

.8 Where coping or barrier is used, the wall facing panels shall extend up into the coping or barrier a minimum of 50 mm.

.9 Weeping Drains:

.1 Weeping drains shall be provided near the front and back bottom corner of the MSE mass.

.2 The weeping drains shall be daylighted and sloped for positive drainage.

.3 A water level within the MSE mass shall be assumed to the invert level of weeping drains.

3.2 Corrosion Monitoring Components

.1 Galvanized steel inspection coupons or wires shall be provided for all MSE walls; provide one inspection bar and wire for each 25 square metres (m^2) of wall facing area.

.2 Inspection wires for each area shall be located in the centre of the top and bottom facing panels for walls shorter than 6.0 m; and in the centre of top, middle, and bottom panels for walls 6.0 m or taller.

.3 Sets of four inspection wires so arranged shall be distributed evenly along the length of the wall.

.4 Inspection coupon and wire access ports shall be a minimum of 150 mm in diameter and shall be sealed against ingress of runoff and road splash.

.5 Ports shall be formed in the panels during fabrication, grouted with an approved vertical and overhead repair mortar, and marked with 25-mm diameter galvanized or plastic survey markers.

.6 Inspection coupon and wires shall match the actual soil reinforcement with regards to cross-section and coating thickness, shall be a minimum of 1.0 m in length, shall be installed perpendicular to the wall facing, and shall be detailed to permit the bar and wires to be pulled out of the reinforced soil without damage to the facing panels.

.7 Inspection coupons and wires shall be weighed and measured prior to installation. The Contractor shall provide record drawings showing all test coupon locations and coupon properties.

3.3 Sample Panels

.1 Two sample precast facing panels shall be constructed for the EOR's approval, demonstrating the required standard for concrete colour, quality, and finish including form liners. One panel shall have pigmented sealer applied (colour per Drawings), and the second panel shall be without colour.

.2 After approval, these samples shall be maintained in the plant as a control sample of Materials and workmanship. These samples may constitute part of the last delivery to the site and be permanently built into the Work.

.3 The standard of these finishes on the sample panels shall be rigidly adhered to, and any panels not meeting this standard will be rejected.

3.4 Facing Panel Fabrication

.1 Place reinforcing steel per Section 03200, Concrete Reinforcement.

.2 Place, cure and finish concrete per Section 03300, Cast-In-Place Concrete and Section 03301, High-Performance Concrete, as applicable.

.3 Do not core concrete without prior written approval of the EOR.

.4 Do not drill inserts or drive power-actuated fasteners into concrete without prior written approval of the EOR.

.5 For HPC, cure precast concrete panels by one of the following methods:

.1 Steam cure for a minimum 4 Days or

.2 Moist cure for a minimum of 7 Days

.6 Panel Finishing:

.1 The front face of all panels shall have a smooth finish conforming to a Class 2 - Rubbed finish unless otherwise noted on the Drawings.

.2 Consistency of the finish shall be maintained with the use of the same concrete mix for the entire Project.

.3 The rear face of the panel shall be an unformed surface finish, screeded with no open pockets or distortions in excess of 6 mm.

.4 Patch defects, and remove fins exceeding 5 mm.

.5 Repair cavities produced by temporary inserts, honeycomb spots, broken corners or edges, and other defects using approved procedures and Materials.

.6 Repair mortar shall be compatible with concrete materials.

.7 Sandblasting:

.1 Sandblasting, if approved, is not to occur before the recommended curing period has elapsed.

.2 Use only competent and qualified workers experienced in sandblasting techniques with adequate plant and equipment.

.3 Protect from damage all surfaces not scheduled for sandblast finish by hoarding around the Work area. Make good any damaged surfaces to the satisfaction of the EOR.

.4 Provide a mock-up area of minimum dimensions 1 m by 1 m of the sandblast finish, for The City and EOR’s review. The mock-up may be permanently built into the Work, if approved.

.8 Sealers:

.1 Apply silane or pigmented sealer as specified on the IFC Drawings.

.2 Apply approved coating sealer after the curing period in strict accordance with the manufacturer’s recommendations.

.3 If panels are to be sealed, apply to front face, top, and sides of panels.

.4 See Section 03300, Cast-in-Place Concrete for approved products.

.9 Deficient Work:

.1 Inspect panels onsite prior to installation. Panels shall be subject to rejection due to failure to meet the requirements in the Technical Specifications. In addition, any of the following Deficiencies shall be sufficient reason for rejection:

.1 Deficiencies that indicate imperfect moulding

.2 Deficiencies indicating honeycombed or open-texture concrete

.3 Lifting inserts, tie strips, and pin and pipe not properly set

.4 Broken or cracked corners or texture details

.5 Soil reinforcement attachment devices improperly installed or damaged

.6 Precast component thickness in excess of ±5 mm from that shown in the Technical Specifications

.7 Stained front face due to excess form oil or other reasons

.2 Repair cracks per Section 03300, Cast-In-Place Concrete and Section 03301, High-Performance Concrete, as applicable.

3.5 Handling, Transportation and Storage

.1 Lifting Inserts:

.1 Lifting inserts shall be cast in the locations shown on the Shop Drawings.

.2 Lifting hooks should be designed so that capacity is adequate for lifting the element safely without compromising the integrity of the element.

.2 Inserts shall be clean and free of all obstructions for rapid connection of lifting devices.

.3 Cover and protect all Materials from rain, snow, and dirt.

.4 Handle, store and ship all panels in such a manner as to eliminate the potential for damage, such as chipping, cracks, and fractures, as well as excessive bending stresses and damage to protruding or otherwise exposed components.

.5 Stack precast panels on timber planks and separated by firm timber blocks 300 mm in from the panel ends and immediately adjacent to tie-strips to avoid bending the tie-strips, in stacks of no more than five panels high.

.6 Protect panels from discolouration and staining of the front face.

.7 Store soil reinforcing materials and connectors clear of the ground.

.8 Take care to prevent mud, cement, and other contaminants from sticking to the soil reinforcing materials.

.9 Take care not to break or pull out geogrid or soil reinforcing strips that are attached to panels.

3.6 Wall Excavation

.1 Establish the locations and extents of all Utility Facilities in the Work area prior to commencement of excavation work by notifying the applicable Utility Owners. Clearly mark such locations.

.2 Confirm locations of Utility Facilities by careful test excavations.

.3 Protect benchmarks, existing structures, roads, sidewalks, paving, curbs, and Utility Facilities that could be damaged by excavation work. Repair any damage done to existing Facilities or Utility Facilities at no additional cost to The City.

.4 Comply with the requirements of the responsible regulatory agencies, such as the Workers' Compensation Board of Alberta and OH&S Legislation. The excavation cut slope that can be safely cut shall be determined by the Contractor's Geotechnical Engineer.

.5 When draining excavations, direct discharge from pumps so that damage does not occur to the Project Site and adjacent properties. Do not discharge water containing silt into City sewers or rivers. A drainage permit may be required.

.6 Protect excavations by shoring, bracing, sheet piling, under-pinning, or by other methods as required to prevent cave-ins or loose dirt from falling into excavations.

.7 Remove from the site excavated material not used for backfilling.

.8 Remove all organic material from the area.

.9 Use best practices for erosion and sediment control, as defined in the submitted Environmental Construction Operations (ECO) Plan.

.10 Inspection of Excavation:

  .1 Proof-roll the foundation subgrade to identify soft spots.

  .2 Soft material identified by the Contractor shall be excavated and replaced with compacted, crushed aggregate as approved by the Designer.

  .3 When the subgrade is prepared, arrange for an inspection by the Designer to confirm conformance with the approved wall design parameters. Notify The City two days prior to this inspection.

  .4 Once foundation subgrade has been inspected, submit documentation confirming acceptance of the foundation by the Designer.

3.7 Wall Backfilling

.1 Backfill MSE wall excavations with pre-approved, free-draining material, or low fines crushed granular fill conforming to Material requirements included in Section 2.

.2 Confirm areas to be backfilled and backfill stockpiles are free from debris, snow, ice, and water.

.3 Do not backfill against frozen ground.

.4 Place and compact backfill in an unfrozen state.

.5 Place backfill closely following the erection of each course of panels.

.6 Place backfill in such a manner as to avoid damage or disturbances of the wall materials or misalignment of the facing panels.

.7 Remove and replace, at the Contractor's own expense, any wall materials that become damaged during backfill placement.

.8 Correct any misalignment or distortion of the facing panels due to placement of backfill outside the limits of the Technical Specifications at the Contractor's own expense.

.9 The maximum lift thickness after compaction shall not exceed 200 mm, regardless of the vertical spacing between layers of soil reinforcements.

.10 Use only hand-held power tampers and vibrators for compaction within 1,000 mm of walls.

.11 At the end of each day’s operation, slope the last level of backfill away from the wall facing to direct runoff away from the wall face. In addition, do not allow surface runoff from adjacent areas to enter the wall construction site.

.12 Bring backfill up to 400 mm from the final intended grade.

.13 Remove and replace or rework Materials not conforming to the Technical Specifications. The cost of replacing or reworking and retesting is shall be borne by the Contractor.

.14 Install drainage swales and any other features as shown on the IFC Drawings upon completion and acceptance of the wall erection and backfilling.

3.8 Tolerances

.1 Precast Facing Panel Tolerances:

.1 Precast Component Dimensions:

.1 Lateral position of soil reinforcement attachment devices shall be within 25 mm.

.2 All other dimensions shall be within 5 mm.

.2 Precast Component Squareness shall meet an angular distortion of the component not exceeding 5 mm in 1.5 m.

.3 Precast Component Surface Finishes shall include surface defects on smooth, formed surfaces measured on a length of 1.5 m not exceeding more than 3 mm. Surface defects on textured finished surfaces measured on a length of 1.5 m shall not exceed 6 mm.

.4 If cumulative distortions or defects are preventing proper installation of the MSE wall system, panels shall be rejected and shall be replaced at the Contractor's own expense.

.2 Tolerances for Permanent Walls:

.1 The Contractor shall verify that horizontal alignment tolerances do not exceed 15 mm when measured with a 3-m straight edge.

.2 The final overall vertical tolerance of the completed wall (plumbness from top to bottom relative to the plane of the wall shown on the Shop Drawings) shall not exceed 5 millimetres per metre (mm/m) of wall height.

.3 The offset of adjacent panel edges at joints shall not exceed 10 mm.

.4 The variation for minimal joint gap shall not exceed ±10 mm.

.5 Walls that do not meet these tolerances will not be accepted by The City and shall be removed and reconstructed at no cost to The City.

3.9 Certification

.1 Certify, at the completion of Work, under the seal and signature of the Designer responsible for this Work, that all connections and components designed and installed by the Contractor are capable of supporting the loads and forces indicated in the Technical Specifications.

.2 Certify that all connections and components are fabricated and installed in accordance with the reviewed design and Shop Drawings.

4 MEASUREMENT AND PAYMENT

4.1 Measurement

.1 Measurement of MSE wall systems including variations from the tendered area shall be measured in square metres (m^2) of total face of wall placed in accordance with the approved Shop Drawings.

.1 Measurement shall be from the top of the wall coping to the top of the levelling pad from the final Shop Drawings.

4.2 Payment

.1 Payment for the Work of this section shall be on a unit price basis per square metre (m^2) of total face of wall as tendered, which shall be full compensation for the following:

.1 MSE wall design including the cost of engineering and revisions, Quality Control, inspections and project closure documentation including Record Drawings.

.2 Labour, Materials, and Construction Equipment necessary to complete the Work, including all subsidiary and incidental items necessary to the complete construction, in accordance with the Agreement.

END OF SECTION

1 GENERAL

1.1 Work Included

.1 This section outlines the requirements for the supply, fabrication, delivery and erection of structural steel for use in bridges and other steel structures.

1.2 Related Work Specified in Other Sections

.1	Metal Fabrications	Section 05500
.2	Bridge Bearings	Section 05650
.3	Expansion Joint Assemblies	Section 05820
.4	Coatings for Steel	Section 09719

1.3 Reference Standards

.1 Perform the Work of this section in accordance with the latest edition of the following standards available at the Effective Date, except where specified otherwise.

.2 Alberta Transportation - Approved Products List.

.3 ASTM International (ASTM):

- .1 ASTM A6/A6M - 17a, Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling
- .2 ASTM A29/A29M, Standard Specification for General Requirements for Steel Bars, Carbon and Alloy, Hot-Wrought
- .3 ASTM A108, Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished
- .4 ASTM A123/ A123M, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
- .5 ASTM A276, Standard Specification for Stainless Steel Bars and Shapes
- .6 ASTM A563/A563M, Standard Specification for Carbon and Alloy Steel Nuts
- .7 ASTM A780, Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
- .8 ASTM E10, Standard Test Method for Brinell Hardness of Metallic Materials
- .9 ASTM E165, Standard Test Method for Liquid Penetrant Examination for General Industry
- .10 ASTM E709, Standard Guide for Magnetic Particle Testing
- .11 ASTM F2329/ F2329M, Standard Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners

.12 ASTM F3125/F3125M, Standard Specification for High Strength Structural Bolts and Assemblies, Steel and Alloy Steel, Heat Treated, 830 MPa and 1040 MPa Minimum Tensile Strength

.13 ASTM F436/F436M, Standard Specification for Hardened Steel Washers Inch and Metric Dimensions

.4 Canadian General Standards Board (CGSB):

.1 CAN/CGSB, 1.171, Inorganic Zinc Coating

.2 CAN/CGSB-48.9712, Non-destructive testing — Qualification and certification of NDT personnel (International Organization for Standardization [ISO] 9712:2012, IDT)

.5 CSA Group (CSA):

.1 CAN/CSA S6, Canadian Highway Bridge Design Code

.2 CSA G40.20/G40.21, General requirements for rolled or welded structural quality steel / Structural quality steel

.3 CSA W178.1, Certification of welding inspection organizations

.4 CSA W178.2, Certification of welding inspectors

.5 CSA W47.1, Certification of companies for fusion welding of steel

.6 CSA W48, Filler metals and allied materials for metal arc welding

.7 CSA W59, Welded steel construction

.8 CSA Z245.1, Steel pipe

.6 International Organization for Standardization and International Electrotechnical Commission (ISO/IEC):

.1 ISO/IEC 17025, General requirements for the competence of testing and calibration laboratories

.7 The Society for Protective Coatings (SSPC):

.1 SSPC PA 2, Determining Compliance to Required DFT

.2 SSPC PA Guide 13 – Guide for Application of Coating Systems with Zinc Rich Primers to Steel Bridges

.3 SSPC-SP 10, Near-White Metal Blast Cleaning (NACE No. 2)

.4 SSPC-SP 2, Hand Tool Cleaning

.5 SSPC-SP 3, Power Tool Cleaning

.6 SSPC-SP 6, Commercial Blast Cleaning (NACE No. 3)

.8 Other American Standards:

.1 Aerospace Material Specification (AMS) - Standard 595A, Standard Colors Used in U.S. Government Procurement

.2 American Association of State Highway and Transportation Officials (AASHTO) LRFD Bridge Design Specifications

.3 American National Standards Institute (ANSI) American Society of Mechanical Engineers (ASME) B46.1, Surface Texture (Surface Roughness, Waviness, and Lay)

.4 American Welding Society (AWS) D1.5M, Bridge Welding Code

.5 AWS A5.1/A5.1M, Specification for Carbon Steel Electrodes for Shielded Metal Arc-Welding

.6 American Petroleum Institute (API) API Spec 5L, Specification for Line Pipe

1.4 Definitions

.1 Unless a word is defined within this section, capitalized words used herein reference the definition provided within The City of Calgary Standard General Conditions.

.2 “Girders” as used in this document shall be defined as primary bridge superstructure elements, including girders, trusses, and arches.

1.5 Qualifications

.1 Shop qualification:

.1 The Contractor shall be certified by the Canadian Welding Bureau (CWB) per CSA W47.1 as follows:

i.	Steel girders, girder components,	Division 1
ii.	All other bridge elements,	Division 1 or 2
iii.	Field welds or repairs,	Division 1 or 2

An equivalent agency approved by the Engineer may be considered as an alternate.

.2 Welding procedures shall be submitted for each type of weld used in the structure. The procedures shall bear the approval of the CWB and are also to be approved by the Engineer prior to use on the structure.

.3 Fabricators of steel plate girders shall have Canadian Institute of Steel Construction (CISC) Quality Certification in the Steel Bridges category. Fabricators of steel trusses shall have CISC Quality Certification in the Steel Bridges or Steel Structures Category.

.2 Welder qualifications:

.1 Only welders, welding operators, and tackers approved by the CWB or by an equivalent agency approved by the Engineer in the particular category under consideration shall be permitted to perform weldments. Their qualifications shall be current and available for examination by the Engineer.

.3 Weld inspection:

.1 The organization and individual performing weld inspections shall be certified by the CWB under the requirements of CSA-W178.1.

.2 Visual inspectors shall be certified under the requirements of CSA W178.2 Level 2 or 3.

.3 Inspectors performing non-destructive testing shall be qualified for the relevant testing method in accordance with the requirements of CAN/CGSB-48.9712, Level 2 or 3.

.4 Procedure Qualification Tests:

.1 Procedure Qualification Tests shall be performed on all non-standard weld types, which shall be tested in accordance with CSA W59 and CSA W47.1.

.2 Procedure Qualification Tests shall be completed sufficiently in advance of the start of the affected work to allow time for review by the Engineer and correction by the Contractor without delaying the Work.

1.6 Submittals

.1 Shop Drawings, or the equivalent, shall be submitted by the Contractor.

.2 The Contractor shall submit, in writing, evidence of welding qualifications under CWB.

.3 The Contractor shall provide and keep current a complete fabrication schedule in a form satisfactory to the City's Engineer.

.4 The Contractor shall submit mill certificates for all steel including fasteners and shear studs, used in fabrication, as follows:

.1 Fabrication shall only be allowed with materials having mill certificates properly correlated to the materials used on the Project and that have been reviewed and accepted by the City's Engineer.

.2 Mill test reports shall be submitted to the City's Engineer for review and acceptance at least twenty (20) Business Days prior to the scheduled start of fabrication.

.3 Test reports for all materials shall be written in English.

.4 The Contractor shall have all steel, including billets, bars, and fasteners, originating outside of Canada or the United States (U.S.) verified by a certified laboratory in Canada, as follows:

.1 This laboratory shall be certified by an organization accredited by the Standards Council of Canada to comply with the requirements of ISO/IEC 17025 for the specific tests, or type of tests, required by the material standard specified in the mill test report.

.2 The material shall be tested to the specified material standards, including a determination of boron content, which is not permitted to exceed 0.0008%.

.3 Preparation and collection of samples for testing shall be directed and witnessed by, or completed by, personnel employed by the testing lab.

.5 A verification letter, signed and sealed by an Engineer registered in the Province of Alberta in the field of metallurgy and bearing the signature of an authorized officer of the testing laboratory, shall be provided by the laboratory and shall include references to the following:

.1 Appropriate mill test report(s)

.2 material specification number(s)

.3 Testing standards

.4 Date(s) of testing

.5 Statements indicating material compliance with the requirements of the Agreement.

.5 Prior to commencement of fabrication, the Contractor shall present for acceptance an outline of the fabrication sequence that clearly describes the order of make-up and assembly of all component parts, as well as shop assembly, hold points and cleaning.

.6 The Contractor shall provide CWB-certified welding procedures for all processes, joint configurations and materials for approval by the City's Engineer. All welding procedures submitted are to bear the seal of an Engineer registered in the Province of Alberta with the appropriate CWB qualification. Approval of submitted procedures does not relieve the Contractor of responsibility for compliance with the project Technical Specifications and all referenced standards.

.7 Contractor to submit written procedures for fracture-critical, non-critical repairs and cutting methods to the City's Engineer in accordance with Section 3.1 of this specification.

.8 The Contractor shall provide certification for the welding consumables.

.9 The Contractor shall provide a fabricated sample of steel, including machine and manual welds (ground flush and sanded with laminar discs) and internal and external corners of steel plate no less than 10 millimetres (mm) thick with the coating system applied for approval. The sample shall be submitted sufficiently in advance of the start of the affected work to allow time for review by the City's Engineer and correction by the Contractor without delaying the Work.

.10 Shop Drawings:

.1 Fabrication drawings (Shop Drawings) showing details of all steel elements shall be prepared by the Contractor and submitted to the City's Engineer for review prior to fabrication.

.2 Fabrication drawings shall be submitted at least 20 Business Days prior to the scheduled start of fabrication. Fabrication drawings shall be submitted sufficiently in advance of the start of the affected work to allow time for review by the City's Engineer and correction by the Contractor without delaying the Work.

.3 Fabrication drawings shall be submitted for review electronically in unlocked Adobe Portable Document Format (PDF).

.4 In addition to specific details, the shop drawings shall include the following items:

.1 All bolted and welded connections. Connections designed by the Contractor shall be authenticated by an Engineer registered in the Province of Alberta.

.2 Material properties with reference to the mill certificates.

.3 Temporary attachments if permitted by the City's Engineer.

.4 Weld procedure identification shall be shown on the Shop Drawings in the tail of the weld symbols.

.5 All material splice locations.

.6 Identification of all material heat numbers on the Shop Drawings shall be required per Clause 3.3.3.

.7 Proposed variations, either to suit fabrication in the Contractor's works or to suit the chosen erection procedure, such as extra welds or relocated joints.

.8 Dimensions for all elements, with dimensions shown correct at 15 degrees (°) unless otherwise noted and shall account for any dimensional changes during fabrication.

.9 Bearings shall be detailed per the setting table shown on the Issued Construction Drawings.

.5 Shop drawings shall cover all elements of the structure. Shop drawings showing partial details or details of some elements, but not all, will not be reviewed until all details are submitted to the City's Engineer.

.6 No departure from the approved welding procedure or from the details shown on the reviewed Shop Drawings shall be made without the approval of the City's Engineer. Such approval does not relieve the Contractor of their responsibility for compliance with Project Technical Specifications.

.11 The Contractor is to prepare and submit a transportation plan to the City's Engineer for approval.

1.7 Quality Control, Quality Assurance, and Inspection and Testing

.1 Quality Control:

.1 The Contractor's QC shall include, at a minimum:

.1 The Contractor shall submit documentation to the City's Engineer verifying conformance to the requirements for any QC certification programs and all applicable governing Technical Specifications and standards. As part of their quality assurance (QA) program, the Contractor shall be responsible for engaging an independent quality control (QC) organization for welding inspection on all structural steel fabrication.

.2 The documentation shall be submitted with the QC plan submitted to the City's Engineer or The City's testing agency.

.2 Quality Assurance:

.1 The Contractor's plan for QA/QC shall be included in the Quality Management Plan (QMP) and submitted to the City's Engineer for review prior to starting any steel fabrication.

.2 All QA/QC, including testing as part of the Contractor's QMP, shall be paid for by the Contractor.

.3 The Contractor's QA shall include the following:

.1 All welds shall be visually inspected.

.2 Methods of non-destructive examination shall be in accordance with the TABLE A.

TABLE A – Non-destructive Examination Requirements

Examination	Standard
Radiography	CSA W59
Ultrasonic	CSA W59
Magnetic Particle Inspection (MPI)	ASTM E709
Dye-Penetrant	ASTM E165
Hardness Tests	ASTM E10

Unless otherwise noted, evaluation of all flaws shall be in accordance with CSA W59.

.3 Testing and Inspection:

.1 Testing by the Contractor:

.1 The Contractor's inspection and testing scope is as detailed herein.

.2 Additional testing made necessary by material substitutions, the repair of faulty work, and additional unspecified material splices shall be paid for by the Contractor.

.3 Any test records made by the fabricating shop in the course of QA/QC shall be submitted to the Engineer for review and acceptance.

.4 The results of all QA/QC testing shall be submitted to the Engineer immediately as they become available.

.2 Testing by The City:

.1 In addition to the Contractor's responsibility for QA/QC, The City may appoint a testing agency to review the Contractor's QA/QC results and to perform independent QA testing as deemed necessary.

.2 The City may perform visual, radiographic, ultrasonic, and magnetic particle (MPI) testing, as well as other inspections. These inspections will be performed by testing agencies appointed by and paid for by The City.

.3 This testing is independent of the Contractor's QMP and shall not replace the Contractor's QA testing.

.4 In the event of discrepancies in test results between City- tests and Contractor-performed tests, additional testing may be ordered by The City. The costs of additional testing may be charged to the Contractor if the additional tests confirm that material or workmanship is Deficient.

.3 QA Inspection Schedules:

.1 Welds shall be tested at the frequency described in TABLE B.

.2 The percentage indicated for every type of non-destructive test applies to every weld longer than 1.5 metres (m) unless otherwise indicated by the City's Engineer. Welds shorter than 1.5 m shall be grouped, and the inspection shall be done for the full length to the percentage of welds indicated.

.4 Hardness tests:

.1 Hardness tests will be performed by the Contractor's QA testing agency on the flame-cut edges of Girder flanges prior to assembly.

.2 Unless otherwise noted, the hardness of the flame cut edges shall not exceed a maximum Brinell, noted as follows:

.1 For carbon steels with a yield strength less than and including 300MPa, the maximum Brinell shall be 200 Brinell hardness number (BHN).

.2 For carbon steels with yield strength greater than 300 MPa, the maximum Brinell shall be 220 BHN.

.3 Remedial work shall be performed to any edges that exceed the specified hardness and the repaired area re-inspected prior to assembly.

.4 A minimum of three readings for each cut edge of the plate (one each end and one at the mid-point along the length of a cut edge) shall be taken.

.5 Dye Penetrates Inspection: Dye penetrates inspection shall be performed at the ends of the weld metal of all flange butt welds after the removal of runoff tabs. Defects discovered by this inspection shall be repaired by the Contractor at the Contractor's expense and the suspect area re-inspected.

.6 Shear Stud Connectors: Shear stud connector testing standards and frequency shall meet requirements outlined in CSA W59.

TABLE B – Weld Inspection Schedule

Examination	Element	Inspection Schedule	
		Weld Type	**Percent Tested**
Radiographic or Ultrasonic	Trusses and Arches	Tension Chord Butt Welds	100%
		Compression Chord Butt Welds	50%
		Groove welds connection tension and compression chords	100%
		Groove welds between web members and compression or tension chords	100%
		Groove welds between floor beams and tension chords	100%
	Welded plate girders	All tension flange and stress reversal butt welds, all diaphragm butt welds, and any groove welded attachments to flange plates	100%
		All other flange butt welds randomly selected by The City's Engineer	25%
		Web butt welds in tension and stress reversal zones, plus an additional 300 mm of web butt weld in the compression zone at the end of the web	100%
Magnetic Particle Inspection	Trusses and Arches	Fillet welds between floor beams and tension chords	50%
		Groove and fillet welds between tension chords and embedded stiffener plate	50%
		All other fillet welds	25%
		All manual (shielded metal arc welding [SMAW]) welds	100%
	Welded plate girders	Web to flange welds or any filet welds placed on flange plates	50%
		Web to stiffener plates	20%
		Stiffener to flange welds	100%
		Bearing sole plate to flange welds	100%
		Diaphragm connector plate welds	20%

.7 Testing Coordination:

.1 The Contractor shall provide adequate notice of fabrication and inspection schedules to the City's Engineer and any City-retained inspection agencies.

.2 Access to the Work shall be assured at all times.

.3 The Contractor shall provide the City's Engineer with the sequence of fabrication so that the inspection program can be properly integrated and agreed to prior to commencement of fabrication.

.8 Inspection Hold Points:

.1 To perform each stage of inspection in an orderly manner during the fabrication of major structures, inspection hold points shall be set up at specific stages of fabrication.

.2 Certain items of the Work shall then be checked, and Deficiencies shall be corrected prior to the Work progressing to the next stage of fabrication.

.3 These hold points shall be determined by the Contractor and coordinated with the City's Engineer and any City-retained inspection agencies prior to commencement of fabrication.

.4 The City's Engineer reserves the right to stop detrimental fabrication between checkpoints if deemed necessary.

.5 An Inspection Hold Point Plan shall be included in the Contractor's QMP.

.9 The fabricator shall notify the City's Engineer and The City's QA Inspector a minimum of two Business Days prior to shipment of any fabricated materials leaving the fabricator's shop. This notice is to facilitate final inspection of the materials.

.10 Steel work inspections:

.1 Steel work shall be inspected for surface defects and exposed edge laminations during fabrication and blast cleaning.

.2 Significant edge laminations found shall be reported to the City's Engineer for evaluation.

.3 Following rectification, these areas shall be re-tested to the satisfaction of the City's Engineer.

.11 No protective treatment shall be applied to the Work until the appropriate inspection and testing has been carried out.

.12 All loose rust and scale, slag residue, and weld spatter shall be removed prior to inspection.

.13 The City's Engineer may request additional specific testing during the construction of the steel structure.

.14 Destructive testing shall be performed on all failed procedure trials and as requested by the City's Engineer at the Contractor's expense.

1.8 Acceptability

.1 Failure to comply with the requirements of these Technical Specifications will result in the structure being considered potentially Deficient.

.2 Any Deficient work identified through QA/QC shall be documented on a Non-conformance Report (NCR) with a proposed remedial solution and measures to prevent a recurrence.

.3 The NCR shall be forwarded to the City's Engineer or testing agency, or both, for review and acceptance.

.4 Additional testing, inspection, and evaluation may be required where QA testing and inspection suggest a potentially Deficient structure. All additional testing deemed necessary to determine the extent of Deficient work shall be paid for by the Contractor.

.5 The Contractor shall be responsible for the costs and schedule implications for any corrective action required.

.6 The Contractor shall pay all costs for additional testing, inspection, and analysis required to demonstrate the adequacy of a structure that does not meet the requirements of the Agreement. The Contractor shall be responsible for any project costs associated with schedule delays related to demonstrating the adequacy of the structure.

.7 All structure or Material judged inadequate by structural analysis or by testing and inspection at any time up to the end of the Warranty Period shall be reinforced by additional construction or replaced as directed by the City's Engineer at the Contractor's expense, including all direct and indirect costs.

.8 The City's Engineer may order further testing, inspection, and analysis at any time. If additional testing is outside the scope of this Agreement, The City will pay for those tests, inspections, or analysis that meet the specified requirements, and the Contractor will pay for those that do not.

1.9 Access

.1 The Contractor shall provide full facilities for the inspection of Material and workmanship and shall allow free access for the Engineer to all parts of the Work.

.2 The Contractor shall assist the City's Engineer and provide resources for checking layout and performing inspection duties.

2 PRODUCTS

2.1 Structural Steel

.1 All steel work to conform to CSA G40.21, except as noted, having the following properties unless otherwise noted on the Drawings or in the Technical Specifications:

- .1 W-shapes and plates shall conform to CSA G40.20/G40.21M-350-WT, Charpy Category 3 minimum for fracture-critical members, and Category 2 for all other members.
- .2 Hollow structural sections, channels, tees, and angles shall conform to CSA G40.20/G40.21M-350-W, Charpy Category 3 minimum for fracture-critical members, and Category 2 for all other members.

.3 Pipes or structural tubes shall conform to API-5L X52 PSL-2, Charpy Category 3 minimum for fracture-critical members, Category 2 for all other members.

.2 Substitutions:

.1 Substitutions for structural steel not readily available shall be subject to review and acceptance by the City's Engineer.

.2 At a minimum, all steel proposed for substitution originating outside of Canada or the U.S. shall include a review and written conformance by a metallurgical testing company as specified in Clause 1.6.4 herein.

.3 Total boron content of the steel shall not exceed 0.0008%.

.3 Steel shall be marked in accordance with the requirements of the appropriate standard. Where steels of differing grades are used in the same Agreement, they shall be so marked.

.4 Welding electrodes:

.1 Electrodes shall match the structural steel in accordance with CSA W59, unless otherwise approved by the City's Engineer.

.2 Welding consumables for all processes shall be fully approved by the CWB and certified by the manufacturers as complying with the requirements of this specification.

.3 Electrodes shall conform to the requirements of CAN/CSA S6.

2.2 Bolts, Nuts and Washers

.1 All bolts shall conform to ASTM F3125/F3125M Grade A325.

.2 Nuts and washers shall be in accordance with ASTM A563/ASTM A563M and ASTM F436, respectively.

.3 Unless otherwise specified, Type 3 bolts, nuts and washers shall be used for connections to weathering steel.

.4 For painted structures, Type 1 bolts, nuts, and washers shall be used.

.5 Type 1 bolt assemblies shall be field-painted after erection.

.6 Certified mill test reports for the fastener material shall be provided.

.7 Bolts, nuts and washers shall be supplied as a complete assembly.

2.3 Shear Stud Connectors

.1 All shear stud connectors shall conform to the chemical requirements of ASTM A29 and A108, Grades 1015, 1018, or 1020.

.2 In addition, they shall meet the mechanical properties specified in CSA W59, Appendix H, for Type B studs.

.3 Certified mill test reports for the stud material shall be provided.

3 EXECUTION

3.1 Welding

.1 Except as otherwise noted on the Drawings, all welding, cutting and preparation shall be in accordance with CSA W59.

.2 Filler metals:

  .1 All filler material shall comply with CSA W48 or AWS A5.01/A5.01M and A5.02/A5.02M, as appropriate.

  .2 Low-hydrogen filler, fluxes and low-hydrogen welding practices shall be used throughout.

  .3 The low-hydrogen covering and flux shall be protected and stored as specified by CSA W59.

  .4 Flux-cored welding or use of cored filler wires in the submerged arc process or shielding gas process shall have diffusible hydrogen designators of H4 or lower.

.3 Cleaning prior to welding:

  .1 Weld areas shall be clean and free of mill scale, dirt, grease and other contaminants prior to welding.

  .2 For multi-pass welds, weld metal deposited in previous passes shall be thoroughly cleaned between passes.

.4 Tack and temporary welds:

  .1 Tack and temporary welds shall not be allowed unless they are to be incorporated in the final weld.

  .2 Tack welds, where allowed, shall be of a minimum length of four times the nominal size of the weld, and length shall not exceed 15 times the weld size and shall be subject to the same quality requirements as the final welds.

  .3 Cracked tack welds shall be completely removed prior to rewelding.

.5 Preheat requirements shall be performed and maintained per CSA W59.

.6 Gaps between parts joined by fillet welds shall conform to the requirements of Clause 5.4.1 of CSA W59. In addition, stiffeners to which cross-bracing or diaphragms are attached shall have a tight fit to the flanges as defined in Clause 5.8(h) of CSA-W59. Bearing stiffeners, at points of loading, shall be fit to bear as defined in Clause 5.8(g) of CSA W59.

.7 Parts to be joined by groove welds shall conform to the requirements of CSA-W59.

.8 The use of filler plates shall not be permitted unless specified on the Drawings or approved by the City's Engineer.

.9 Parts to be welded shall be fastened properly without excessive constraint to avoid any heat distortion. Any distortion shall not be corrected by hammering.

.10 In case of weld access holes that must be closed for cosmetic or corrosion protection reasons, the Contractor shall apply a suitable mastic material approved by the City's Engineer.

.11 Artificial cooling of welds shall not be permitted.

.12 To enable full-throat thickness to be provided at the ends of butt-welded joints, run-on and run-off plate extension pieces shall be used. Run-on plates and run-off plates shall comply with the following requirements:

.1 One pair of run-on plates and one pair of run-off plates prepared to the same thickness and profile as the parent metal shall be attached, preferably by clamps, to the start and finish of all butt welds.

.2 Butt welds shall extend at the full weld profile for a distance of 25 mm into both the run-on and the run off plates.

.3 When removing the run-on and run-off plates by flame cutting, the cuts shall not be nearer than 3 mm to the sides of the parent metal and the remaining metal shall be removed by grinding or another method agreed to by the City's Engineer.

.13 Visible weld surfaces shall be cleaned of slag residue. All weld spatters shall be removed and affected surfaces dressed and cleaned.

.14 The Contractor shall maintain traceability of the welding consumables used.

.15 To prevent notching effects, stiffeners and attachments fillet welded to structural members shall have the fillet welds terminate ten (10) mm short of edges.

.16 Methods of weldments repair:

.1 Repairs to fracture-critical members shall conform to the requirements of CAN/CSA S6.

.2 A repair drawing for unsatisfactory weldments, authenticated by a welding Engineer, shall be submitted to the City's Engineer for acceptance prior to repair work commencing.

.3 Procedures for non-critical repairs may be submitted for pre-approval prior to commencing fabrication.

.4 As a minimum, all weld repairs shall be inspected using the same methods specified for the original welds.

.5 Inspection and testing of repairs to fracture-critical members shall also conform to the requirements of Clause 10.23.5 of CAN/CSA S6.

.17 Arc strikes: Arc strikes are not permitted. In the event of accidental arc strikes, the Contractor shall submit a proposed repair procedure conforming to CSA W59 to the City's Engineer for approval. The repair procedure shall include confirming the soundness of affected metal by MPI and hardness testing of the repair area.

.18 Grinding of welds:

.1 Where specified, butt welds shall be ground flush or to a specified slope on both sides.

.2 Fillet welds not conforming to an acceptable profile shall be ground to the proper profile without substantial removal of the base metal.

.3 Grinding shall be smooth and parallel to the line of stress. Caution shall be exercised to prevent over-grinding.

.19 All welds shall be continuous, full profile and complete joint penetration, unless otherwise specified by the City's Engineer. The tolerances of fit-up between elements shall be the most stringent of this Technical Specification or the requirements of CSA W59.

.20 Slot or plug welds shall not be permitted unless approved.

.21 Identification shall be provided to enable each weld to be traced to the welder or operator who completed the Work.

.22 Flame cutting:

.1 The Contractor shall submit written procedures for flame cutting before commencing fabrication.

.2 Joint edges shall be ground and free of imperfections.

.23 Welding shear stud connectors:

.1 The Contractor shall submit written procedures for welding shear stud connectors, confirming compliance with requirements of CSW W59, before commencing fabrication.

.2 The procedure trials shall be witnessed by an independent inspection agency.

3.2 High-Tensile Strength Bolted Connections

.1 Bolted connections shall conform to CAN/CSA S6, A10.1.6.

3.3 Fabrication

.1 All fabrication shall be in accordance with the CAN/CSA S6, CSA W59, and this Technical Specification.

.2 Fabrication shall be performed in an adequately heated and enclosed area. The shop temperature shall be a minimum of 10 degrees Celsius (°C).

.3 Heat number transfer:

.1 As the plate is subdivided for webs and flanges, all heat numbers shall be transferred to each individual section.

.2 The numbers shall remain legible until such time as the material location in the final assembly has been recorded on an approved set of Shop Drawings provided for this purpose.

.3 Mill identification numbers stamped into the material shall be removed by grinding at an appropriate time, as approved by the Engineer.

.4 Marking systems:

.1 Methods for marking and the location of marks are to be approved by the City's Engineer.

.2 Every part shall be marked with a durable and distinguished mark in such a way as not to damage the material.

.3 Steel stamps are not to be used. The only exception shall be the marking of splice plates which may be steel stamped using low-stress dies. The location of such stamps is to be approved by the City's Engineer.

.5 Flame cutting of plate:

.1 All plate material for main members, splice plates and any plate material welded to the main member shall be flame or plasma cut using an automatic cutting machine. Shearing is not allowed.

.2 Where specified, flame-cut edges shall be ground or machined to remove all visible signs of drag lines.

.3 Hardness testing of cut edges shall comply with requirements of Clause 1.7.3 with respect to criteria and frequency. The surface roughness of the flame-cut edge, defined per ASME B46.1, shall not be greater than, 0.5 thousandths of an inch (µin) (12.7 micrometres [µm]) and shall permit Brinell hardness testing without spot grinding.

.4 If the hardness exceeds the specified limits, the Contractor shall submit for review their procedures for repairing the edges to meet the requirements.

.5 The surface of flame-cut apertures shall be finished by grinding and shall be free of nicks and gouges.

.6 The Contractor shall record all blowbacks, signs of delamination or other discontinuities detected on cut edges of tension members during the cutting of the material. The extent of the damage shall be identified as part of the Contractor's QA/QC responsibilities, and a proposed repair procedure, prepared by an Engineer retained by the Contractor, shall be forwarded to the City's Engineer for review and acceptance.

.6 Material splices:

.1 Splices other than those shown on the Drawings require approval of the City's Engineer.

.2 The Contractor shall bear the cost of inspection of these splices. Inspection reports shall be made available to the City's Engineer and The City.

.7 Vertical alignment:

.1 The structure shall be fabricated to conform to the requirements of the deflection and vertical curve as noted on the Drawings.

.2 For rolled shapes, advantage shall be taken of mill camber that may be inherent in the material.

.8 Shop assembly:

.1 The exact detailed method of assembly, including points of support, dimension checks, method of trimming to length and drilling and marking of splices, shall conform to the fabrication sequence submitted under Section 1.6.5 and as accepted by the City's Engineer.

.2 Each individual section shall meet the camber requirements for that particular length, with the splices between these sections falling on the theoretical camber line for the entire span. When the camber of the section fails to meet the required tolerance, the Contractor shall submit a proposed method of repair for review and acceptance by the City's Engineer.

.3 For plate girders and box girders, shop assembly shall conform to the requirements of Section A10.1.6 of CAN/CSA S6.

.4 All splices shall be drilled from solid material while assembled or shall be sub-punched or sub-drilled and then reamed to full size while in the shop assembly position.

.5 No reaming shall take place until approval of the assembly has been obtained from the City's Engineer. Such approval does not relieve the Contractor of any responsibility.

.6 Where specified in the Technical Specifications, all bolted connections shall be pre-assembled in the shop to ensure that assemblies fit within the specified tolerance.

.7 After shop assembly, splice plates and Girders shall be match-marked for erection.

.8 Splice plates shall be removed from girders, de-burred, solvent cleaned and sandblasted free of all mill scale to provide the specified faying surface acceptable to the City's Engineer. Plates shall be securely bolted to the girders for shipping and match-markings shall be shown on the erection drawings.

.9 Bolt holes shall conform to the requirements of A10.1.4.5 of CAN/CSA S6.

.10 Dimensional tolerances shall conform to the requirements of A10.1.7 of CAN/CSA S6.

.11 The fabrication contractor shall shop prepare all material for required field welds.

.12 Flame straightening:

.1 Flame straightening shall not be performed on any material or member without acceptance by the City's Engineer.

.2 The Contractor is to submit a procedure indicating location, temperatures and cooling rates to the City's Engineer for acceptance.

.13 Artificial and accelerated cooling above 315°C of heated areas shall not be permitted.

.14 Stress relieving:

.1 When stress relieving is specified, it shall be performed in accordance with CSA W59.

.2 Copies of the furnace charts shall be supplied to the City's Engineer.

.15 Machining at butted joints shall comply with A10.1.7.2 of CAN/CSA S6.

.16 Plates shall conform to the requirements of CSA-G40.21. The surface quality of sections shall conform to the requirements of ASTM A6.

.17 Combined warpage and tilt:

.1 Combined warpage and tilt of flanges at any cross-section of welded I-shaped beams or Girders shall be determined by measuring the offset at the toe of the flange from a line normal to the plane of the web through the intersection of the centreline of the web with the outside surface of the flange plate.

.2 This offset shall not exceed 1/200th of the total width of the flange or 3 mm, whichever is greater at the bolted splice location.

.3 Connection plates at Girder splices shall be in parallel planes and shall uniformly be in full contact with connected members.

.18 Girder camber:

.1 Camber of beams and girders shall be uniform, true and accurate to the centreline of the top flange.

.3 The camber shall be within a tolerance of ±(0.2Lt+3) mm, where Lt is the reference length in metres. The camber tolerance specified is applicable to fabricated members prior to shop assembly.

.19 Tolerances for box girder camber, sweep and section depth shall be measured from two imaginary surfaces; a vertical plane passing through the girder's centre line and a perpendicular surface representing the theoretical underside of the top flanges on the theoretical camber.

.20 Splices:

.1 Filler plates will not be permitted at main girder splices unless specified.

.2 The gap between the end of spliced girders shall not exceed 10 mm ±5 mm.

.21 Surfaces of flanges in contact with bearing sole plates shall have a flatness tolerance in each direction not exceeding 0.001 times the bearing dimension.

.22 Corner chamfer:

.1 Corners of all flanges shall be ground to a 2-mm chamfer.

.2 Corners of structural sections, plates and exterior edge corners shall be ground to a 1-mm chamfer.

.23 Web panning:

.1 Girder web variation from flatness shall not exceed 0.01d, where d is the least dimension of the panel formed by the flanges, stiffeners, or both.

.2 If adjacent panels alternate concave to convex, the sum of the panning in the adjacent panels shall not exceed the tolerance for a single panel.

.3 Localized deformation in the web shall not exceed 1 mm in 1.0 m.

.24 Repair of defects:

.1 All standard and specific repair methods proposed for use shall be submitted to the City's Engineer for acceptance prior to proceeding with the repair.

.2 The third repair of a defect will be considered unacceptable. Rejected defects and affected elements shall be replaced at the Contractor's cost.

.25 Structural steel shall be reviewed by the City's Engineer at the shop to confirm any Deficiencies identified during fabrication have been corrected. The Contractor shall provide a minimum of 2 Business Days' notice to the City's Engineer prior to shipment to facilitate final inspection.

.26 Handling and storage:

.1 All lifting and handling shall be done using devices that do not mark, damage, or distort the assemblies or members in any way.

.2 Arches shall be stored upright, supported on sufficient skids, and safely shored to maintain the proper section without buckling, twisting, or in any way damaging or misaligning the material.

.3 Temporary attachments shall be removed by cutting and not by hitting or bending. They shall be removed in a manner avoiding any damage to the base material of the structure.

3.4 Surface Preparation

.1 Blast cleaning: All steel components to be coated shall be sandblast cleaned after fabrication in accordance with SSPC to SP 10/NACE No. 2. The surface roughness of the cleaned surface shall be in accordance with the coating manufacturer's recommendations.

.2 The Contractor shall employ or retain a NACE Certified Level 3 coating inspector, or equivalent as approved by the City's Engineer, to verify compliance of the coating application. Coating thickness compliance shall be determined in accordance with SSPC PA 2.

.3 All atmospheric corrosion resistant (ACR) steel components shall be abrasive sandblast cleaned after fabrication according to SSPC-SP 6/NACE No. 3 to completely remove mill scale, rust, coating, oxides, corrosion products, oil, grease, dust, dirt and all other foreign matter.

.4 Where specified, ACR-type structural steel, including diaphragms and bracing, but excluding surfaces in contact with concrete and the contact surfaces of bolted joints, shall be coated for a distance of 3,000 mm from the ends of girders at expansion joints. In addition, exterior girders at intermediate piers shall be coated for a distance of 3,000 mm each way from the centre of the pier. The colour of the top coat shall conform to AMS Standard 595A colour AMS-STD 30045 (flat).

3.5 Galvanizing

.1 Galvanizing, when specified, shall be by hot-dipped method after fabrication, conforming to ASTM A123/A123M.

.2 Damaged areas of galvanized members are to be repaired to the satisfaction of the City's Engineer. Repair to damaged galvanizing is required using sprayed zinc (hot-applied metalizing), and shall be applied in multiple coats to a minimum dry film thickness of 0.20 mm per ASTM A780, Method A3-Metalizing. The finish of all repairs shall match that of adjacent areas as closely as practical.

.3 A galvanizing procedure shall be provided to the City's Engineer for review prior to the material being dipped or repaired. The plan shall include details required for safe handling, to prevent warping, to provide adequate drainage and all related quality control measures.

.4 Galvanized faying surfaces of bolted connections shall be hand wire-brushed to a Class A slip coefficient surface meeting the requirements of Table 10.9 of CSA S6, unless otherwise specified on the Drawings.

3.6 Erection Procedure

.1 The Contractor is responsible to complete the erection in accordance with the Agreement and the Technical Specifications.

.2 The Contractor shall be fully responsible for the means and methods throughout erection to final installation.

.3 All engineered erection plans, procedures, and shop drawings shall be prepared by the Contractor and authenticated by an experienced and qualified Engineer prior to submission to the City's Engineer.

.4 Work is not to commence until approval of the erection proposal has been obtained from the City's Engineer. The City Engineer's approval does not relieve the Contractor of the responsibility for means, methods, or equipment, nor from carrying out the work in full accordance with the Technical Specifications.

.5 Shop Drawings and the detailed erection proposal shall be prepared and submitted to the City's Engineer at least 21 Calendar Days in advance of the scheduled start of erection.

.6 Shop Drawings are to cover the erection of all steel elements of the bridge. Shop drawings showing partial details or details of some elements, but not all, will not be reviewed until all details have been submitted to the City's Engineer.

.7 The erection proposal is to include all drawings and documents necessary to describe the following:

- .1 Access to the Work, including any temporary berms and work bridges
- .2 Traffic accommodation strategy during the erection and construction periods
- .3 Type and capacity of equipment to be used
- .4 As-constructed survey of the substructure, including the location (longitudinal and transverse dimensions) and top-of-concrete elevation at all bearing centre locations
- .5 Sequence of operation, including anticipated duration of all activities, and positioning and movement of cranes and delivery trucks

.6 Details of locations of cranes, including distance to substructure elements, such as abutment backwalls and piers, and relative to the roadway, as well as to the property right-of-way (ROW)

.7 Details of cranes, including lift radius, and load distribution of wheels and outriggers

.8 Lifting devices and lifting points on girders

.9 Details of temporary works, including complete falsework plans, where required, as well as proposed methods to be used to maintain the required splice elevations and structure shape prior to bolt tensioning and method of providing temporary support for stability; plans are to bear the seal and signature of an Engineer retained by the Contractor

.10 Bolt tensioning sequence and method, as appropriate

.11 Details of release of falsework

.12 Survey of structure as-constructed; the Contractor shall use an additional independent third-party licensed surveyor and precise three-dimensional (3D) geometric modelling of the superstructure and substructure, in addition to its own survey to verify fit-up in accordance with the plans

.8 Steel erection shall not commence until supporting substructure elements have been cured a minimum of 3 Calendar Days and have attained sufficient compressive strength (verified by field-cured test cylinders as required) as approved by the City's Engineer.

.9 Before erection begins, the Contractor shall perform a complete superstructure layout by means of chalk lines and markings applied to all substructure units, showing bearing positions and all other structure elements in accordance with the Contractor's accepted layout plan.

3.7 Handling, Storing, and Transporting Materials

.1 Materials to be stored onsite are to be placed on timber blocking above the ground. All materials shall be kept clean and properly drained. Long members are to be supported on timber blocking placed close enough together to prevent damage from deflection.

.2 Steel in transport shall be protected from road spray or other hazards that could cause damage.

.3 The Contractor is to prepare and submit a transportation plan to the Engineer for approval. The transportation plan shall include details of:

i. Lifting

ii. Transportation route

iii. Support and blocking, including stability during transport

iv. Methods to prevent components from becoming overstressed

v. Approval of the Contractor's plans does not relieve the Contractor of any responsibility. All plans submitted are to bear the seal of an Engineer.

3.8 Falsework

.1 The falsework shall be properly designed, constructed, and maintained for the forces that may act on it.

.2 The Contractor shall prepare and submit plans of falsework to the City's Engineer for approval.

.3 Approval of the Contractor's plans does not relieve the Contractor of any responsibility.

.4 All plans submitted are to bear the seal of an Engineer registered in the Province of Alberta.

3.9 Structure Adjustment

.1 It is essential that the elements of the structure are erected with utmost attention to the positioning, alignment, and elevation as shown on the plans. Any adjustment to the position, bearing location, or bearing elevation shall be approved in writing by the City's Engineer.

.2 Any additional cost or schedule impacts associated with repositioning and correction of misalignment shall be the responsibility of the Contractor.

3.10 Straightening Bent Material

.1 No straightening of plates, angles, or other shapes will be permitted without the express approval of the City's Engineer. In all cases, a detailed written procedure must be submitted by the Contractor and approved by the City's Engineer prior to any straightening being undertaken. Such approval does not relieve the Contractor of any responsibility.

.2 Following approved straightening of a bend or buckle, the surface of the metal is to be carefully inspected for evidence of fractures. This may include non-destructive testing. All costs are to be the responsibility of the Contractor.

3.11 Assembly

.1

.1 Field assembly shall conform with A10.1.10.5 of CAN/CSA S6.

.2 The Contractor shall survey the structural components with permanent support condition prior to erection. For arches, this shall include the full assembly. The survey shall include, at a minimum:

- .1 Centres of bearing locations
- .2 Span dimensions
- .3 Skew angles and offsets
- .4 Elevations at supports
- .5 Alignment of the chords
- .6 Dimensional tolerance
- .7 Alignment of joints to be welded or bolted

.3 The results of the survey shall be supplied to the erection engineer and the Engineer for review prior to commencing erection.

.4 Bolts and bolted pieces:

.1 Bolted pieces shall fit solidly together when assembled. Contact surfaces shall be clean and free of defects that could prevent solid seating of the pieces.

.2 Bolt storage, handling, installation, and tightening shall comply with the requirements of CAN/CSA S6, Clause A10.1.6.

.3 Bolts in exterior Girders shall be installed with the heads on the outside face of the girder web. Bolts located in the bottom flange of all girders shall have the heads installed on the bottom face of the lower splice plate. Nuts for bolts that will be embedded in concrete deck haunches shall be located on the side of the member being encased in the concrete.

.4 ASTM A325 bolts shall be installed using the turn-of-nut method unless otherwise approved by the City's Engineer. Installation sequence, contact surface condition, and tightening criteria shall be in accordance with the Standards.

.5 Inspection:

.1 The Contractor shall provide safe and adequate access to all working areas, including all necessary scaffolding, to enable the City's Engineer to carry out inspections. In addition, the Contractor is to make available a capable worker, acceptable to the City's Engineer, to assist in the tensioning inspection work when requested by the City's Engineer.

.2 The City's Engineer shall observe the installation of the first ten bolts installed by each approved technique to determine that the tightening procedure is properly used and that all bolts are tightened.

3.12 Misfits

.1 The correction of minor misfits involving reasonable amounts of reaming, cold cutting, and chipping is to be considered incidental to the work of erection.

.2 Any deformation that prevents proper assembling and fitting up of parts by the moderate use of drift pins or by a moderate amount of reaming and slight chipping or cutting shall be reported immediately to the City's Engineer, and their approval of the method of correction shall be obtained. The correction is to be made in the presence of the City's Engineer.

3.13 Removal of Falsework and Site Cleanup

.1 Upon completion of erection and before Final Acceptance, the Contractor shall remove any earth material or falsework placed during construction.

.2 The Contractor is to remove any piling, excavated or surplus materials, rubbish, and temporary buildings; replace or renew any damaged fences; and restore in an acceptable manner any property damaged during the execution of the Work.

.3 Disposal of surplus materials is to be in a manner and location consistent with the Contractor’s ECO Plan.

.4 The Contractor is to leave the bridge site, roadway, and adjacent property in a neat, restored, and presentable condition satisfactory to the City’s Engineer.

.5 When required, the Contractor is to provide written evidence that regulatory agencies have been satisfied.

3.14 Structural Cleanup

.1 Following installation, all steel shall be left clean and free of oil, grease, mud, dust, road spray, or any other deleterious matter.

4 MEASUREMENT AND PAYMENT

4.1 Measurement

.1 The quantity measured for payment of this section shall be on a lump sum basis for the type and size specified, as tendered in the Agreement.

4.2 Payment

.1 Payment for the Work in this section shall be as tendered and will be full compensation for the supply and fabrication of:

  .1 Structural steel

  .2 Quality control and assurance measures

  .3 Loading

  .4 Transport to the project site

  .5 Unloading

  .6 Erection

  .7 All labour, materials, and equipment necessary to complete the Work, including all subsidiary and incidental items thereto.

.2 Payment for this Work shall be issued upon 100% completion of the Work as described in this section, including submission of all documentation per this Technical Specification.

END OF SECTION

1 GENERAL

1.1 Work Included

.1 The Work of this section covers metal fabrications indicated on the Drawings and includes:

.1 Pedestrian and bicycle railing and stair railing, including anchorages

.2 Vehicle barriers, including anchorages

.3 Maintenance platforms, such as catwalks, ladders, and associated access structures

.4 Light pole anchor assemblies

.5 Sign support anchor assemblies

.6 Miscellaneous inserts, sleeves, plates, anchors and railing anchor assemblies

.7 Bearing plates

.8 Ramp trench drain grating and deck drains, including fittings

.9 Expansion joint assemblies, including cover plates

.10 Utility conduit hanger supports

.2 This section does not cover the supply and fabrication of structural steel elements.

1.2 Related Work Specified in Other Sections

.1	Structural Steel Supply, Fabrication and Erection	05120
.2	Bridge Bearings	05650
.3	Expansion Joint Assemblies	05820
.4	Coatings for Steel	09719

1.3 Reference Standards

.1 Perform the Work of this section in accordance with the latest edition of the following standards available at the Effective Date, except where specified otherwise. Provide one copy onsite, and at any fabrication shops, of CAN/CSA S6, CSA W59 and AWS D1.5 in either in hard copy or digital format.

.2 American Welding Society (AWS):

.1 AWS D1.5, Bridge Welding Code

.3 ASTM International (ASTM):

.1 ASTM A48/A48M, Standard Specification for Gray Iron Castings

.2 ASTM A108, Standard Specification for Steel-Bar, Carbon and Alloy, Cold-Finished

.3 ASTM A123/123M, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

.4 ASTM A143/143M, Standard Practice for Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement

.5 ASTM A153/153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

.6 ASTM A252, Standard Specification for Welded and Seamless Steel Pipe Piles

.7 ASTM A307, Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength

.8 ASTM A385/A385M, Standard Practice for Providing High-Quality Zinc Coatings (Hot-Dip)

.9 ASTM A563M, Standard Specification for Carbon and Alloy Steel Nuts

.10 ASTM A780/780M, Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings

.11 ASTM F1554, Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength

.12 ASTM F2329/F2329M, Standard Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners

.13 ASTM F3125/F3125M, Standard Specification for High Strength Structural Bolts and Assemblies, Steel and Alloy Steel, Heat Treated, Inch Dimensions 120 ksi and 150 ksi Minimum Tensile Strength, and Metric Dimensions 830 MPa and 1040 MPa Minimum Tensile Strength

.14 ASTM F436/F436M, Standard Specification for Hardened Steel Washers Inch and Metric Dimensions

.4 Canadian General Standards Board (CGSB):

.1 CAN/CGSB-48.9712, Non-destructive testing — Qualification and certification of NDT personnel (ISO 9712:2012, IDT)

.5 CSA Group (CSA):

.1 CAN/CSA S6, Canadian Highway Bridge Design Code

.2 CSA G40.20/G40.21, General requirements for rolled or welded structural quality steels/Structural quality steels

.3 CSA S16, Design of steel structures

.4 CSA W178.1, Certification of welding inspection organizations

.5 CSA W178.2, Certification of welding inspectors

.6 CSA W47.1, Certification of companies for fusion welding of steel

.7 CSA W48, Filler metals and allied materials for metal arc welding

.8 CSA W59, Welded steel construction (metal arc welding)

.6 International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC):

.1 ISO/IEC 17025, General requirements for the competence of testing and calibration laboratories

.7 The Society for Protective Coatings (SSPC):

.1 SSPC-SP 5, White Metal Wet Abrasive Blast Cleaning (NACE No. 1)

1.4 Definitions

.1 All defined words or phrases shall have meaning given the City of Calgary Standard General Conditions and the Agreement, unless noted otherwise.

1.5 Regulations

.1 Abide by the current bylaws and regulations of the province and municipality in which the Work is located and abide by the current laws and regulations with regard to public safety.

.2 The regulations of the Minister of Labour, OH&S Legislation, the Workers' Compensation Board, and other applicable acts administered by the authority having jurisdiction of the province apply to the Work of this section.

1.6 Qualifications

.1 The organization undertaking to weld under this section shall be fully approved by the CWB under the requirements of CSA W47.1, Division 1 or 2, only. Division 3 qualification is not sufficient for the work of this section.

.2 Only welders, welding operators, and tackers approved by the CWB shall be permitted to perform weldments. Their qualifications shall be current and available for examination by The City’s Engineer.

.3 All welders employed in the field to weld load-carrying structures in the field shall possess valid "S" Classification, Class "O" certificates issued by the CWB. If the structures incorporate complete penetration welds, without backing, on hollow structural sections and pipe, welders shall possess valid "T" Classification, Class "O" certificates.

.4 The organization undertaking to perform weld inspections under this section shall be fully approved by the CWB under the requirements of CSA W178.

.1 Visual inspectors shall be certified under the requirements of CSA W178.2, Level 2 or 3.

.2 Inspectors performing non-destructive testing shall be qualified for the relevant testing method in accordance with the requirements of CAN/CGSB-48.9712, Level 2 or 3.

1.7 Submittals

.1 Provide submittals for review in accordance with the latest edition of The City of Calgary Standard General Conditions.

.2 Submit, in writing, evidence of qualification for welding under the Canadian Welding Bureau (CWB).

.3 Provide fabricated full-scale mock-ups per Section 3.2.

.4 Provide and keep current a complete fabrication schedule in a form satisfactory to the Engineer.

.5 Shop Drawings

- .1 Prepare Shop Drawings of all connections and components designed by the fabricator under the seal and signature of the Contractor’s Engineer responsible for this design.
- .2 Clearly indicate profiles, sizes, connection attachments, reinforcing, anchorage, size, and type of fasteners and accessories.
- .3 Include erection Drawings, elevations, and details where applicable.
- .4 Indicate welded connections using Canadian Institute of Steel Construction (CISC) Handbook for Steel Construction standard welding symbols. Clearly indicate net weld lengths.

.6 Review of the Shop Drawings by the Engineer is intended as an assistance to the Contractor and does not relieve the Contractor of responsibility for the completeness and accuracy of the Work and its conformance with the Technical Specifications.

.7 Fabrication shall not commence prior to Shop Drawing review by the Engineer.

.8 Submit mill certificates for all steel used in fabrication, as follows:

- .1 Fabrication shall only be allowed with Materials having mill certificates properly correlated to the Materials used on the Project and that have been reviewed and accepted by the Engineer.
- .2 Mill test reports shall be submitted to the Engineer for review and acceptance at least 20 Business Days prior to the scheduled start of fabrication.
- .3 Test reports for all Materials shall be written in English.
- .4 A list of all Material shall be provided for each structure, showing the component designation from the Shop Drawings and the associated mill test report heat numbers.
- .5 The Contractor shall have all steel, including billets, bars, and fasteners, originating outside of Canada or the United States (U.S.) verified by a certified laboratory in Canada, as follows:
  - .1 This laboratory shall be certified by an organization accredited by the Standards Council of Canada to comply with the requirements

of ISO/IEC 17025 for the specific tests, or type of tests, required by the Material standard specified on the mill test report.

.2 The Material shall be tested to the specified Material standards, including a determination of boron content, which is not permitted to exceed 0.0008%.

.3 Preparation and collection of samples for testing shall be directed and witnessed by, or completed by, personnel employed by the testing lab.

.6 A verification letter, signed and sealed by a Professional Engineer in the field of metallurgy and bearing the signature of an authorized officer of the testing laboratory, shall be provided by the laboratory and shall include references to the following:

.1 Appropriate mill test report(s)

.2 Material specification number(s)

.3 Testing standards

.4 Date(s) of testing

.5 Statements indicating Material compliance with the requirements of the Agreement

1.8 Quality Control, Quality Assurance, and Inspection and Testing

.1 The Contractor's plan for Quality Assurance (QA) and Quality Control (QC) shall be included in the Quality Management Plan (QMP) and submitted to The City's Engineer for review prior to starting steel fabrication. All QC testing as part of the Contractor's QMP shall be paid for by the Contractor.

.2 Notify The City's Engineer no less than 3 Business Days prior to commencement of shop work.

.3 The Contractor will engage a testing agency, certified in accordance with CSA W178.1, to perform QC testing of the Work.

.4 Testing of welds shall include visual examination of all welding procedures at the plant and in the field, plus magnetic particle, x-ray, or other means deemed necessary by the testing agency to permit certification of welds.

.5 Testing of headed concrete anchors shall verify that welded stud connectors meet all requirements outlined in CSA W59.

.6 The City's Engineer may request additional testing of welds and bolts to ascertain the full number of defects if the tests noted herein indicate excessive Deficiencies. Additional costs for extra testing to be borne by the Contractor.

.7 In addition to the Contractor's responsibility for QA/QC, The City may appoint a testing agency to perform independent QA testing as deemed necessary. This testing is independent of the Contractor's QMP and shall not replace the Contractor's QA testing.

1.9 Acceptability

.1 Failure to comply with the requirements of these Technical Specifications will result in the Work being considered potentially Deficient.

.2 Additional testing, inspection, and evaluation may be required where evidence points to potentially Deficient Work.

.3 The Contractor shall pay all costs for additional testing, inspection, and analysis required to demonstrate the adequacy of the Work that does not meet the requirements of the Agreement.

.4 The Contractor shall reinforce by additional construction or replace as directed by The City's Engineer, at the Contractor's expense, all Work judged inadequate by structural analysis or by testing and inspection.

2 PRODUCTS

2.1 Materials

.1 General:

- .1 Metals shall be free from defects impairing strength, durability, and appearance of the best commercial quality for the purpose specified.
- .2 All Materials shall be new.
- .3 All exposed fastenings shall be of the same Material, colour, and finish as the metal to which the fastenings are applied, unless otherwise noted.

.2 Steel plates, bars, and rolled sections shall conform to CSA G40.21, Grade 300W.

.3 Steel hollow structural sections shall conform to CSA G40.21, Grade 350W, Class C.

.4 Steel pipe shall conform to ASTM A252.

.5 Welding materials shall conform to CSA W59.

.6 Welding electrodes shall conform to CSA W48.

.7 Cast iron shall conform to ASTM A48/A48M, Class 30, free from faults, sponginess, cracks, and sandholes.

.8 The Contractor shall machine-grind frames, gratings, and covers to even, non-rocking surfaces.

.9 High-strength bolts shall conform to ASTM F3125M.

.10 Standard machine bolts, threaded anchor rods, and nuts shall conform to ASTM A307 Grade A.

.11 Anchor bolts shall conform to ASTM F1554 Grade 55.

.12 Nuts shall conform to ASTM A563M Heavy HEX.

.13 Washers shall conform to ASTM F436M.

.14 Shear stud connectors shall conform to ASTM A108, Grades 1015, 1018, or 1020, meeting the mechanical properties specified in AWS D1.5, Table 7.1 for Type B studs.

2.2 Finishes

.1 Hot-dipped galvanizing shall conform to ASTM A123/A123M, ASTM A153/A153M, ASTM A385/A385M, and ASTM F2329/F2329M; minimum 600 grams per square metres (gm/m^2) coating.

.2 The steel properties, galvanizing process, and any final finishing shall produce a smooth surface on all handrail railings.

.3 Field touch-up of damaged galvanizing shall use zinc metalizing conforming to ASTM A780/780M, Method 3.

.4 Metalizing shall be 180 micrometres (μ) thick.

.5 Paint, where indicated on the Drawings, shall be in accordance with Section 09719, Coatings for Steel.

2.3 Fabrication

.1 Verify all dimensions onsite prior to shop fabrication.

.2 Fabricate items of sizes and profiles detailed on Drawings with joints neatly fitted and properly secured.

.3 Fit and shop assemble in the largest practical sections for delivery to site.

.4 Supply all components required for proper anchorage of miscellaneous metals. Fabricate anchorage and related components of the same Material and finish as the metal to which the anchorages are connected, unless otherwise noted.

.5 Connections:

- .1 Weld connections where possible; otherwise, bolt connections.
- .2 Counter-sink all exposed fastenings where projection of the fasteners impairs an element's use or constitutes a safety hazard.
- .3 Bolts projecting more than 25mm beyond the nuts after installation shall be cut flush. Any cut galvanized bolt shall be metalized.
- .4 Accurately form all connections and joints with exposed faces flush, miters and joints tight.

.6 Grind or file exposed welds and metal sections smooth and flush.

.7 Provide for flush-welded or hairline butt field joints. Splicing of continuous sections is not permitted without prior approval by the Engineer.

.8 Shop fabricate openings in members for other components. Reinforce openings to restore member to original design strengths.

.9 Provide lugs, clips, brackets, hangers, and struts as required for attaching miscellaneous metal items securely to the structure.

.10 Galvanizing:

.1 Galvanize all items indicated on the Drawings.

.2 Thoroughly clean all surfaces of rust, scale, slag, grease, and foreign matter prior to galvanizing.

.3 Grind all welds smooth prior to galvanizing.

3 EXECUTION

3.1 Installation

.1 Obtain the Engineer's permission prior to site cutting or making adjustments that are not part of the scheduled Work.

.2 Install items plumb, square, and level, to fit accurately and maintain free from distortion or defects detrimental to appearance and performance.

.3 Make provision for erection stresses and temporary bracing. Keep Work in alignment at all times.

.4 Replace damaged items during installation.

.5 Field Welding:

.1 Perform required field welding.

.2 Grind all visible field welds smooth.

.3 Conform to the requirements of CSA W47.1.

.6 Perform necessary cutting and altering for the installation of work of other sections and as indicated on the Drawings. No additional cutting shall be done without the approval of the Engineer.

.7 Perform all field assembly bolting and welding to match the standard of shop bolting and welding. Bolts and screws shall be concealed whenever possible.

.8 Bolt storage, handling, installation, and pretensioning if noted on drawings shall comply with the requirements of CSA S6, Clause A10.1.6.

.9 After installation, touch-up all damage to painted and galvanized surfaces, including all bolts, nuts, and welds as follows:

.1 Field touch-up primer shall be the same as shop primer. Preparation and procedures shall be the same as shop-applied primer.

.2 Touch-up galvanized surfaces by metallizing.

.10 Supply to appropriate sections items required to be cast into concrete complete with necessary setting templates.

3.2 Mock-Ups

.1 The Contractor shall create mock-ups of portions of the Work described in this section.

.2 The Contractor shall complete a QC review of each mock-up prior to requesting review by The City's Engineer and prior to any additional fabrication of items matching the mock-ups.

.3 The mock-ups shall be finished to match the indicated finishes on the Drawings, including galvanizing and paint.

.4 The Contractor shall provide a full-size mock-up section of all pedestrian, bicycle, and stair railings. These mock-ups shall be made available for review and acceptance by The City's Engineer before fabrication commences for the remaining railing sections.

.5 Mock-ups accepted by The City's Engineer shall form the standard of acceptance for the remainder of the Project and will be permitted to form a part of the permanent Work.

.6 Mock-ups not accepted shall be repaired or replaced as directed by The City's Engineer. All costs for repair or replacement shall be borne by the Contractor.

3.3 Guarantee

.1 The Contractor shall guarantee, in writing, the performance of the galvanized finish for a 5-year period from the date of Substantial Completion.

.2 The Contractor shall provide in the guarantee for the replacement of the galvanizing at no cost to The City if the galvanized surface does not perform satisfactorily under normal environmental exposure.

.3 The Contractor shall verify the galvanized components are installed in a manner that will not void the guarantee.

4 MEASUREMENT AND PAYMENT

4.1 Payment

.1 Payment for the Work in this section shall be on a unit price basis as tendered, which shall be full compensation for all labour, Material, and equipment necessary to complete the Work, including all subsidiary and incidental items thereto for which separate payment is not elsewhere provided.

.2 Payment for this Work shall be issued upon 100% completion, including submission of all documentation per this Technical Specification.

END OF SECTION

1 GENERAL

1.1 Work Included

.1 This section outlines the requirements for the design, supply, fabrication, delivery, and installation of the following bearing types for new bridges:

.1 Plain elastomeric bearings

.2 laminated elastomeric bearings

.3 Rotational and sliding surface bearing assemblies including pot, disc and spherical bearings

.2 The Work is defined as:

.1 Design of bearings by an Engineer retained by the Contractor's bearing supplier (where design is not provided on IFC Drawings).

.2 Fabrication, delivery, and installation of all necessary components, including bearings, anchor bolts, anchorages, sole plates, base (masonry) plates, shoe plates, guides, restraints, shear studs, shims, coring where specified and grout.

.3 Coordination with steel or precast girder fabricator to provide proper fit-up and alignment.

.4 Quality assurance (QA) and quality control (QC) during fabrication, delivery, and installation, including the securing of bearings during girder erection and bridge deck construction.

.3 The Prime Contractor is responsible for ensuring coordination between the bridge girder fabricator and bearing supplier.

.4 This section does not cover the staged replacement of existing in-service bearings and bearing assemblies.

1.2 Related Work Specified in Other Sections

.1	Structural Steel Supply, Fabrication, and Erection	Section 05120
.2	Metal Fabrications	Section 05500

1.3 Reference Standards

.1 Perform the Work of this section in accordance with the latest edition of the following standards available at the Effective Date, except where specified otherwise. Provide one copy of each standard at the fabrication shop.

.2 American Association of State Highway Transportation Officials (AASHTO):

.1 AASHTO LRFD Bridge Construction Specifications

.2 AASHTO LRFD Bridge Design Specifications

.3 AASHTO M251, Standard Specification for Plain and Laminated Elastomeric Bridge Bearings

.4 AASHTO HB, Standard Specifications for Highway Bridges

.5 AASHTO Standard Specifications for Transportation Materials and Methods of Sampling and Testing

.3 American National Standards Institute (ANSI):

.1 ANSI/ American Society of Mechanical Engineers (ASME) B4.1, Preferred Limits and Fits for Cylindrical Parts

.2 ASME B46.1, Surface Texture

.4 American Welding Society (AWS):

.1 AWS D1.5M, Bridge Welding Code

.2 AWS D1.6M, Structural Welding Code – Stainless Steel

.5 ASTM International (ASTM):

.1 ASTM A29 / A29M - 16, Standard Specification for General Requirements for Steel Bars, Carbon and Alloy, Hot-Wrought

.2 ASTM A108, Standard Specification for Steel-Bar, Carbon and Alloy, Cold-Finished

.3 ASTM A123/A123M, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

.4 ASTM A143/A143M, Standard Practice for Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement

.5 ASTM A153/A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

.6 ASTM A193/A193M, Grade B7, Standard Specification for Alloy-Steel and Stainless-Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications

.7 ASTM A240/A240M, Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications

.8 ASTM A563M, Standard Specification for Carbon and Alloy Steel Nuts

.9 ASTM A709/A709M, Standard Specification for Structural Steel for Bridges

.10 ASTM A780/A780M, Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings

.11 ASTM B137, Standard Test Method for Measurement of Coating Mass Per Unit Area on Anodically Coated Aluminium

.12 ASTM B36/B36M, Standard Specification for Brass Plate, Sheet, Strip, And Rolled Bar

.13 ASTM B487, Standard Test Method for Measurement of Metal and Oxide Coating Thickness by Microscopical Examination of a Cross Section

.14 ASTM B833, Standard Specification for Zinc and Zinc Alloy Wire for Thermal Spraying (Metallizing) for the Corrosion Protection of Steel

.15 ASTM D1056, Standard Specification for Flexible Cellular Materials—Sponge or Expanded Rubber

.16 ASTM D1149, Standard Test Methods for Rubber Deterioration—Cracking in an Ozone Controlled Environment

.17 ASTM D2240, Standard Test Method for Rubber Property—Durometer Hardness

.18 ASTM D3359, Standard Test Methods for Measuring Adhesion by Tape Test

.19 ASTM D395, Test Methods for Rubber Property—Compression Set

.20 ASTM D4014, Standard Specification for Plain and Steel-Laminated Elastomeric Bearings for Bridges

.21 ASTM D412, Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers—Tension

.22 ASTM D429, Standard Test Methods for Rubber Property—Adhesion to Rigid Substrates

.23 ASTM D471, Standard Test Method for Rubber Property—Effects of Liquids

.24 ASTM D4894, Standard Specification for Polytetrafluoroethylene (PTFE) Granular Molding and Ram Extrusion Materials

.25 ASTM D573, Standard Test Method for Rubber—Deterioration in an Air Oven

.26 ASTM D5977, Standard Specification for High Load Rotational Spherical Bearings for Bridges and Structures

.27 ASTM D638, Standard Test Method for Tensile Properties of Plastics

.28 ASTM D746, Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact

.29 ASTM D792, Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement

.30 ASTM D832, Standard Practice for Rubber Conditioning For Low Temperature Testing

.31 ASTM F2329/F2329M, Standard Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners

.32 ASTM F3125/F3125M, Standard Specification for High Strength Structural Bolts and Assemblies, Steel and Alloy Steel, Heat Treated, Inch Dimensions 120 ksi and 150 ksi Minimum Tensile Strength, and Metric Dimensions 830 MPa and 1040 MPa Minimum Tensile Strength

.33 ASTM F436/F436M, Standard Specification for Hardened Steel Washers Inch and Metric Dimensions

.34 ASTM F835, Standard Specification for Alloy Steel Socket Button and Flat Countersunk Head Cap Screws

.6 CSA Group (CSA):

.1 CAN/CSA S6, Canadian Highway Bridge Design Code

.2 CSA A23.1/A23.2, Concrete materials and methods of concrete construction/ Test methods and standard practices for concrete

.3 CSA A3004, Physical test methods for cementitious materials for use in concrete and masonry

.4 CSA B95, Surface Texture (Roughness, Waviness and Lay)

.5 CSA G189, Sprayed Metal Coatings for Atmospheric Corrosion Protection

.6 CSA G30.18, Billet-Steel Bars for Concrete Reinforcement

.7 CSA G40.20/G40.21, General Requirements for Rolled or Welded Structural Quality Steel/Structural Quality Steel

.8 CSA S157, Strength design in aluminium

.9 CSA W178.1, Certification of welding inspection organizations

.10 CSA W178.2, Certification of welding inspectors

.11 CSA W47.1, Certification of companies for fusion welding steel

.12 CSA W48, Filler metals and allied materials for metal arc welding

.13 CSA W59, Welded steel construction

.14 CSA Z234.1, Metric Practice Guide

.7 The City of Calgary:

.1 The City of Calgary’s Design Guidelines for Bridges and Structures

.8 International Organization for Standardization and International Electrotechnical Commission (ISO/IEC):

.1 ISO/IEC 17025, General requirements for the competence of testing and calibration laboratories

.9 Research Council on Structural Connections (RCSC):

.1 Specification for Structural Joints Using High-Strength Bolts

.10 Steel Structures Painting Council (SSPC):

.1 SSPC-SP 2, Hand Tool Cleaning

.2 SSPC-SP 3, Power Tool Cleaning

.11 SSPC and NACE International (NACE) Joint Publications:

.1 SSPC-SP 6, Commercial Blast Cleaning (NACE No. 3)

.12 SSPC, American Welding Society (AWS), and NACE Joint Publications:

.1 SSPC-CS 23.00/AWS C2.23M/NACE No. 12, Specification for the Application of Thermal Spray Coatings (Metallizing) of Aluminum, Zinc, and Their Alloys and Composites for the Corrosion Protection of Steel

.13 United States (U.S.) Military Specifications:

.1 MIL-A-907F – Antiseize Thread Compound, High Temperature

.2 SAE AMS8660 – Silicone Compound NATO Code Number S-736

.14 Ministry of Transportation, Ontario

.1 Laboratory Testing Manual, Test Method LS-428 Method of Test for Compressive Deformation of Laminated Bearings.

.2 Laboratory Testing Manual, Test Method LS-427 Method of Test for Compressive Deformation of Plain Bearings.

1.4 Definitions

.1 **Extended Warranty Period** means a period starting from the issuance of The City's Substantial Completion Certificate and lasting for 5 years.

.2 **Laminated Bearing** means a bearing composed of elastomer laminates separated by and fully bonded to steel plates.

1.5 Qualifications

.1 Bearing suppliers shall meet the qualification requirements as described in Section 05500 – Metal Fabrications.

.2 List of approved bearing suppliers:

- Glacier
- Goodco Z-Tech
- LCL-Bridge
- R.J. Watson
- Watson Bowman Acme
- Wercholoz Canada

.3 The bearing supplier's design Engineer shall be a Professional Engineer registered in the Province of Alberta with a minimum of 10 years' experience in both fabrication and installation of bridge bearings.

.4 If required by The City's Engineer, provide satisfactory information to verify appropriate expertise and experience.

1.6 Design Requirements

.1 Bearing design shall be carried out by the bearing supplier.

.2 Conform to CAN/CSA S6, except where noted by the Technical Specifications.

.3 Bearings shall be designed for the loadings, translations, and rotations specified on the IFC Drawings.

.4 Design Life: Bearings and their installations shall be designed to be compatible with the design life of the bridge while considering the consequences of maintenance and replacement.

.5 Serviceability Limit State: The design shall be such that bearings will not suffer damage that would affect their correct functioning or incur excessive maintenance costs during their intended life.

.6 Ultimate Limit State: The strength and stability of bearings shall be adequate to withstand the ultimate design loads and movement of the structure without irreparable damage.

.7 Durability:

.1 Bearings shall be detailed to exclude crevices and the like that allow moisture and dirt to be trapped and prevent moisture and dirt from entering the internal surfaces.

.2 All exposed steel components shall be protected against corrosion.

.3 Contact between dissimilar metals that could have the potential for galvanic corrosion and/or contact between aluminum alloys and concrete shall be prevented by use of suitable insulation.

.4 The materials used in their manufacture and the protective and maintenance measures adopted against corrosion and deterioration due to environmental effects shall keep bearings functioning correctly as intended throughout their service life.

.8 Where the IFC Drawings show the base of the bearings at or below the high-water elevation, bearings shall be able to be submerged in a flood event with minimal damage as defined in CSA S6 Table 4.16 Performance Criteria.

.9 Plain and laminated bearings shall not be exposed to uplift under any design load combination.

.10 Bearing assemblies subject to uplift shall limit the separation of the bearing components to the values specified on the IFC Drawings.

.11 Critical components shall not be susceptible to brittle fracture at low temperature. Designers should be aware that the availability of notch-tough steel is somewhat limited.

.12 Bearings shall be designed and detailed so that bearing installation does not require field welding to masonry plates, girder sole plates, or directly to girders.

.13 In addition to the bearing itself, sole plates, bevel plates, and base plates shall be designed by the bearing supplier, and shall conform to the details shown on the IFC Drawings. Bearings shall be installed at locations and in orientations per the IFC Drawings to mate with the bottom of the girder. Any adjustments of these details require review and acceptance by The City's Engineer prior to fabrication.

.14 The entire bearing assembly, excluding the sole plate used to attach it to the superstructure and the base plate used to anchor it to the substructure, but including both contact surfaces of the sliding interface, where present, shall be replaceable without damage to the structure and without removal of any concrete, welds, or anchorages permanently attached to the structure and without lifting the superstructure more than the amount of vertical relaxation recovery of bearing material plus 5 millimetres (mm). Bearings shall not be recessed into plates that are permanently attached to the structure.

.15 Use of A490 bolts is not permitted.

.16 Design of weld connections shall be to the requirements of the more stringent of AWS D1.5M and CAN/CSA W59.

.17 Rotational and sliding surface bearings

.1 Translations and Rotation

.1 Provision for translation shall be through sliding of a stainless steel surface against a mating Polytetrafluoroethylene (PTFE) element. The translational capacity in an unrestrained direction shall be as specified on the IFC Drawings.

.2 The bearing guide system shall be self-aligning to provide complete contact of the PTFE and stainless steel surfaces along the entire length of the guide providing the lateral restraint. The sole plate shall be restrained through a central pin or by guide bars that do not use the bottom or baseplate as the restraining device.

.3 Provision for rotation about any horizontal axis shall be by means of a single disc of confined elastomer for pot bearings, a single disc of polyether urethane polymer compound for disc bearings, and a spherical sliding surface of stainless steel or anodized aluminum alloy against PTFE for spherical bearings.

.4 The effective thickness of the elastomeric disc to evaluate the rotational capacity shall be limited to the thickness of the disc excluding the brass rings.

.5 The rotational capacity about any horizontal axis shall be the rotation caused by ultimate limit state (ULS) loads specified on the IFC Drawings plus 1.2 degrees (°).

.6 The rotational capacity about the vertical axis through the centre of the bearing shall be ±1° or the rotation caused by ULS loads specified on the IFC Drawings plus 1°, whichever is greater.

.7 Rotational bearings shall be capable of resisting the specified lateral loads in any direction in combination with the applicable vertical loads.

.8 The average stress in the elastomer at serviceability limit state (SLS) loads shall not exceed 30 megapascal (MPa).

.9 All surfaces of the elastomeric disc shall be treated with a lubricant that is not detrimental to the elastomer.

.10 Brass sealing rings shall have a rectangular cross-section.

.11 The depth of the pot wall shall be such that a minimum vertical distance of 2.5 mm remains between the top of the pot wall and the closest point of contact of the brass sealing rings with the pot wall upon rotating the piston about any horizontal axis to the maximum rotation at ULS plus 1.2°.

.12 The pot and piston surfaces in contact with the confined elastomer shall be lubricated with silicone grease. The bearing shall be sealed by a one-piece continuous preformed closed-cell compressible ring, per ASTM D1056, against entry of dirt, dust, and moisture between the elastomer and the pot and piston contact surfaces. Any joint in the ring shall be bonded, and the strength shall be at least equal to the strength of the ring.

.13 For disc bearings, the upper and lower plates in contact with the elastomer shall be provided with outer limiting rings to restrict the horizontal movement of the elastomer and a centrally located shear restriction mechanism.

.2 Sliding Surfaces:

.1 Sliding surfaces shall allow translation by sliding of a metal surface against a mating PTFE element. The metal sliding surfaces shall be stainless steel. The metal surface shall overlap the PTFE by at least 25 mm at extremes of movement on each side and, except for guides for lateral restraint, shall be positioned above the PTFE element.

.2 Polytetrafluoroethylene Polymer Layer:

.1 Except when used as mating surfaces for guides for lateral restraint, the PTFE resin shall be virgin material, shall be used as unfilled sheets, and shall contain spherical reservoirs for lubricant pressed into its surface. The diameter of the reservoirs shall not exceed 8 mm measured at the surface of the PTFE. The depth of the reservoirs shall not be less than 2 mm but not exceed half the thickness of the PTFE. The reservoirs shall be evenly distributed across the surface of the PTFE and shall occupy 20 to 30% of the surface.

.2 Material used as mating surface for guides for lateral restraint shall not be dimpled or lubricated.

.3 All PTFE elements shall be fully bonded and recessed in a rigid backing material.

.3 All PTFE surfaces, except those that act as mating surfaces for guides for lateral restraint or that are subject to a contact pressure of less than 5.0 MPa, shall be permanently lubricated with silicone grease.

.4 The coefficient of friction between stainless steel sliding surfaces and lubricated virgin PTFE shall be per Clause 14.7.2.5 and Table 14.7.2.5-1 of the AASHTO LRFD Bridge Design Specifications.

.5 Contact Pressure:

.1 The average contact pressure for unfilled PTFE elements based on the gross area of the PTFE shall not exceed the following:

Limit State	Dead Load, MPa	Total Load, MPa
Serviceability	25	35
Ultimate	40	55

.2 The maximum contact pressures at the extreme edges of flat and curved PTFE elements shall not exceed 1.2 times the values indicated above.

.3 The average contact pressure at any SLS combination for filled PTFE elements used to face mating surfaces for guides for lateral restraint shall not exceed the following:

PTFE filled with up to 15% by mass of glass fibres, 45 MPa

Lead-filled PTFE in a bronze matrix, 60 MPa

.3 Guides for Lateral Restraint:

.1 Shall be arranged to permit the required rotations about both the horizontal and vertical axis.

.2 Unless the guide bars are machined to form an integral part of the sole plate, they shall be recessed not less than 5 mm into the plate to which they are attached and fastened with bolts.

.3 The translational elements of guides for lateral restraints shall be faced with stainless steel and shall provide lateral restraint by sliding against mating surfaces faced with PTFE. Lead-filled PTFE shall be at least 2 mm thick and shall be mechanically fastened and bonded to the substrate. Glass-filled or virgin PTFE shall be recessed and bonded to the substrate.

.4 Sole and Base Plates:

.1 The sole and base plates that are permanently attached to the structure shall be provided with the bearings.

.5 Fasteners and Anchorage:

.1 The beneficial effect of friction shall be neglected in proportioning the fasteners and anchors, except for slip-resistant connections. Slip-resistant connections shall be designed to the requirements of CAN/CSA S6.

.2 Fasteners used to attach the bearing to the sole and base plates and the anchorage devices shall be capable of resisting lateral loads specified in the IFC Drawings.

.18 Plain Bearings and Laminated Bearings

.1 The shape factors for plain and the inner layers of laminated bearings shall not be less than 1.25 or greater than 12.

.2 The average vertical deformation at serviceability limit state loads shall not exceed 7% of the effective elastomer thickness.

.3 The total vertical deformation at the edge of bearings due to the vertical load and rotation at serviceability limit state loads shall not exceed 14% of the effective elastomer thickness.

.4 Provision for rotation shall be through vertical deformation of the elastomer without any uplift at the edge of the bearing at serviceability limit state loads.

.5 The thickness of the internal steel plates for laminated bearings shall be greater than 3 mm and less than 5 mm.

.6 The effective elastomer thickness for plain bearings shall be greater than or equal to 15 mm and less than or equal to 25 mm.

1.7 Submittals

.1 Shop Drawings

.1 Submit bearing assembly Shop Drawings, signed and sealed by the bearing supplier’s design Engineer, to The City’s Engineer at least 15 Business Days prior to the anticipated start of fabrication.

.2 The shop drawings shall clearly indicate the following:

.1 Specified vertical and transverse bearing design capacity data including dead load, total load, and lateral load, with corresponding vertical load at SLS and ULS, and movements in longitudinal and transverse directions, including rotations at SLS and ULS.

.2 Material properties, including compressive and shear stiffness at +20 degrees Celsius (°C) and -40°C

.3 Details and dimensions of bearing assembly, including individual components, connection attachments, fasteners, accessories, and anchorages

.4 Bearing layout and orientation

.5 Bearing identification coding

.6 Manufacturer's installation procedure

.7 Installation details

.8 Tolerance shall be provided on drawings for centring and setting, indicating permissible range of movement and other tolerances

.9 Indicate welded connections using Canadian Institute of Steel Construction (CISC) Handbook for Steel Construction standard weld symbols, including net weld lengths where applicable.

.3 The City's Engineer will return a copy of the reviewed bearing assembly Shop Drawings marked as one of the following:

.1 Stamped with wording that allows for permission to fabricate. In such a case, Work can commence on receipt of the drawings by the Contractor. A copy of these drawings shall be available at the site prior to and during construction.

.2 Stamped with wording that allows for permission to fabricate as noted. In such a case, Work can start on receipt of the drawings by the Contractor. The drawings are to be updated as noted and shall have a stamp affixed that is signed by the bearing supplier's design Engineer stating the drawings have been revised according to the noted comments. A copy of the stamped, updated drawings shall be available at the site prior to and during construction.

.3 Stamped with wording that requires revision and resubmission. Required changes shall be clearly shown on the drawings. The Contractor shall have the drawings updated as required and the submission process repeated.

.2 Submit design calculations, signed and sealed by the bearing supplier's design Engineer, to The City's Engineer for review, prior to commencing fabrication. Review by The City's Engineer does not relieve the responsibility of the Contractor or their supplier:

.1 For each bearing, clearly indicate how it satisfies the design criteria indicated in the Technical Specifications.

.2 For guide bars, clearly indicate the adequacy of fastening PTFE to the guide bar.

.3 Notify the City's Engineer, in writing, of the name and address of the bearing supplier within 20 Business Days of the Contractor receiving Notice to Proceed.

.4 Submit in writing evidence of qualifications for welding under the Canadian Welding Bureau (CWB) CSA W47.1 Division 1 or 2 to the City's Engineer.

.5 Submit for review CWB approved welding procedures for each type of weld required for the fabrication and field installation of the bearings. The welding procedures shall be reviewed by The City's Engineer before welding proceeds.

.6 Submit to The City's Engineer the bearing supplier's QC and Contractor's QA procedures to be followed during the manufacture of each bearing. These procedures are to be submitted to The City's Engineer not later than 10 Business Days prior to submitting the Shop Drawings and shall identify the following:

.1 A material verification process for determining that the materials have the specification and grade indicated on the Shop Drawings and that this is supported by mill test certificates.

.2 Welder certification that indicates welders involved in the fabrication are certified by the CWB to undertake the welding required. Acceptance of certification from a similar organization will not be considered without approval from The City.

.3 A welding procedure review process to verify the bearing supplier's welding procedures are certified by CWB as qualified welds.

.4 A non-destructive testing plan that indicates the qualifications of the firm that will be responsible for completion of the non-destructive testing.

.5 A fit-up verification process that confirms the fit-up of the various components and parts meets the tolerances identified on the approved Shop Drawings.

.6 A dimensional check process to confirm that overall dimensions, bevel sole plate slopes, and other tolerances relating to the assembly are being achieved.

.7 Submit mill certificates for all steel utilized in fabrication. Fabrication shall only be allowed with materials having mill certificates properly correlated to the materials used on the project and that have been reviewed and accepted by The City's Engineer. Mill test reports are to be submitted for review at least 20 Business Days prior to the scheduled start of fabrication. Test reports for all materials shall be written in English.

The Contractor shall have all steel, including billets, bars and fasteners, originating outside of Canada or the U.S. verified by a certified laboratory in Canada by testing to the specified material standards, and shall include a determination of boron content (not permitted to exceed 0.0008%). This laboratory shall be certified by an organization accredited by the Standards Council of Canada to comply with the requirements of ISO/IEC 17025 for the specific tests, or type of tests, required by the material standard specified on the mill test report. Preparation and collection of samples for testing shall be directed and witnessed by, or completed by, personnel employed by the testing lab. A verification letter, signed and sealed by a Canadian registered Professional Engineer in the field of metallurgy and bearing the signature of an authorized officer of the testing laboratory, shall be provided by the laboratory and shall include references to the appropriate mill test report(s), material specification number(s), testing standards, date of testing, and statements indicating material compliance with the requirements of the Contract documents.

A verification letter, signed and sealed by a Professional Engineer registered in the Province of Alberta in the field of metallurgy and bearing the signature of an authorized officer of the testing laboratory shall be provided by the laboratory and shall include references to the following:

.1 Appropriate mill test report(s)

.2 Material specification number(s)

.3 Testing standards

.4 Date(s) of testing

.5 Statements indicating material compliance with the requirements of the Agreement.

.8 Upon completion of fabrication the bearing supplier's design Engineer shall conduct a final fabrication inspection and prepare and submit a report of the Work. This report shall including the following:

.1 Verification from the bearing supplier's design Engineer that the fabrication of the bearing has been carried out in general conformance with the approved Shop Drawings and the Agreement.

.2 Certificate of compliance for all materials incorporated into the bearings (not older than 12 months) signed by the bearing supplier. The certificate of compliance shall include test results according to tables of this specification.

.3 Statement granting permission to proceed with installation.

.9 Submit the bearing supplier's recommended installation procedures for the bearing assemblies and datasheets to The City's Engineer 5 Business Days prior to installation of the bearing assembly.

.10 Submit erection drawings, including elevations and details as applicable, for each bridge.

.11 Submit a bearing replacement procedures as part of the Operation and Maintenance Manual for the project to The City's Engineer prior to issuance of the Construction Completion Certificate.

.12 Submit a bearing inspection and maintenance plans as part of the Operation and Maintenance Manual for the project to The City's Engineer prior to issuance of the Construction Completion Certificate.

.13 When required, submit a grouting plan to The City's Engineer at least 5 Business Days prior to installation of grout.

.14 When required, submit a description of the proposed method to control the grout temperature during cold weather to The City's Engineer at least 5 Business Days prior to installation of the bearings. The submission shall be accompanied by samples of insulation. The description shall contain the following information:

i. Weather conditions for which the procedure is applicable to

ii. Type of insulation, metric R value, and number of layers to be used

iii. Description of housing and heating

1.8 Quality Control and Quality Assurance Inspection and Testing

.1 The Contractor shall be responsible for QA/QC testing required to verify the Work meets the design parameters and specification requirements.

.2 The Contractor's plan for QA/QC shall be included in the Quality Management Plan (QMP) and submitted to The City's Engineer for review prior to starting any fabrication. All QA/QC, including testing, associated methods, means, materials, equipment, and labour, as part of the Contractor's QMP shall be paid for by the Contractor.

.3 Testing by The City: In addition to the Contractor's responsibility for QA/QC, The City may appoint a testing agency to perform independent QA testing as deemed necessary by The City. These inspections will be performed by testing agencies appointed by and paid for by The City. This testing is independent of the

Contractor's QMP and shall not replace the Contractor's QC testing and QA review documentation.

.4 Testing by the Contractor: The Contractor's inspection and testing scope is as detailed below. Additional testing made necessary by material substitutions, the repair of Deficiencies shall be paid for by the Contractor. All test records shall be submitted to the City's Engineer for review and acceptance.

.5 Any QA/QC testing and inspection records made by the Contractor shall be open to The City's Engineer for auditing.

.6 The bearing supplier's design Engineer shall inspect the fabrication and erection of these components onsite and advise the Contractor accordingly. Performance of these duties shall generally be in accordance with the Association of Professional Engineers and Geoscientists of Alberta's (APEGA's) Responsibilities for Engineering Services for Building Projects.

.7 The Contractor shall engage an independent accredited testing company at the Contractor's expense to perform the following:

.1 Material property testing and dimensional checks of all bearing materials in advance of bearing production, including elastomer hardness

.2 Loads, properties, and dimensional checks of the finished bearings.

All testing and verification shall be completed in accordance with the Technical Specifications and AASHTO M251. Where differences from AASHTO M251 appear in the Technical Specifications, the Technical Specifications shall govern.

.8 The Contractor and their supplier are responsible for the quality of materials and products incorporated in the Work and for the quality of the Work. The burden of proof is on the Contractor and their supplier for the quality of the Work. The absence of QA/QC documentation may result in Work being deemed incomplete or deficient, and may result in corrective work, the costs of which, direct and indirect, are to be borne by the Contractor.

.9 Contractors Testing Requirements

.1 Welding

.1 The Contractor shall engage a testing agency, certified in accordance with CSA W178.1, to perform QC weld testing.

.2 Testing of welds shall include visual examination of all welding procedures at the plant and in the field, as well as any magnetic particle, ultrasonic, or radiographic inspections, or other examination procedures deemed necessary by the testing agency to permit certification of welds.

.3 The Contractor shall provide a copy of all weld test results to The City's Engineer within 3 Business Days of testing. The City's Engineer may require additional testing.

.4 Unless otherwise noted, evaluation of flaws shall be to the more stringent of AWS D1.5M and CSA W59.

.2 Plain Bearings:

.1 Compressive Deformation Testing

.1 Each bearing shall be tested for compressive deformation in accordance with LS-427.

.2 The increment in compressive deformation of plain bearings shall not exceed 0.06 of the thickness of the bearing when the bearing load is increased from an initial pressure of 20% of the average pressure to the average pressure, and not greater than 7 MPa.

.2 Bond strength testing

.1 One sample bearing per lot shall be tested for bond strength in accordance with AASHTO M251 Appendix X2.

.2 If the test bearing fails to meet the required minimum bond strength, the lot shall be rejected.

.3 Inclined Compression Test for Shear Modulus

.1 One bearing per lot shall be tested to confirm shear modulus in accordance with AASHTO M251 Annex A1.

.2 If the test bearing fails to meet the required minimum shear modulus, the lot shall be rejected.

.3 Laminated Bearings:

.1 Compressive Deformation Testing

.1 One bearing per lot shall be tested for compressive deformation in accordance with LS-428.

.2 The increment in compressive deformation of laminated bearings shall not exceed 0.05 of the effective elastomer thickness, when the bearing load is increased from an initial pressure of 1.5 MPa to a pressure of 7 MPa.

.2 Bond strength testing

.1 One bearing per lot shall be tested for bond strength in accordance with AASHTO M251 Appendix X2.

.2 If the test bearing fails to meet the required minimum bond strength, the lot shall be rejected.

.3 Inclined Compression Test for Shear Modulus

.1 One bearing sample per lot shall be tested to confirm shear modulus in accordance with AASHTO M251 Annex A1.

.2 If the test bearing fails to meet the required minimum shear modulus, the lot shall be rejected.

.4 Creep and Shear bond strength test

.1 One bearing sample per lot shall be tested to confirm creep and shear bond strength in accordance with AASHTO M251 Annex A2.

.2 The percent creep at 25 years shall be documented and shown on the Shop Drawings.

.4 Rotational and sliding surface bearings

.1 For rotational and sliding surface bearings, one bearing per lot shall be tested as specified by AASHTO and ASTM D5977 to confirm the requirements of the Technical Specifications. The tested bearing shall be visually examined both during the test and upon disassembly after the test. Visual Deficiencies may include:

.1 Extruded or deformed elastomer, polyether urethane, or PTFE

.2 Insufficient clearances, such as evidence of metal-to-metal contact between the pot wall and the sole plate

.3 Damaged components, such as cracked steel, damaged seal rings, or damaged limiting rings

.4 Bond failure

.5 Visual signs of rubbing or binding

.6 Visual signs of excessive wear, cracks, or splits after proof load testing

.7 Other testing failures

.8 If any of these items are found, or do not comply with the requirements of the Technical Specifications, it shall be grounds for rejection of all the bearings of the lot.

.2 Coefficient of Friction Test:

.1 Sliding coefficient of friction tests shall be performed by the bearing supplier on one expansion-bearing device from each lot per type per the AASHTO LRFD Bridge Construction Specifications.

.2 The measured sliding coefficient of friction shall be documented and shown on the shop drawings.

.3 Proof Load Test:

.1 Proof load tests shall be performed by the bearing supplier on one bearing assembly from each lot per type per the AASHTO LRFD Bridge Construction Specifications. After the test, dismantle the bearing, and check surfaces for visible excessive wear, cracks, or splits.

.2 If set is excessive, all bearings shall be preloaded prior to delivery.

.3 The measured rotations shall be documented and shown on the shop drawings.

.4 Clearance Tests:

.1 Clearance tests shall be performed by the bearing supplier on one bearing assembly from each lot per type per the AASHTO LRFD Bridge Construction Specifications. The bearing selected for this test shall be the one with the least amount of clearance based on the dimension check.

.5 Grout

.1 The Contractor shall conduct compressive strength testing (28-Day, 7-Day, and early strength as required) of the grout. One set of three compressive strength cubes shall be cast for each day of production of grout. Casting of cubes shall be according to CAN/CSA-A3004-C2. One set of three cubes shall be tested for 7-Day compressive strength according to CAN/CSA-A3004-C2. Grout shall be acceptable if the average 7-Day compressive strength of the set of three cubes is greater than or equal to 35 MPa. Unacceptable grout shall be removed and replaced at the Contractor's expense. For early strength testing, additional cubes shall be similarly cast.

1.9 Acceptability

.1 Failure to comply with the requirements of the Technical Specifications will result in the structure being considered potentially deficient.

.2 The Contractor shall pay all costs for additional testing, inspection, and analysis required to demonstrate the adequacy of items that do not meet the requirements of the Agreement. The Contractor shall be responsible for any project costs associated with schedule delays related to demonstrating adequacy.

.3 If any inspection, either by visual or by physical testing, shows that any part of the bearing assembly does not meet the requirements of the Technical Specifications, the unsatisfactory part or parts are to be replaced at no cost to The City.

.4 Any material judged inadequate by testing and inspection shall be replaced at any time up to the end of the Extended Warranty Period at the Contractor's expense.

.5 The City's Engineer may order further testing, inspection, and analysis at any time. If additional testing is outside the scope of this contract, The City will pay for those tests, inspections, or chemical analyses that meet the Technical Specifications, and the Contractor will pay for those that do not.

.6 Acceptance of Corrective Work:

.1 Submit a proposal for the method and description of corrective work to The City's Engineer for review and acceptance not less than 10 Business Days prior to the commencement of any corrective work. The submission is to be accompanied by a report indicating the cause of each Deficiency.

.2 Upon acceptance of the proposal, carry out all corrective work immediately. Provide a minimum of 3 Business Days' notice to The City's Engineer prior to carrying out any corrective work.

.3 Repair all Deficiencies according to the requirements of these Technical Specifications and the accepted proposal. If the bearing assembly requires replacement, its successor is to be from the same bearing supplier. The cost of all corrective work, including labour, equipment, material, deck joints, and traffic control, be borne by the Contractor, while maintaining all aspects of these Specifications.

2 PRODUCTS

2.1 General

.1 Bearings shall be fabricated from new and unused materials. Reclaimed material shall not be incorporated into the finished bearings.

.2 Metals are to be free from defects impairing strength, durability, and appearance. All exposed fastenings are to be of the same material, colour, and finish as the metal to which applied, unless otherwise noted.

2.2 Steel

.1 Steel components shall be according to CSA G40.20/40.21, Grade 300W, unless noted otherwise.

.2 Components permanently attached to steel superstructures shall be CSA G40.20/40.21, Grade 350A.

.3 Internal steel plates for Laminated Bearings shall be rolled mild steel conforming to ASTM A36/A36M, or equivalent, with a minimum yield strength of 230 MPa.

.4 All steel materials are to have a total maximum boron of 0.0008%.

.5 Stainless steel for sliding surfaces shall have a minimum corrosion resistance according to ASTM A240/A240M, Type 304, with a #8 mirror finish.

2.3 Aluminum Alloy

.1 Aluminium alloys shall be according to CSA S157.

2.4 Brass

.1 Brass sealing rings for confined elastomer bearings shall be according to ASTM B36/B36M, half-hard.

2.5 Fasteners

.1 Steel fasteners shall be Grade A325/A325M Type 1 heavy hex style bolts according to ASTM F3125/F3125M with nuts per ASTM A563M and hardened washers per ASTM F436/F436M. All fastener components shall be hot-dipped galvanized according to ASTM F2329/F2329M. For guide bars, alternative steel fasteners and corrosion protection systems shall be as specified in the Agreement.

.2 All stud shear connectors shall conform to the chemical requirements of ASTM A29 and A108, Grades 1015, 1018, or 1020. In addition, they shall meet the mechanical properties specified in CSA W59, Appendix H, for Type B studs. Certified mill test reports for the stud material shall be provided.

.3 High-strength anchor rods shall be ASTM A193/A193M Grade B7. Where anchor rods are in contact with galvanized bearing plates, the anchor rods and associated stainless steel nuts and washers shall be isolated from the galvanized bearing plates with stiff rubber grommets and rubber plies.

2.6 Elastomers

.1 Elastomers shall be made from one of the following materials:

i. Virgin natural polyisoprene: For plain, laminated, and pot bearings

ii. Virgin polychloroprene: For plain and laminated bearings

iii. Polyether-urethane polymer: For disc bearings

.2 Virgin natural polyisoprene or virgin polychloroprene elastomer shall be the only raw polymers permitted.

.3 Where used as a component in pot bearings, disc bearings, or other assembly type bearings, elastomers shall provide a service life equal to or greater than that of the bearing.

.4 Cured elastomeric compounds shall be low-temperature Grade 5 according to the AASHTO LRFD Bridge Design Specifications and shall meet or exceed the requirements of Table 1 of this specification.

.5 Elastomers shall have a 60 durometer hardness Shore A for elastomeric bearing pads (laminated and plain) and a 50 durometer hardness Shore A for rotational and sliding surface bearings (elastomeric disc), measured according to ASTM D2240.

TABLE 1 - Physical Requirements for Polyisoprene and Polychloroprene

Property	Test	Requirements	
		Polyisoprene	Polychloroprene
Shear modulus G_{RT}, MPa at 20°C[a.]	ASTM D4014, Annex A1, as modified by AASHTO M251 and Annexes	0.80 ± 0.15	0.80 ± 0.15
Shear modulus G_{LT}, MPa at (-)ve 40°C[b.]	ASTM D4014, Annex A1, as modified by AASHTO M251 and Annexes	Not more than 3 times the value at room temperature $G_{LT} \leq 3\ G_{RT}$	Not more than 3 times the value at room temperature $G_{LT} \leq 3\ G_{RT}$
Tensile strength, MPa	ASTM D412, Method A	Minimum 17.0	Minimum 17.0
Ultimate elongation, %	ASTM D412, Method A	Minimum 400	Minimum 400
Heat resistance	ASTM D573	168 h at 70°C	70 h at 100°C
Change in hardness, °Shore A	ASTM D2240	Maximum (+)ve 10	Maximum (+)ve 15
Change in tensile strength, %	ASTM D412, Method A	Maximum (-)ve 25	Maximum (-)ve 15

TABLE 1 - Physical Requirements for Polyisoprene and Polychloroprene

Property	Test	Requirements	
		Polyisoprene	**Polychloroprene**
Change in ultimate elongation, %	ASTM D412, Method A	Maximum (-)ve 25	Maximum (-)ve 40
Compression set, %[c.]	ASTM D395, Method B	22 h at 70°C, maximum 25	22 h at 100°C, maximum 35
Ozone resistance	ASTM D1149, Mounting Procedure A, 20% strain, 40 ± 2 °C	25 pphm, 48 h, no cracks	100 pphm, 100 h, no cracks
Bond between steel and elastomer laminae (Peel bond test), N/mm	ASTM D429, Method B	Minimum 7.0	Minimum 7.0
Brittleness at (-)ve 40°C	ASTM D746, Procedure B	No failure	No failure
Low-temperature crystallization increase in hardness, °Shore A	ASTM D2240	168 h at (-)ve 25°C, maximum (+)ve 15	168 h at (-)ve 10°C, maximum (+)ve 15

Notes:

[a] Shear modulus shall be determined at ambient temperature in accordance with ASTM D4014 Annex A1, modified as follows: The initial cycles shall be taken to a strain of 0.7, and on the last cycle, the shear modulus shall be determined at 0.5 strain.

[b] Shear modulus testing shall be performed with the test specimen in an enclosed freezer unit capable of maintaining the specified conditioning temperature. A ±25% strain cycle shall be applied for a period of 100 seconds. The first three-quarter cycle of strain shall be discarded, and the stiffness shall be determined by the slope of the force deflection curve for the next half-cycle of loading.

[c] All test specimens of steel-laminated bearings used for compression set test ASTM D395, Method B, shall be prepared from the representative bearing pads and may consist of a single layer or multiple layers of elastomer.

≤ = less than or equal to

(+)ve = positive

(-)ve = negative

G_{LT} = Shear Modulus (Low Temperature)

G_{RT} = Shear Modulus (Room Temperature)

h = hour(s)

N/mm = newtons per millimetre

pphm = part(s) per hundred million

.6 Where polyether-urethane polymer is used for rotational and sliding surface bearings, the polyether urethane polymer shall be according to Table 2 of this specification.

Table 2 – Physical Requirements for Polyether-Urethane Polymer

Property	Test	Requirements	
		Minimum	**Maximum**
Hardness, Scale D	ASTM D2240	60	64
Tensile Stress, MPa at 100% elongation at 200% elongation	ASTM D412	 14 26	 - -
Tensile Strength, MPa	ASTM D412	35	-
Ultimate Elongation, %	ASTM D412	220	-
Compression Set, %	ASTM D395	-	40

Notes:

- = not applicable

2.7 Polytetrafluoroethylene (PTFE) Polymer

.1 Material used in sliding surfaces shall be virgin PTFE according to ASTM D4894. The PTFE shall be unfilled and according to Table 3 of this specification.

Table 3 – Physical Requirements for Polytetrafluoroethylene Polymer

Property	Test	Requirement
Tensile Stress, MPa	ASTM D638	Minimum 20
Elongation, %	ASTM D638	Minimum 200
Relative Density	ASTM D792	2.16 ± 0.03

.2 Material used as the mating surface for guides for lateral restraint may be one of the following:

.1 Unfilled PTFE

.2 PTFE filled with up to 15% by mass of glass fibres

.3 Lead-filled PTFE in a bronze matrix

2.8 Lubricant

.1 Lubricant shall be silicone grease, effective to -40°C, according to SAE AMS8660.

2.9 Adhesives

.1 Adhesives for bonding PTFE to metal shall produce a bond with a minimum peel strength of 7.0 N/mm, as measured by ASTM D429, Method B. Adhesives shall not degrade in the service environment.

2.10 **Grout**

.1 Grout shall be non-shrink, non-staining with a minimum 7-Day compressive strength of 35 MPa, unless specified otherwise on the IFC Drawings. The following products shall be used:

.1 Sika 212 or approved equal.

.2 The Contractor shall submit details of the proposed grout mix to The City's Engineer for acceptance.

3 EXECUTION

3.1 Fabrication

.1 No fabrication shall be performed until the following conditions are met:

.1 The accepted Shop Drawings are in the hands of the Bearing Supplier's Design Engineer

.2 The Contractor has approved proceeding with the fabrication

.3 The City's Engineer has accepted proceeding with the fabrication

Any materials purchased or any fabrication work started before these three conditions are met is at the Contractor's risk.

.2 Any changes made to approved Shop Drawings or design calculations during the fabrication process are subject to review and acceptance by the City's Engineer. Submit revised sheets of the same size and format as those originally approved.

.3 Fabrication shall be performed in a fully enclosed area that is adequately heated. The shop temperature shall be at least 10°C.

.4 Each bearing shall be marked with the fabricator's name, date of manufacture, type, orientation and unique identification number that will be easily visible after installation. The characters shall not be less than 10 mm in height.

.5 Welding:

.1 Welding of structural steel shall be according to the more stringent of AWS D1.5M and CSA W59.

.2 Welding of stainless steel shall be according to the more stringent of AWS D1.6M and CSA W47.1.

.3 All welding shall be done with electrodes certified by the CWB to the requirements of CSA W48.

.6 Machining:

.1 Machining shall be done after welding. All metal-to-metal contact surfaces shall be machined or fine ground.

.2 The pots and pistons for confined elastomer bearings and the upper and lower plates with limiting rings for disc bearings shall be machined from solid metal plate or castings.

.3 The concave and convex plates for spherical bearings shall be machined from solid metal plate or castings.

.7 Plain Bearings:

.1 Plain bearing pads shall be moulded individually, cut from moulded strips or slabs of the required thickness, or extruded and cut to length.

.8 Laminated Bearings:

.1 Laminated Bearings shall be moulded under pressure as a single unit and heated in moulds that have a smooth surface finish.

.2 Elastomer laminates shall be of uniform thickness.

.3 The steel laminates shall be of uniform thickness without any sharp edges.

.4 Laminated bearings shall be vulcanized to the adjacent upper and lower bearing plates.

.5 Steel plates shall be completely bonded on all surfaces to the elastomeric material during moulding. The bond between the elastomer and the metal laminates shall be such that when a sample is tested for separation, failure shall occur within the elastomer and not between the elastomer and metal laminate.

.6 The minimum cover of elastomer over the edges of reinforcing plates shall be 8 mm. The minimum cover on the top and bottom surfaces shall be 5 mm, unless shown otherwise on the Drawings, except that no cover is required over pintle holes.

.7 When pintles are specified in the Agreement, the depth of pintle holes shall be such that the pintle engages only one steel plate through the entire thickness of the plate.

.9 Rotational and Sliding Surface Bearings:

.1 All rotational and sliding surface bearings shall be plant-assembled. The Contractor shall notify The City's Engineer at least 5 Business Days before assembly so that they can arrange for an inspection.

.2 Elastomeric rotational elements shall be molded as a single piece; separate layers are not permitted.

.3 The piston shall not be made from a steel with a higher yield strength than that of the pot.

.4 Finish of all surfaces of steel components, including shoe plates, sole plates, and base plates, except stainless steel for sliding surfaces, shall be as follows unless noted otherwise on the Drawings:

.1 Blast cleaned in accordance with SSPC-SP-6

.2 Hot-dip galvanized in accordance with ASTM A123/A123M

.5 The surface finish of any metal plate in contact with any other metal plate or with confined elastomer in pot bearings shall be machined to a surface finish of 6.4 micrometres (µm) and a flatness tolerance of 0.001 times the bearing thickness, unless noted otherwise on the IFC Drawings.

.6 For sliding bearings, the top 10 mm of galvanized laminate shall have a 2.5-mm recess. The recessed surface shall be machined to a surface finish of 6.4 µm and a flatness tolerance of 0.001 times the bearing thickness, unless noted otherwise on the IFC Drawings.

.7 Stainless steel sheets in contact with PTFE shall be one piece continuously welded around the perimeter to its backing plate to prevent ingress of moisture. The weld shall be clean, uniform, and without overlaps and located outside the area in contact with PTFE.

.8 The roughness of sliding stainless steel metallic surfaces in contact with PTFE, measured according to CSA B95, shall not be greater than 0.25 µm arithmetic average for plane surfaces and 0.50 µm arithmetic average for spherical surfaces.

.9 The roughness of anodized aluminium metallic surfaces shall not be greater than 0.40 µm arithmetic average, measured according to CSA B95.

.10 The roughness of metal surfaces in contact with elastomer measured according to CSA B95 shall not be greater than 3.0 µm arithmetic average.

.11 There shall be no openings or discontinuities in the metal surfaces in contact with the confined elastomer or PTFE.

.12 Virgin or glass-filled PTFE elements shall be recessed in a rigid backing material and shall be bonded over the entire area with an adhesive. The rigid backing material shall be grit blasted and cleaned with oil-free compressed air prior to applying the adhesive.

.13 Lead filled PTFE shall be mechanically fastened and bonded to the backing plates.

.14 The PTFE elements used as mating surfaces for guides for lateral restraint shall extend to within 10 mm from the ends of the backing plates.

.15 Aluminium alloy surfaces shall be anodized using the sulphuric acid process and shall meet the requirements in Table 4:

Table 4 – Aluminum Alloy Surface Requirements

Physical Property of **Sealed Anodic Coating**	Units	Test Method	Requirement
Thickness, t	µm	ASTM B487	25 minimum
Mass, w	mg/cm^2	ASTM B137	5.8 minimum
Apparent density, d	g/cm^3	ASTM B137	2.32 minimum

Notes:

The apparent density shall be determined as: d = 10 w/t

g/cm^3 = gram(s) per cubic centimetre

mg/cm^2 = milligram(s) per square centimetre

.16 The sole and base plate anchorage to concrete shall be by studs that are fusion welded to the plates.

.10 After verification that the gap tolerances are met, the bearing assembly shall be preset for a +15°C installation day and shipped securely to the Project Site.

.11 Bearing assembly plates to be in contact with wet-cure grout pads shall receive two coats of epoxy mastic paint on the galvanized surface. Bond shall be tested to ASTM D3359 and shall meet a minimum of 4B classification (a maximum allowable flaking of 5%).

3.2

3.3 Fabrication Tolerance

.1 Bearings shall be shop assembled for inspection in a relaxed condition. The assembly shall be properly supported throughout its length to facilitate the checking of tolerances. Tolerances shall be checked by the fabricator before and after galvanizing.

.2 Bearings shall be fabricated to the more stringent of this specification and AASHTO M251, Section 6.

.3 Plain and Laminated Bearings:

.1 Bearing thickness:

.1 Less than or equal to 40 mm: 0 to +3 mm

.2 Greater than 40 mm: 0 to +6 mm

.2 Bearing plan dimension: 0 to +6 mm

.3 Thickness of individual layers of elastomer: ± 20%

.4 Deviation from plane parallel to theoretical surface:

.1 Top and bottom: 1 in 200

.2 Sides: 0 to +6 mm: 1 in 100

.5 Cover to embed steel on: 0 to + 2 mm

.6 Pintle hole diameter: 0 to +2 mm

.7 Position of pintle holes relative to each other: ±2 mm

.4 Rotational and Sliding Surface Bearings:

.1 For PTFE components:

.1 Plan dimension: 0 to -0.2% of diameter or diagonal

.2 Thickness: Within 0 to +10.0% of design thickness

.3 Recess depth: 0 to +0.3 mm of design depth

.2 The plan dimensions of the recess for PTFE shall be the same as the nominal plan dimensions of the PTFE and shall be machined to a tolerance of 0 to +0.2% of the diameter or diagonal.

.3 For PTFE surfaces, the deviation from flatness of shall not exceed:

.1 For diameter or diagonal less than or equal to 800 mm: 0.2 mm

.2 For diameter or diagonal greater than 800 mm: 0.00025 of the diameter or diagonal in mm.

.4 The deviation from flatness of stainless steel or aluminium alloy surfaces in contact with PTFE for plane surfaces and from the theoretical surface for spherical surfaces shall not exceed:

.1 For rectangular PTFE element: 0.0003 LH mm

.2 For circular PTFE element: 0.0006 RH mm

Where:
L = the greater plan dimension for a rectangular bearing
R = the radius of a circular bearing
H = the free height of the PTFE element

.5 For confined elastomer bearings, the tolerance of fit between the piston and the pot shall be +0.75 to +1.25 mm.

.6 The inside diameter of the pot cylinder shall be the same as the nominal diameter of the elastomer and shall be machined to a tolerance of:

.1 Diameters less than or equal to 500 mm: 0 to +0.125 mm

.2 Diameters greater than 500 mm: 0 to +0.175 mm

.7 For disc bearings, the gap between the edge of the polyether urethane polymer disc and the inside face of the limiting ring shall be 1.25% ±0.25% of the diameter of the disc.

.8 Overall bearing plan dimension: ±3 mm

.9 Overall bearing height: ±3 mm

.10 Machined surface dimensions: ±0.4 mm

.11 For elastomeric components diameter:

.1 Diameters less than or equal to 500 mm: 0.0 to -1.5 mm

.2 Diameters greater than 500 mm: 0.0 to -2.0 mm

.12 For elastomeric components thickness: 0.0 to +1.0 mm

.13 For brass rings the difference between:

.1 Internal diameter of brass ring and diameter of recess in the moulded elastomer: 0.0 to +0.5 mm

.2 Sum of thicknesses of brass rings and recess depth in the moulded elastomer: 0.0 to +0.25 mm

.14 Recessed guide bars shall meet the requirements of the American Standard Clearance Locational Fit Class LC3 according to ANSI/ASME B4.1.

.15 Gap between metal restraints surfaces and mating PTFE elements of guides for lateral restraint: 0.5 mm ±0.25

3.4 Application for Hot-Dipped Galvanizing

.1 All structural steel and metal components of the bearing assembly, except internal steel laminates, weathering steel (CSA G40.21 350A and 350AT), and stainless steel, shall be hot-dip galvanized according to ASTM A123/A123M after fabrication. All hardware, except for high strength anchor rods and their associated nuts and washers, shall be galvanized according to the more stringent of ASTM A153/A153M and ASTM F2329/F2329M.

.2 Hot-dipped galvanizing shall conform to ASTM A123M, ASTM A153M, and ASTM F2329M; minimum 610 grams per square metre (g/m^2) coating.

.3 Field touch-up of damaged galvanizing or zinc metalizing shall conform to ASTM A780/780M Method 3. Metalizing shall be 180 μm thick.

.4 At least 72 hours prior to commencement of galvanizing, The Contractor shall provide The City's Engineer with written notice of the intent to hot-dip galvanize. Hot-dip galvanizing done without this prior notification can be rejected at The City Engineer's discretion.

.5 Two copies of the galvanizer's coating thickness readings shall be submitted to The City's Engineer prior to the installation of the component in the structure.

3.5 Bearing Supplier's Instructions

.1 The bearing supplier's written product data and instructions for storage, handling, care, and installation of bearing assemblies shall be complied with throughout the entirety of the project.

.2 Where there is a conflict between the bearing supplier's recommendations and the Agreement the more stringent requirements apply as determined by The City's Engineer.

3.6 Delivery, Storage, and Handling

.1 Rotational or sliding-surface bearings shall not be dismantled at the Project Site.

.2 The City's Engineer will visually inspect the bearings when delivered to the Project Site to determine compliance with requirements of the Technical Specifications.

.3 Bearings shall be stored and covered securely to avoid contaminating or damaging bearing components.

.4 Bearings shall be protected during handling, transport, storage, and installation from damage or distortion; and kept clean and free of deleterious matter and contaminants, including moisture and dust.

.5 Clearly marked transportation clamps and bolts shall be shop installed. Temporary transportation devices are to be solely designed for handling during transportation of bearings and shall in no way be used to stabilize the structure during erection of girders or construction. Remove such temporary transportation devices once structure is secured on bearings. In the case of such devices using threaded holes in assembly plates, such threaded holes are to be galvanized during fabrication and finally sealed with flexible silicone sealant to protect from potential corrosion.

3.7 Examination of Works by Other Trades

.1 Before commencing fabrication of the Work of this section, the supplier or their representative shall inspect and, as far as practical, take field measurements of work done by other trades that may affect the Work. Before the commencement of the Work of this section, the supplier shall notify The City's Engineer, in writing, of their acceptance of work done under other sections or by other trades. If any conditions exist that will prejudice a proper installation of the Work, the supplier is to notify the Contractor in writing and is not to proceed with installation of the Work until Deficiencies are corrected and The City's Engineer has received the letter of acceptance.

.2 Stay-in-place forms are not permitted. The Contractor shall verify that there are no stay-in-place forms for preformed holes and shall coordinate with the bearing supplier for any preformed hole requirements.

.3 Prior to installing the bearings, the Contractor shall confirm that an organic zinc epoxy primer meeting Class B coating requirements per Appendix A of the RCSC Specification for Structural Joints Using High-Strength Bolts has been applied to the steel girders in the following locations:

  .1 At the pier locations (when applicable): Top, bottom, and side surfaces of the bottom flange

  .2 At the abutment locations: Top, bottom, and side surfaces of the bottom flange; outside surface of the webs; and the bottom surface of the top flange

.4 Organic zinc epoxy primer shall extend a minimum of 100 mm beyond the bearing dimensions.

3.8 Installation

.1 Installation Tolerance

  .1 Installation tolerances shall be to the more stringent of CAN/CSA S6, AASHTO Standard Specification for Highway Bridges, Division II, Section 18.9, and the Technical Specifications.

  .2 Bearings shall be located so that their longitudinal and transverse centrelines are within ±3 mm of their positions specified on the IFC Drawings.

  .3 Elevation of a single bearing or the mean elevations of more than one bearing at any support shall be within a tolerance of ±0.0001 times the sum of the adjacent spans of a continuous girder but not exceeding ±3 mm.

  .4 Bearings shall be set to their correct inclination to the horizontal within a tolerance of ±0.1° in any direction.

.5 Concrete surfaces in contact with the bearings shall not vary from a flat plane by more than 2 mm in 1,000 mm within the plan area of the bearing, and local irregularities shall not exceed 1 mm.

.2 The threaded portion of the bolts shall be coated with silicone grease prior to installation.

.3 Temporary clamping devices shall be used to maintain correct orientation and setting, and to prevent movement or separation of the bearing components during handling, transportation, and installation. The clamping devices shall not be used for lifting or suspending the bearings. Clamping devices shall be removed after each bearing is in its final position, with all permanent connections made, and after all grout and concrete in contact with the bearing have been placed.

.4 Adjustment devices shall be provided for the bearing assembly to allow for setting the bearing position to suit the temperature when the bearings are placed into final position.

.5 The bearing seats shall be finished level and to an established elevation as specified in the IFC Drawings.

.6 Any concrete surface area prepared by grinding shall not allow water to pond in the bearing area. For elastomeric bearings, the bearing seat areas prepared by grinding shall be intentionally roughened such that the surface has an equivalent texture to a trowel finish. All surface areas shall be inspected and deemed acceptable by The City's Engineer prior to installation of bearings.

.7 Where coring of the bearing seats to receive anchors is specified on the IFC Drawings, care shall be taken so that coring does not damage or cut the steel reinforcement. Coring shall not commence earlier than 15 Business Days prior to bearing installation. In lieu of coring, the holes may be formed.

.8 Bearings shall be installed as shown on the Drawings. Bearings shall be set to the dimensions and offsets prescribed by the bearing supplier and the IFC Drawings, and shall be adjusted as necessary to consider the temperature at the time of installation, future movements of the bridge due to temperature changes, release of falsework, and shortening due to prestressing.

.9 Bearing assemblies shall be installed in accordance with the approved Shop Drawings and installation procedures. Field welding is not permitted.

.10 Notify the bearing supplier 5 Business Days prior to the bearing installation so that the supplier's representative is present onsite during the installation to advise on the proper installation procedure.

.11 Bearings that have been pre-assembled shall not be dismantled, except with the prior approval of the supplier and acceptance of The City's Engineer.

.12 The position of temporary packing between the outer bearing plates and the structure shall be agreed with The City's Engineer.

.13 Threaded fixings shall be tightened uniformly to avoid overstressing any part of the bearing. Vibration-resistant type fasteners shall be supplied where significant vibration may occur.

.14 The Contractor shall bed bearings over their entire area. Voids or hard spots after installation are not acceptable.

.15 The relative locations of the upper and lower sections of the bearing assembly shall reflect the average structure temperature at the time of installation. The Contractor shall provide details of temperature measurements and position of installed bearing reviewed by the bearing supplier to The City’s Engineer.

.16 The diameter, length, and material of the anchor and the diameter and depth of the anchor hole shall be as specified on the IFC Drawings.

.17 The holes for the installation of anchors shall be protected against entry of moisture and shall be completely filled with grout, when such anchors are installed.

.18 Exposed surfaces, especially the sliding surfaces, shall be covered with pressure-sensitive heavy protection paper or strippable plastic coating shall be applied to prevent overspray from pigmented sealer application or metallizing repairs.

.19 Jacking:

.1 Should jacking operations be required, they shall be carried out under the direct supervision of the Contractor’s Engineer, and the structure shall be jacked the minimum amount required to allow the bearings to be adjusted.

.2 The lifting or lowering of the structure shall be carried out in one uniform and synchronized jacking operation. At no time during jacking operations shall the difference between any of the jacking points be more than 3 mm at the same abutment or pier cap.

.20 After installation, bearings and their surrounding areas shall be left clean. Temporary transit clamps shall be removed at a time to be agreed upon by the supplier and The City’s Engineer. Protective covering shall be left in place until final cleaning of structure. Instructions for removal of protective covering shall be provided.

3.9 **Grouting**

.1 Grout bedding shall not be used with elastomeric bearings unless bearings are specified with base plates.

.2 Grout is not permitted in contact with elastomeric bearings.

.3 Thickness of grout bedding for rotational and sliding surface bearings shall be limited to 15 mm, inclusive of tolerances.

.4 The substrate shall be roughened by bush-hammering, cleaned, and prewetted prior to grouting. Transfer of superstructure load to the bearings shall not be permitted until the grout has reached a minimum strength of 35 MPa.

.5 Where the anchors for rotational and sliding surface bearings require core drilling or preformed holes, the bearings shall be bedded over their entire area on grout that does not contain any voids. The use of permanent shims to achieve the theoretical elevation at the top of the bearing shall not be permitted. Stay-in-place forms for the preformed holes shall not be permitted.

.6 Grout shall be packaged in waterproof containers with the production date and shelf life of the material shown.

.7 The Contractor shall mix, place, and cure grout in strict accordance with the manufacturer's recommendations stated on their published product data sheet.

.8 Dry-pack methods of constructing grout pads will not be accepted.

.9 Filling of anchor rod voids and construction of grout pads shall be done by workers competent in this Work.

.10 All bearings shall be grouted in prior to casting deck concrete.

.11 Cold Weather Grouting Requirements: When the daily minimum air temperature or the temperature of the girders, bearings, or substructure concrete in the immediate area of the grouting is, or is expected to be, below 5°C during the placing and curing period, the following provisions for cold weather grouting shall be applied:

.1 Before grouting, adequate preheat shall be provided to raise the temperature of the adjacent areas of the girders, bearings, and substructure concrete to at least 15°C.

.2 Temperature of the grout during placing shall be between 10 and 25°C.

.3 The grout pads shall be enclosed and kept at 15 to 25°C for a minimum of 5 Days. The enclosure shall meet the requirements of Section 03300, Cast-in-Place Concrete for concreting in cold weather.

3.10 Certification

.1 Certify at the completion of Work all bearings fabricated and erected by the fabricator under the seal and signature of the bearing supplier’s design Engineer responsible for this Work.

.2 Certify that all designed components are fabricated and erected in accordance with the approved Shop Drawings.

3.11 Guarantee

.1 The Contractor shall warranty, in writing, the performance of the bearing assemblies, including all coatings, for the Extended Warranty Period. The Contractor shall provide in the warranty for the replacement of the bearing assemblies at no cost to The City in the event that the assemblies do not perform satisfactorily in the range of design movement and under the design loads. This warranty provides for the complete replacement of the bearing assemblies, including but not limited to:

- all necessary traffic controls
- expansion joint seals
- engineering
- temporary works
- superstructure jacking
- grout pads
- concrete

- attachments to girders, as required.

It is the bearing supplier's responsibility to verify that the bearings and their coatings are installed in a manner that will not void the warranty.

.2 The City's Engineer shall evaluate the bearing assembly 3 months prior to the expiry of the Extended Warranty Period, according to the requirements of the Agreement. The Engineer will notify the Contractor of the time and date of the inspection. The Contractor shall be present during this inspection.

.3 Where time is required beyond the Extended Warranty Period for the Contractor to correct bearing assembly defects, the warranty is to continue until repair or replacement has been completed.

4 MEASUREMENT AND PAYMENT

4.1 Measurement

.1 The Work under this section shall be lump sum and will not be separately measured.

4.2 Payment

.1 Payment for the Work in this section shall be as tendered for the types and sizes of bearings specified, and will be full compensation for the following:

.1 Supply and fabrication; coatings; loading; hauling to the project site; unloading; installation; supply and placement of grout; quality control and quality assurance; engineering services; engineering drawings and design calculations; shop drawings; testing and certificates; temporary structures design and works; heating and housing; bridge jacking; and all labour, equipment, tools and incidentals necessary to complete the work.

.2 All costs associated with grouting in cold weather, when required, will be considered incidental to the Work, and no separate or additional payment will be made.

.3 All costs associated with temporary supports and superstructure stabilization will be considered incidental to the Work, and no separate or additional payment will be made.

.4 Payment for this Work shall be issued upon 100% completion, including submission of all documentation per the Technical Specifications.

END OF SECTION

1 GENERAL

1.1 Work Included

.1 This section outlines the requirements for design, supply, fabrication, delivery, and installation of new strip seal and modular expansion joint assemblies, including cover plates and anchorages for bridge decks, as shown on the Drawings.

.2 This section does not cover the staged replacement of existing in-service expansion joint assemblies.

.3 The Work is defined as:

.1 Design of expansion joints, concrete blockout anchorages, and reinforcement by an Engineer retained by the Contractor's supplier.

.2 Fabrication, delivery, and installation of all necessary components.

.3 Quality Assurance (QA) and Quality Control (QC) during fabrication, delivery, and installation, including the concrete and reinforcement placement within the concrete blockouts.

.4 The Contractor shall cover the cost of engineering, fabrication, delivery, installation, QA/QC, and Project closure documentation.

1.2 Related Work Specified in Other Sections

.1	Structural Steel Supply, Fabrication, and Erection	Section 05120
.2	Metal Fabrications	Section 05500
.3	Cast-In-Place Concrete	Section 03300
.4	Concrete Reinforcing	Section 03200
.5	Coatings for Steel	Section 09719
.6	Bridge Deck Waterproofing	Section 07100

1.3 Reference Standards

.1 Perform the Work of this section in accordance with the latest edition of the following standards available at the Effective Date, except where specified otherwise. Provide one copy of the standards at the fabrication shop in hard copy or digital format.

.2 Alberta Transportation:

.1 Alberta Transportation Standard Deck Joint Drawings

.3 ASTM International (ASTM):

.1 ASTM A29/A29M - 16, Standard Specification for General Requirements for Steel Bars, Carbon and Alloy, Hot-Wrought

.2 ASTM A108, Standard Specification for Steel-Bar, Carbon and Alloy, Cold-Finished

.3 ASTM A123/A123M, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

.4 ASTM A143/A143M, Standard Practice for Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement

.5 ASTM A153/A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

.6 ASTM A240/A240M, Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications

.7 ASTM A385/385M, Standard Practice for Providing High-Quality Zinc Coatings (Hot Dip)

.8 ASTM A780/A780M, Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings

.9 ASTM B833, Standard Specification for Zinc and Zinc Alloy Wire for Thermal Spraying (Metallizing) for the Corrosion Protection of Steel

.10 ASTM D412, Standard Test Methods for Vulcanized Rubber and Thermoplastic Rubbers—Tension

.11 ASTM D471, Standard Test Method for Rubber Property—Effects of Liquids

.12 ASTM D573, Standard Test Method for Rubber—Deterioration in an Air Oven

.13 ASTM D832, Standard Practice for Rubber Conditioning For Low Temperature Testing

.14 ASTM D1056, Standard Specification for Flexible Cellular Materials—Sponge or Expanded Rubber

.15 ASTM D1149, Standard Test Methods for Rubber Deterioration—Cracking in an Ozone Controlled Environment

.16 ASTM D2240, Standard Test Method for Rubber Property—Durometer Hardness

.17 ASTM D5329, Standard Test Methods for Sealants and Fillers, Hot-Applied, for Joints and Cracks in Asphaltic and Portland Cement Concrete Pavements

.18 ASTM D5973, Standard Specification for Elastomeric Strip Seals with Steel Locking Edge Rails Used in Expansion Joint Sealing

.19 ASTM F835, Standard Specification for Alloy Steel Socket Button and Flat Countersunk Head Cap Screws

.20 ASTM F2329/F2329M, Standard Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners

.21 ASTM F3125/ F3125M, Standard Specification for High Strength Structural Bolts and Assemblies, Steel and Alloy Steel, Heat Treated, Inch Dimensions 120 ksi and 150 ksi Minimum Tensile Strength, and Metric Dimensions 830 MPa and 1040 MPa Minimum Tensile Strength

.4 CSA Group (CSA):

.1 CAN/CSA S6, Canadian Highway Bridge Design Code

.2 CSA G30.18M, Billet-Steel Bars for Concrete Reinforcement

.3 CSA G40.20/G40.21, General Requirements for Rolled or Welded Structural Quality Steel/Structural Quality Steel

.4 CSA G189, Sprayed Metal Coatings for Atmospheric Corrosion Protection

.5 CSA W47.1, Certification of companies for fusion welding steel

.6 CSA W59, Welded steel construction

.7 CSA W178.1, Certification of welding inspection organizations

.8 CSA W178.2, Certification of welding inspectors

.9 CSA W186, Welding of Reinforcing Bars in Reinforced Concrete Construction

.5 International Organization for Standardization and International Electrotechnical Commission (ISO/IEC):

.1 ISO/IEC 17025, General requirements for the competence of testing and calibration laboratories

.6 Research Council on Structural Connections (RCSC):

.1 Specification for Structural Joints Using High-Strength Bolts

.7 United States (U.S.) Government:

.1 Military Specification MIL-A-907F – Antiseize Thread Compound, High Temperature

1.4 Definitions

.1 All defined words or phrases shall have meaning given the City of Calgary Standard General Conditions and the Agreement, unless noted otherwise.

.2 "Designer" means an Engineer or team of Engineers retained by the Contractor (either directly or through the Supplier) to perform the design of the Expansion Joint Assembly. The Designer shall have a minimum of 10 years' experience in both fabrication and installation of expansion joints, as well as experience in and the ability to certify conformance with the Agreement and Shop Drawings.

.3 "Engineer of Record (EOR)" means a team of Engineers engaged by The City to perform design for the overall Project, assigned among Geotechnical, Structural, and Civil disciplines. The EOR shall not be responsible for the design of the Expansion Joint Assembly itself.

.4 "Joint Supplier" means the company responsible for fabricating and supplying all necessary Materials for the Expansion Joint Assembly and confirming the supplied products meet the specified quality standards. The Supplier shall be retained by the Contractor.

1.5 Qualifications

.1 Joint Suppliers shall conform to Section 05500, Metal Fabrications.

.2 List of Approved Joint Suppliers:

.1 D.S. Brown

.2 Goodco Z-Tech

.3 LCL-Bridge

.4 Watson Bowman Acme

.3 If required by the Engineer of Record (EOR), the Contractor shall provide satisfactory information to verify appropriate expertise and experience of the Designer.

1.6 Design Requirements

.1 The design shall conform to CAN/CSA S6, except where noted by these Technical Specifications.

.2 Expansion joints shall only be permitted at abutment ends of the bridge. Expansion joints shall be designed to accommodate for movement (including thermal, creep, shrinkage, elastic shortening), as well as vertical and horizontal rotations.

.3 Expansion joints and their supports shall satisfy the requirements of service limit state (SLS), fatigue limit state (FLS), and ultimate limit state (ULS), and be detailed in such a way that any damage to the joint is repairable while the bridge is in service.

.4 The transverse separation beams, support bars, and other structural elements shall be fatigue tested.

.5 Joints shall provide a watertight seal for the deck. Modular expansion joints shall be used when strip seals cannot provide adequate movement capability.

.6 Expansion joints shall incorporate stop movement bars to maintain a minimum joint gap to facilitate seal replacement.

.7 Where bicycle paths and pedestrian walkways are designed as part of the roadway, the gap opening shall be controlled by skid-resistance cover plates or bridging plates so that the maximum opening does not exceed 25 millimetres (mm).

.8 All steel surfaces shall be protected against corrosion by hot-dip galvanized coating.

.9 Use of ASTM F3125 Grade A490 bolts is not allowed.

1.7 Submittals

.1 Notify the City's Engineer, in writing, of the name and address of the manufacturer of the expansion joint assembly within 30 Days after Notice to Proceed.

.2 Submit to the City's Engineer the QC/QA procedures to be followed during the manufacture of each expansion joint. These procedures shall be submitted to the City's Engineer not later than 10 Business Days prior to submitting the Shop Drawings. These written procedures shall identify the following:

  .1 Material verification procedures for determining that the Materials have the specification and grade indicated on the Drawings and that this is supported by mill test certificates

  .2 Welder certification indicating that the welders involved in the fabrication are certified by the Canadian Welding Bureau (CWB) or similar organization to undertake the welding required

  .3 Review of the manufacturer's welding procedures, confirming welds will be certified by CSA as qualified welds

  .4 Nondestructive testing plan indicating the qualifications of the firm that will be responsible for completion of the nondestructive testing of the completed welds

  .5 Fit-up verification procedures that confirm the fit-up of the various components and parts meets the tolerances identified on the Shop Drawings

  .6 Dimensional verification procedures that confirm the overall dimensions, cross-fall, and other tolerances relating to assembly are being achieved

.3 Submit mill certificates for all steel used in fabrication, as follows:

  .1 Fabrication shall only be allowed with Materials with mill certificates properly correlated to the Materials used on the Project and that have been reviewed and accepted by The City's Engineer.

  .2 Mill test reports shall be submitted to The City's Engineer for review and acceptance at least 20 Business Days prior to the scheduled start of fabrication.

  .3 Test reports for all Materials shall be written in English.

  .4 A list of all Material shall be provided for each joint, showing the component designation from the Shop Drawings and the associated mill test report heat numbers.

  .5 The Contractor shall have all steel, including billets and fasteners, originating outside of Canada or the U.S. tested and verified by a certified laboratory in Canada, as follows:

    .1 This laboratory shall be certified by an organization accredited by the Standards Council of Canada to comply with the requirements of ISO/IEC 17025 for the specific tests or type of tests required by the Material standard specified on the mill test report.

.2 The Material shall be tested to the specified Material standards, including a determination of boron content, which is not permitted to exceed 0.0008%.

.3 Preparation and collection of samples for testing shall be directed and witnessed by, or completed by, personnel employed by the testing lab.

.6 A verification letter, signed and sealed by an Engineer specialized in the field of metallurgy and bearing the signature of an authorized officer of the testing laboratory, shall be provided by the laboratory and shall include references to the following:

.1 Appropriate mill test report(s)

.2 Material specification number(s)

.3 Testing standards

.4 Date(s) of testing

.5 Statements indicating Material compliance with the requirements of the Agreement

.4 Upon completion of fabrication, the Joint Supplier's Designer shall conduct an interim inspection and prepare and submit a report about the Work to the City's Engineer verifying that the fabrication of the expansion joint has been carried out in conformance with the sealed and signed expansion joint assembly Shop Drawings and the Agreement. This report shall be submitted to the City prior to shipping of the expansion joints.

.5 Epoxy Injection during Cold Weather:

.1 In the case of epoxy injection during cold weather, 1 week prior to the commencement of epoxy injection of the expansion joint assembly, submit to the City's Engineer a description of the method to be used to control the concrete temperature.

.2 The submission shall be accompanied by samples of insulation.

.3 The description shall contain the following information:

.1 Weather conditions for working days during injection

.2 Type of insulation, metric R value, and number of layers to be used

.3 Description of housing and heating

.4 Method of protection employed to effectively maintain the concrete temperature above 5 degrees Celsius (°C) in the expansion joint blockout during the injection and continuously for a period of 48 hours after epoxy injection

.6 Manufacturer's product to describe:

.1 Caulking compound

.2 Primers

.3 Sealing compound, each type, including compatibility when different sealants are in contact with each other

.4 Installation instructions, surface preparation, and product limitations

.7 Submit manufacturer's recommended installation procedures for the expansion joint assemblies and data sheets to the Engineer 7 Days prior to installation of the expansion joint assembly.

.8 Shop Drawings

.1 Submit expansion joint assembly Shop Drawings to the City's Engineer 15 Business Days prior to fabrication.

.2 Submit expansion joint assembly Shop Drawings that clearly indicate the following:

.1 Material properties

.2 Dimensions

.3 Connection attachments

.4 Seal lengths, while maintaining end of seal is parallel to edge of deck at upturns

.5 Injection hose system components, and name of approved injection company

.6 Shop, field, and stage construction splices where permitted

.7 Fasteners and accessories

.8 Lifting locations and mechanisms

.9 Installation details

.10 Individual alphanumeric identification number for each stage of installation

.11 Handling procedures, including lifting points

.12 Manufacturer's installation procedure

.13 Turn-of-nut procedure for achieving the required bolt pretension

.14 Details and dimensions of all other components as may be required to manufacture and assemble the modular expansion joints, including all bearings, springs, sliding materials, and all other secondary and primary components

.15 For modular joints, the stiffness of the mechanism

.16 Tolerance shall be provided on drawings for fit-up, indicating permissible sweep, camber, gaps, and other tolerances

.3 The expansion joint assembly Shop Drawings shall be according to the Agreement and shall bear the seal and signature of the Joint Supplier's Designer.

.4 Return of Submissions: Shop Drawings shall be returned and marked as one of the following:

.1 Stamped with wording that allows for permission to fabricate. In such a case, Work can commence on receipt of the Shop Drawings by the Contractor. A copy of these Shop Drawings shall be available at the site prior to and during construction.

.2 Stamped with wording that allows for permission to fabricate as noted. In such a case, Work can start on receipt of the Shop Drawings by the Contractor. The Shop Drawings shall be updated as noted and shall have a stamp affixed that is signed by the Joint Supplier's Designer stating the Shop Drawings have been revised according to the noted comments. A copy of the stamped, updated Shop Drawings shall be available at the site prior to and during construction.

.3 Stamped with wording that requires revision and resubmission. Required changes shall be clearly shown on the drawings. The Contractor shall have the drawings updated as required and the submission process repeated.

1.8 Quality Control, Quality Assurance, and Inspection and Testing

.1 Quality Control and Quality Assurance

.1 The Contractor shall be responsible for QA/QC testing required to verify the Work meets the design parameters and Technical Specification requirements

.2 The Contractor's plan for QA/QC shall be included in the Quality Management Plan (QMP) and submitted to the City's Engineer for review prior to starting any fabrication.

.3 All QA/QC, including testing, associated methods, means, Materials, Construction Equipment, and labour, as part of the Contractor's QMP shall be paid for by the Contractor.

.4 Any Contractor QA/QC testing and inspection records shall be available to the City's Engineer for auditing.

.2 Inspection and Testing

.1 The Contractor shall inspect and test all welds.

.2 The Contractor shall inspect for all tolerances.

.3 The Contractor shall inspect and test galvanized coat.

.4 The air, concrete, and expansion joint assembly temperature shall be 2°C or higher at the time of testing the epoxy concrete within the expansion joint blockout dam.

.5 Water Testing:

.1 After the epoxy has set and before acceptance, the Contractor shall water test the joint over its entire length where there are no upturns.

.2 Where there are upturns, the Contractor shall test the joint between the gutter lines.

.3 The water should be continuously ponded for a minimum of 1 hour, maintaining a minimum depth of 25 mm along the tested length and a minimum depth of 100 mm above the expansion joint assembly at the gutter lines.

.4 For super-elevated decks, only the lower gutter line requires testing at a depth of 100 mm. The width shall extend 50 mm beyond the concrete dams on both sides of the expansion joint assembly.

.5 If water leaks through the expansion joint assembly during this test, including the interface between the preformed seal and the seal retainers, concrete to steel, the expansion joint assembly shall be repaired or replaced at the Contractor’s expense and the water test repeated. The Contractor shall submit the method of repair in writing to the City’s Engineer for review prior to commencement of repair work.

.6 Leakage at an elastomeric concrete-to-steel interface, or at an elastomeric concrete-to-concrete interface, or both will require replacement of the elastomeric concrete joint system and the water test repeated at the Contractor’s expense.

.6 The Contractor shall permit sampling and testing in the field of the preformed seal by exceeding the required length by 1 metre (m).

.7 The Contractor shall complete the water test and related corrective work prior to seasonal shutdowns. When this is not feasible, a proposal detailing an alternative solution shall be submitted to the City’s Engineer for acceptance.

.8 The Contractor shall submit to the City’s Engineer a Certificate of Conformance sealed and signed by the Joint Supplier’s Designer, upon completion of installation of expansion joints.

1.9 Acceptability

.1 Failure to comply with the requirements of the Technical Specifications will result in the structure being considered potentially Deficient.

.2 Additional testing, inspection, and evaluation may be required where evidence points to a potentially Deficient structure and shall be paid for by the Contractor. The Contractor shall be responsible for the costs and schedule implications for any corrective action required.

.3 The Contractor shall pay all costs for additional testing, inspection, and analysis required to demonstrate the adequacy of coatings that do not meet the requirements of the Agreement. The Contractor shall be responsible for any

Project costs associated with schedule delays related to demonstrating the adequacy of coatings.

.4 The Contractor will replace at their own expense, including all direct and indirect costs, all coating material judged inadequate by testing and inspection at any time up to the end of the Warranty Period.

.5 The City's Engineer may order further testing, inspection, and analysis at any time. If additional testing is outside the scope of this contract, The City will pay for those tests, inspections, or chemical analysis that meet the specified requirements; and the Contractor will pay for those that do not.

.6 Minimum inspection criteria for initial acceptance of the Expansion Joint Assembly:

Upon completion, prior to payment, the City's Engineer will inspect to the Expansion Joint Assembly to ensure the following Deficiencies do not exist:

.1 Defective seals

.2 Seal section parallel to deck edge at upturn ends

.3 Cracks wider than 0.3 mm and voids in concrete end-dams

.4 Defective coating

.5 Seal not completely held in retainer

.6 Turn-of-nut procedure for bolt installation not followed

.7 Defective, loose, or missing structural components and welds

.8 Leakage at interfaces determined according to water test

.9 A line parallel to the centreline of the structure joining the tops of all steel components of the expansion joint assembly that deviates from a line parallel to the pavement profile between nosing angles by more than 3 mm, at any location along the length of the expansion joint

.10 For modular joints, at any location along the length of the expansion joint assembly, the relative difference in the opening between the steel retainers exceeds the narrowest width by 6 mm; this dimension shall be measured at the level of the road surface, perpendicular to the centreline of the expansion joint, and at the inner faces of the retainers

.11 Any portion of the expansion joint assembly is extending above finished road surface

.12 For expansion joints installed at the ends of approach slabs, joints will be accepted based on visual inspection by the City's Engineer to verify seal integrity and retention

.7 Minimum inspection criteria for final acceptance of the Expansion Joint Assembly:

At FAC the City's Engineer will inspect Expansion Joint Assembly to ensure the following Deficiencies do not exist:

.1 Defective seals as a result of Material Deficiencies

.2 Defective coating of components as a result of coating application or Material Deficiencies

.3 Seal section parallel to deck edge at upturn ends

.4 Seal not completely held in retainer

.5 Loose bolts

.6 Defective, loose, or missing structural components and welds

.7 Delaminated or spalled concrete, or both

.8 Visible leakage through joint

.8 The City’s Engineer may notify the Contractor of defects that require corrective work according to the criteria for acceptance of the Expansion Joint Assembly.

.9 When there are Deficiencies, the expansion joint assembly and its installation will not be accepted until appropriate corrective work has taken place.

.10 Acceptance of Corrective Work:

.1 Submit for review and acceptance to the City’s Engineer a proposal for the method and description of corrective work 10 Business Days prior to the commencement of any corrective work of the expansion joint assembly. The submission shall be accompanied by a report indicating the cause of each defect.

.2 Repair all defects or Deficiencies according to the requirements of the Technical Specifications and the accepted proposal.

.3 If the expansion joint assembly has to be replaced, its successor shall be an equivalent or better approved joint.

.4 All costs, including labour, Construction Equipment, Material, and traffic control, shall be borne by the Contractor, while maintaining all aspects of the Technical Specifications.

.5 Upon acceptance of the proposal, the contractor shall carry out all corrective work. The Contractor shall provide a minimum of 3 Days’ notice to the City’s Engineer prior to starting any corrective work.

2 PRODUCTS

2.1 Materials

.1 Metals shall be free from defects impairing strength, durability, and appearance of the best commercial quality for the purpose specified.

.2 All Materials shall be new.

.3 All Materials shall have a total maximum boron content of 0.0008%.

.4 All exposed fastenings shall be of the same Material, colour, and finish as the metal to which applied, unless otherwise noted.

.5 Internal Bearings:

.1 Steel for internal bearings shall comply with the Material requirements of Section 05500 – Metal Fabrications or Section 05120 – Structural Steel Supply, Fabrication, and Erection, as required.

.2 100% virgin polytetrafluoroethylene (PTFE) element shall have a minimum thickness of 1.5 mm.

.6 Expansion Joints shall comply with the Material requirements of Section 05500 – Metal Fabrications, including:

.1 Mild steel components shall be according to CSA G40.20/G40.21, Grade 300W. Sliding plate shall be 350W.

.2 Stainless steel shall have a minimum corrosion resistance according to ASTM A240M.

.3 Steel fasteners other than stainless steel shall be according to ASTM F3125/F3125M (Grade A325) or ASTM F835.

.7 Preformed Joint Seals:

.1 Preformed joint seals shall comply with ASTM D1056 for ethyl vinyl acetate foam. Emboss the top surface of the ethyl vinyl acetate foam with the manufacturer's name and product identification.

.2 The preformed seal shall be manufactured from an elastomer with physical properties according to Table A.

.3 Preformed seals older than 2 years at the time of installation shall not be used.

.4 Manufacturer’s storage and handling requirements shall be followed. The seal shall not be exposed to ultraviolet (UV) rays for more than 3 Days prior to installation.

Table A – Preformed Seal Physical Requirements

Preformed Seal Physical Requirements Property	Physical Requirements	Test Procedure
Tensile Strength	Minimum 13.5 MPa	ASTM D412, Test Method A
Ultimate Elongation	Minimum 250%	ASTM D412, Test Method A
Hardness	55 Shore A, + 7, -5	ASTM D2240
Oven Aging Test, 70 h at 100°C Change in Tensile Strength	Maximum 20%	ASTM D573 ASTM D412, Test Method A
Change in Elongation	Maximum 20%	ASTM D412, Test Method A
Change in Hardness	Maximum 10 points	ASTM D2240
Permanent Set at Break	Maximum 10%	ASTM D412, Test Method A
Low-temperature Crystallization Hardness, Shore A 7 d at -10°C	Maximum 15 points	ASTM D832 ASTM D2240

Table A – Preformed Seal Physical Requirements

Preformed Seal Physical Requirements Property	Physical Requirements	Test Procedure
Change in Hardness		
Oil Swell, ASTM Oil No. 3, 70 h at 100°C Weight Change	Maximum 45%	ASTM D471
Ozone Resistance, 20% Strain, 150 pphm in air 70 h at 40°C	No cracks	ASTM D1149, Method B, Procedure B1

Notes:

All tests shall be made on specimens prepared from the preformed seals.
d = day(s)
h = hour(s)
pphm = part(s) per hundred million

.8 Preformed Compressible and Noncompressible Back-up Materials:

.1 Polyethylene, Urethane, Neoprene, or Vinyl Foam shall be extruded closed-cell foam backer rod oversized 30 to 50%.

.2 Neoprene or Butyl Rubber shall be round, solid rod, with a Shore A hardness of 70.

.3 High-Density Foam shall be:

.1 Extruded closed-cell polyvinyl chloride (PVC)

.2 Extruded polyethylene, closed cell, Shore A hardness 20, tensile strength 140 to 200 kilopascals (kPa)

.3 Extruded polyolefin foam, 32 kilograms per cubic metre (kg/m^3) density or

.4 Neoprene foam backer, size as recommended by manufacturer.

.4 Bond Breaker Tape shall be composed of polyethylene that will not bond to sealant.

.9 The lubricant shall be water-soluble, nonadhesive, and nonstaining. Lubricants used between the steel components and preformed seals shall not be deleterious to the joint Materials or the surrounding concrete.

.10 Epoxy:

.1 The epoxy shall have a minimum 28-Day compressive strength of 40 megapascals (MPa) when tested using a 70-mm cube, unless specified otherwise in the Agreement.

.2 The epoxy shall contain suitable graded sand filler.

.3 The Contractor shall submit details of the proposed mix for acceptance, and prepare samples for determination of compression strengths upon acceptance.

.11 Anchors:

.1 All stud shear connectors shall conform to the chemical requirements of ASTM A29 and A108, Grades 1015, 1018, or 1020.

.2 In addition, shear studs shall meet the mechanical properties specified in CSA W59, Appendix H, for Type B studs.

.3 Certified mill test reports for the stud material shall be provided.

.12 Reinforcing steel bars shall be according to CSA G30.18, Grade 400W and Section 03200.

.13 Antiseize compound shall be according to MIL-A-907F.

.14 Injection Hose System for expansion joint assembly:

.1 The injection hose system shall be installed on the expansion joint assembly for both nosing and armouring angles. This system shall be long enough to extend between the barrier or parapet walls on each side of the structure, including the sidewalks and curbs.

.2 No bleeder holes in the nosing and armouring angles are permitted.

3 EXECUTION

3.1 Fabrication

.1 The expansion joint shall be a purpose-made assembly as detailed in the Agreement.

.2 Do not perform any fabrication until the accepted Shop Drawings are in the hands of the Joint Supplier's Designer, joint supplier, and the City's Engineer has accepted the Shop Drawings.

.3 Any purchase of Materials before fabrication acceptance is at the Contractor's risk.

.4 Changes to accepted Shop Drawings are subject to the acceptance of the City's Engineer. Submit revised sheets of the same size as those originally accepted.

.5 Minimize field splices per Clause 3.6.1.

.6 Weld structural steels according to CSA W59.

.7 Weld stainless steel according to CSA W47.1.

.8 Weld reinforcing steel bars according to CSA W186.

.9 Coat all steel bolts shall with a zinc phosphate coating.

.10 Machine after welding, whenever possible.

.11 Machine grind all rough flame-cut surfaces and metal-to-metal contact surfaces smooth.

.12 Re-entrant corners that are cut shall be free from notches and have the largest practical radius, with a minimum radius of 14 mm. Bearing surfaces shall be in contact over the full area of the mating surfaces.

.13 Hot-dip galvanize all structural steel components of the expansion joint assembly according to ASTM A123/A123M and reference standards within these Technical Specifications after fabrication. Galvanize hardware according to ASTM A153/A153M and ASTM F2329/F2329M.

.14 Marking:

.1 Mark each expansion joint section with the date of manufacture (that is, yyyy-mm-dd), an individual alphanumeric identification, and a sequential number.

.2 Die-stamp characters into an exposed surface at the gutter line at the barrier wall or curb.

.3 The characters shall not be less than 10 mm high, with the indentations not less than 0.5 mm in width and 0.2 mm in depth.

.4 Clearly mark the preformed seal clearly and indelibly at 1-m intervals, indicating manufacturer, lot number, date of manufacture (that is, yyyy-mm-dd), and model number.

.5 Clearly mark the lifting points on the expansion joint assembly.

3.2 Manufacturer's Instructions

.1 Comply with manufacturer's written product data and instructions for storage, handling, care, and installation of joint seals.

.2 Where there is a conflict between the manufacturer's recommendations and the Agreement, the more stringent requirements apply as determined by the City's Engineer.

3.3 Protection and Handling

.1 Package the seal and lubricant-sealer in a suitable fashion to prevent damage and contamination. Materials will not be accepted until they have been inspected by the City's Engineer.

.2 Cover exposed stainless steel surfaces with pressure-sensitive heavy protection paper or apply strippable plastic coating before shipping to the Project Site.

.3 Leave protective covering in place until final cleaning of structure. Provide instructions for removal of protective covering.

3.4 Application for Hot-Dipped Galvanizing

.1 Submit two copies of the galvanizer's coating thickness readings to the City's Engineer prior to the installation of the component in the structure.

.2 At least 3 Days prior to commencement of galvanizing, give the City's Engineer written notice of the intent to hot-dip galvanize. Hot-dip galvanizing done without this prior notification may be rejected.

.3 Perform hot-dip galvanizing conforming to ASTM A123M, ASTM A153M, ASTM A385, and ASTM F2329M, with minimum 610 grams per square metre

(g/m^2) of coating. The steel properties, galvanizing process, and any final finishing shall produce a smooth surface.

.4 Field touch-up damaged galvanizing using zinc metalizing conforming to ASTM A780/780M, Method 3. Metalizing shall be 180 micrometres (µm) thick.

3.5 Delivery and Joint Assembly

.1 Specified tolerances found in the Agreement for expansion joints shall be measured and recorded at a minimum of five inspection hold points, as follows:

.1 Hold Point 1:

.1 Prior to shipment from the fabrication facility, measurement of tolerances at inspection hold point 1 shall occur with the expansion joint fully assembled in a relaxed condition without shipping and erection angles installed and at the -5-degree (°) and +15° ‘X’ gap settings.

.2 For cover-plated v-seal expansion joints, the cover plates shall be installed with bolts tightened.

.3 The assembly shall be properly supported throughout its length for checking the tolerances.

.4 Tolerances shall be checked before and after galvanizing.

.2 Hold Point 2:

.1 After verification that the plate gap tolerances are met, hold point 2 shall verify the joint is shipped with assembly pre-set for gap at +15° and shipping angles shall be securely attached with shipping angle bolts.

.3 Hold Point 3:

.1 After installation of the expansion joint into the blockout and prior to abutment side blockout concrete placement, measurement of tolerances at inspection hold point 3 shall occur with the expansion joint fully assembled, and shipping angles and erection angles shall be installed with bolts tightened.

.4 Hold Point 4:

.1 After the abutment side blockout concrete has been placed, cured, and developed a minimum compressive strength of 25 MPa, and prior to deck-side blockout concrete placement, measurement of tolerances at inspection hold point 4 shall occur with the expansion joint fully assembled, and shipping angles and erection angles shall be installed with bolts tightened.

.2 For cover-plated expansion joints, after completion of curing of abutment- and deck-side blockout concrete and epoxy injection is complete, seals shall be installed, and cover plates shall be reinstalled with bolts tightened.

.5 Hold Point 5:

.1 Measurement of tolerances at inspection hold point 5 shall occur with the expansion joint fully assembled and supported by the concrete, with shipping angles and erection angles removed.

.6 Gap tolerances between cover plates and support plates shall be in accordance with the applicable Alberta Transportation Standard Deck Joint Drawings or as specified in the Agreement.

.7 Tolerances for straightness shall be considered over the length of the assembly between the crown and gutter line, both before and after galvanizing.

.1 Deviation from straightness in a vertical plane shall not exceed ±5 mm.

.2 Horizontal sweep shall not be greater than 6 mm.

.3 Additional tolerances shall be per the Alberta Transportation Standard Deck Joint Drawings or as specified in the Agreement.

.8 If the specified tolerances are not met at each inspection hold point, the Contractor shall repair the expansion joint such that all specified requirements are met.

.9 The Contractor shall prepare and submit a repair procedure to the City's Engineer and The City for review and acceptance prior to commencement of any repair work.

.2 The City's Engineer will visually inspect the seals when delivered to determine compliance with requirements, such as surface quality and dimensional compliance that do not require physical tests.

.3 If any inspection, either by visual or physical testing, shows that any part of the joint assembly does not meet the requirements of this Technical Specification, the unsatisfactory part or parts shall be replaced at no cost to The City.

.4 Adjustment devices for the expansion assembly shall be provided to allow for setting the joint width to suit the temperature when the joints are cast into the blockouts. The Contractor shall place seal between the angles in strict accordance with the manufacturer's instructions just prior to setting the unit into position in the deck.

.5 All buried adjustment clamps and bolts shall be removed prior to concreting.

3.6 Installation

.1 Field splices are permitted as follows:

.1 Field splices are allowed at the crown of the roadway.

.2 Where the length of the expansion joint cannot be shipped due to maximum shipping length restrictions, a field splice shall be located at a lane demarcation line near the centreline of the structure.

.3 Splices shall be designed to provide satisfactory service life.

.4 The preformed seals shall be continuous with no splices.

.2 Expansion joint assemblies shall be installed in accordance with accepted Shop Drawings.

.3 Field installation of preformed seals and bolted components:

.1 Preformed seals shall be installed with lubricant in one continuous piece. Do not bend seals more than 30° at any one location.

.2 Prior to installation of the preformed seal, all steel surfaces in contact with the preformed seal shall be cleaned and the gap completely clear for its full length and width to the depth of the bearing seat.

.3 The preformed seal and bolted components shall be installed according to the expansion joint assembly Shop Drawings.

.4 Field use of adhesives and sealants is not permitted.

.4 Damage to the corrosion protection system, including surface areas of field welds, shall be repaired according to Clause 3.4.4.

.5 Threaded portion of bolts and undersides of bolt heads shall be liberally coated with an antiseize compound immediately prior to installation.

.6 Bolts that have been fully tensioned and require removal after final installation shall not be reused to fasten the clamping bars.

.7 For modular expansion joint installations, the joint supplier shall be informed 7 Days prior to the joint installation so that the manufacturer's representative is present onsite during installation to advise on the proper installation procedure.

.8 The following conditions shall be met prior to permitting traffic, including construction traffic, on any part of the expansion joint:

.1 Concrete:

.1 Concrete shall be cured for a minimum of 7 Days and achieve a minimum compressive strength of 25 MPa.

.2 Epoxy: Concrete:

.1 Epoxy shall be completely injected and cured for a minimum of 24 hours.

.2 For cold weather, epoxy shall be cured as specified by the manufacturer or 48 hours, whichever is longer

.3 Steel-Clamping Bars:

.1 Steel-clamping bars shall be completely installed.

.9 Protection:

.1 Lift expansion joint assembly using nylon slings placed at lifting points indicated on stamped expansion joint Shop Drawings.

.2 During storage, protect expansion joint assembly from dirt and deleterious Materials, and store so that distortion cannot occur. Support expansion joint assemblies on wood blocking spaced a maximum of 2 m apart.

.3 For preformed seals, follow the manufacturer's storage and handling requirements. The seal shall not be exposed to UV rays for more than 3 Days prior to installation.

.10 Expansion joints shall be installed before asphalt paving operations and before construction of parapet walls.

.11 Expansion joint elevations shall be set 3 mm below the finished asphalt grade.

.12 Existing concrete shall be saturated surface dry prior to placing concrete in expansion joint dams.

.13 Setting devices shall be removed as specified by the joint manufacturer, but not less than 4 hours after completion of concrete placement.

.14 Setting device bolt holes shall be drilled to a depth of 20 mm, air-blast cleaned, and holes immediately filled with epoxy for all nosing angles, as well as for the armouring angles of the joints.

.15 Placing:

.1 Before placing the steel reinforcement, and not more than 48 hours prior to placement of concrete in the blockout, the concrete faces of the blockout shall be abrasive-blast cleaned as follows:

.1 Protect areas and components not designated for abrasive-blast cleaning from adjacent abrasive-blast cleaning operations.

.2 Keep concrete surfaces surface dry.

.3 Expose and clean the coarse aggregate; and remove all dirt, laitance, and hardened concrete slurry.

.4 Remove all oil or grease on the surface of the concrete using hand tools.

.5 Check for no fractured concrete or loose aggregate.

.2 Following the abrasive-blast cleaning, the expansion joint assembly shall be placed in the blockout 3 mm below the elevation of the asphalt pavement and in the position specified on the expansion joint assembly Shop Drawings.

.3 Preparation for Concrete Placement:

.1 Immediately prior to placing the concrete in the blockout, the top setting devices shall be adjusted to give the specified setting width required by the expansion joint assembly Shop Drawings.

.2 The setting devices shall then be tightened, and the expansion joint assembly secured at the correct width, line, and grade by welding the loop anchors and stud anchors to the steel reinforcement.

.3 The location of these welds shall be at least 100 mm below the top of the end-dams, and the spacing shall be at approximately 500-mm centre-to-centre.

.4 All concrete surfaces to receive concrete shall be maintained in a wet condition for a period of 1 hour prior to placing any new concrete. Immediately prior to wetting the concrete surface, all dust and loose material shall be removed from the prepared surface using compressed air.

.5 Prior to placing concrete, excess water shall be removed from the surface using oil-free compressed air.

.4 Concrete shall be placed and consolidated to minimize voids under the expansion joint assembly and shall be hand-finished with a wooden float.

.5 All steel surfaces that will be in contact with the preformed seal shall be protected during concrete placement.

.6 After concrete placement, the exposed faces of the structural steel shapes shall be cleaned to remove any concrete and deleterious material.

.7 The setting devices shall be flame cut at the gap between 2 and 4 hours after concrete placement.

.8 The setting device boltholes for all nosing angles, as well as for the armouring angles, of the joints shall be drilled to a depth of 20 mm, air-blast cleaned, and immediately filled with epoxy.

.16 Epoxy injection:

.1 Store epoxy at a temperature of 20°C ±5°C prior to use.

.2 Inject epoxy once the concrete has been in place for a minimum of 7 Days and has reached a compressive strength of 25 MPa.

.3 Injection of epoxy used in the injection hose system shall be done by the joint supplier or an approved representative.

.4 Mix and pressure-inject epoxy according to the manufacturer's specifications

.5 Start at the fitting at one end of a 2-m section of hose to initially fill the hose, and continue until the epoxy discharges at the other injection fitting of the same section. Alternate injection at both fittings of the same section until the epoxy emanates from the voids in the concrete, or at the interface between the steel angles and concrete, or both. The injection ports shall then be plugged.

.6 Repeat this procedure in each section of hose until the full length of the expansion joint system has been filled with epoxy.

.7 Thoroughly clean the top surface of the blockout to remove excess epoxy prior to hardening.

.8 After the epoxy has set, remove all adapters and injection fittings, and then plug holes filled with epoxy.

.9 Check the expansion joint assembly for voids remaining under the angles.

.10 Drill holes in angles where voids are detected, and fill voids and bolt holes with epoxy.

.17 Cold Weather Epoxy Injection Requirements:

.1 Epoxy injection shall not be performed without protection when the ambient air temperature is below 5°C or is likely to fall below 5°C within 48 hours immediately following the epoxy injection.

.2 When the epoxy injection is to be performed under cold weather conditions, the temperature of the concrete in the expansion joint blockout shall be at a minimum of 5°C prior to the commencement of the injection.

.3 Maintain temperature at a minimum of 5°C for a period of 48 hours after injection or the curing time as specified in the manufacturer's data sheet.

.18 Surface Preparation for Caulking and Sealants:

.1 Examine joint sizes and conditions to establish correct depth to width relationship for installation of backup materials and sealants.

.2 Clean bonding joint surfaces of harmful matter and substances, including dust, rust, oil and grease, and other matter that may impair work.

.3 Do not apply sealants to joint surfaces treated with sealer, curing compound, water repellent, or other coatings unless tests have been performed to verify compatibility of Materials. Remove coatings as required.

.4 Verify joint surfaces are dry and frost free.

.5 Prepare surfaces in accordance with the manufacturer's directions.

.19 Surface Preparation for Joint Seals and Joint Sealing Compounds:

.1 Concrete at all joints shall be sound, clean, dry, and free of all dust, debris, and deleterious material.

.2 The joint face shall be true to line such that the joint seal bears on the joint face fully and uniformly.

.20 Priming for Caulking and Sealants:

.1 Where necessary to prevent staining, mask adjacent surfaces prior to priming and caulking.

.2 Prime sides of joints in accordance with the sealant manufacturer's instructions immediately prior to caulking.

.21 Backup Material for Caulking and Sealants:

.1 Apply bond breaker tape where required following the manufacturer's instructions.

.2 Install joint filler to achieve correct joint depth and shape, with approximately 30% compression.

.22 Mixing for Caulking and Sealants:

.1 Mix Materials in strict accordance with the sealant manufacturer's instructions.

.23 Application for Caulking and Sealants:

.1 Sealant:

.1 Apply sealant in accordance with the manufacturer's written instructions.

.2 Mask edges of joint where irregular surface or sensitive joint border exists to provide a neat joint.

.3 Apply sealant in continuous beads.

.4 Apply sealant using a gun with a proper size nozzle or trowel.

.5 Use sufficient pressure to fill voids and joints solid.

.6 Form surface of sealant with full bead, smooth, free from ridges, wrinkles, sags, air pockets, and embedded impurities.

.7 Tool exposed surfaces before skinning begins to give a slightly concave shape.

.8 Remove excess compound promptly as Work progresses and upon completion.

.2 Curing:

.1 Cure sealants in accordance with the sealant manufacturer's instructions.

.2 Do not cover up sealants until proper curing has taken place.

.3 Cleanup:

.1 Clean adjacent surfaces immediately and leave Work neat and clean.

.2 Remove excess and droppings, using recommended cleaners as Work progresses.

.3 Remove masking tape after sealant initial set.

.24 Placing Joint Seals and Joint Sealing Compounds:

.1 Seal any gaps forming longitudinal joints between structures with a joint seal installed with the laminations horizontal.

.2 Abrasive blast clean and air blast the joint recess to remove laitance and deleterious material prior to installation of the joint seal.

.3 Liberally apply adhesive to both vertical sides of the joint seal and to both vertical faces of the joint recess. Remove excess adhesive immediately.

.4 Install the joint seal so that it remains below the level of the concrete surface when fully compressed.

.5 Field splicing of joint seals is not permitted.

3.7 Guarantee

.1 The Contractor shall Warranty, in writing, the performance of the expansion joint assemblies, including all seals and coatings, for a period of 5 years from the date of issuance of The City's Substantial Completion Certificate (the Extended Warranty Period).

.2 The Contractor shall provide in the Warranty for the replacement of the expansion joint assemblies at no cost to The City in the event that the assemblies do not perform satisfactorily in the range of design movement and under the design loads.

.3 This Warranty includes, at no cost to The City, complete replacement of the expansion joint assemblies, including all necessary:

.1 Traffic control and devices

.2 Expansion joint seals

.3 Engineering

.4 Temporary works

.5 Superstructure jacking

.6 Grout pads

.7 Concrete as required

.4 It is the joint supplier's responsibility to verify that the expansion joint and its coatings are installed in a manner that will not void the Warranty.

.5 The City's Engineer will evaluate the expansion joint assembly 40 Business Days prior to the expiry of the Extended Warranty Period, according to the requirements of Clause 1.9.7, Final Criteria for Acceptance of Expansion Joint Assembly.

.6 The City's Engineer will notify the Contractor of the time and date of the inspection.

.7 The Contractor shall be present during this inspection and shall perform a water test in accordance with requirements of Clause 3.6.18.

.8 When time is required beyond the Extended Warranty Period for the Contractor to correct assembly defects, the Warranty shall continue until repair or replacement has been completed.

4 MEASUREMENT AND PAYMENT

4.1 Measurement

.1 The Work under this section shall be lump sum and will not be separately measured.

4.2 Payment

.1 Payment for the Work in this section shall be as tendered for the type and size of expansion joint specified, and will be full compensation for:

.1 Supply and fabrication

.2 Loading

.3 Hauling to the Project site

.4 Unloading

.5 Installation

.6 Engineering services

.7 Temporary structures

.8 Heating and hoarding

.9 All labour, equipment, tools, and incidentals necessary to complete the Work

.2 Payment for this Work shall be issued upon 100% completion, including submission of all documentation per this Technical Specification.

END OF SECTION

1 GENERAL

1.1 Work Included

.1 This section outlines the requirements for the supply and installation of an approved bridge deck waterproofing system on the bridge deck area, as shown on the Drawings.

1.2 Related Work Specified in Other Sections

.1 Bridge Deck Asphaltic Concrete Paving Section 02510

1.3 Reference Standards

.1 Perform the Work of this section in accordance with the latest edition of the following standards available at the Effective Date, except where specified otherwise. Provide one copy onsite of CAN/CSA S6 in either in hard copy or digital format.

.2 ASTM International (ASTM):

- .1 ASTM C403, Standard Test Method for Time of Setting of Concrete Mixtures by Penetration Resistance
- .2 ASTM D449, Standard Specification for Asphalt Used in Dampproofing and Waterproofing
- .3 ASTM D638, Standard Test Method for Tensile Properties of Plastics
- .4 ASTM D3774, Standard Test Method for Width of Textile Fabric
- .5 ASTM D3776, Standard Test Method for Mass Per Unit Area (Weight) of Fabric
- .6 ASTM D4285, Standard Test Method for Indicating Oil or Water in Compressed Air
- .7 ASTM D4355, Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc-Type Apparatus
- .8 ASTM D4491, Standard Test Methods for Water Permeability of Geotextiles by Permittivity
- .9 ASTM D4533, Standard Test Method for Trapezoid Tearing Strength of Geotextiles
- .10 ASTM D4632, Standard Test Method for Grab Breaking Load and Elongation of Geotextiles
- .11 ASTM D4716, Test Method for Determining the (In-plane) Flow Rate per Unit Width and Hydraulic Transmissivity of a Geosynthetic Using a Constant Head
- .12 ASTM D4751, Standard Test Method for Determining Apparent Opening Size of a Geotextile

.13 ASTM D4833/D4833M, Standard Test Method for Index Puncture Resistance of Geomembranes and Related Products

.14 ASTM D5199, Standard Test Method for Measuring the Nominal Thickness of Geosynthetics

.15 ASTM D5261, Standard Test Method for Measuring Mass per Unit Area of Geotextiles

.16 ASTM D5329, Standard Test Methods for Sealants and Fillers, Hot-Applied, for Joints and Cracks in Asphaltic and Portland Cement Concrete Pavements

.17 ASTM D6690, Standard Specification for Joint and Crack Sealants, Hot Applied, for Concrete and Asphalt Pavements

.3 The City of Calgary:

.1 Design Guidelines for Bridges & Structures, Appendix E, Typical Details

.4 CSA Group (CAN/CSA):

.1 CAN/CSA S6, Canadian Highway Bridge Design Code

.5 Ontario Provincial Standard Specifications (OPSS):

.1 OPSS 1213, Material Specification for Hot Applied Rubberized Asphalt Waterproofing Membrane

.2 OPSS 1215, Material Specification for Protection Board

.6 Alberta Transportation (AT) Specifications for Bridge Construction Section 16

1.4 Definitions

.1 All defined words or phrases shall have meaning given the City of Calgary Standard General Conditions and the Agreement, unless noted otherwise.

1.5 Submittals

Sampling and Testing:

.1 The City’s Engineer may require that sufficient quantities of the asphalt membrane, rubber membrane, and protection board be supplied from the Materials being used on the Project for analysis, flow tests, water absorption, or other applicable tests.

.2 Submit a detailed installation procedure including details for the heating and mixing kettle to used to heat the hot-applied rubberized asphalt membrane and product data sheets to the City’s Engineer at least 20 Business Days prior to starting the Work.

1.6 Quality Control, Quality Assurance, and Inspection and Testing

.1 Quality Control

.1 The Contractor is responsible for the quality of Materials and products provided for incorporation in the Work and for the quality of the Work.

.2 The Contractor shall perform inspections and testing necessary to verify that the Work conforms to the requirements of the Agreement.

.3 The Contractor's Quality Control Plan and record documentation shall be made available for review by the City's Engineer upon request.

.2 Quality Assurance

.1 Products and asphalt mix may be tested for conformance to the specified requirements.

.2 Notify The City's Engineer in writing at least 48 hours in advance of the date and time the contractor intends to commence the waterproofing operations.

.3 In case of ambiguity about whether the product, system, or work conforms to the applicable standard, The City's Engineer reserves the right to have such product or system tested or re-inspected to ascertain conformance. The cost of such testing will be borne by The City in the event of conformance and by the Contractor in the event of nonconformance with the Agreement.

.3 Inspection and Testing

.1 All products and workmanship shall be inspected by the Contractor.

.2 Deck preparation and application of the waterproofing system will be inspected by The City's Engineer.

1.7 Delivery and Storage

.1 Products and Materials shall be stored in accordance with the manufacturers' recommendations.

.2 Protection board should be stored in an area that is free from debris, contamination, or moisture until time of application.

.3 Boards that are dirty, cracked, or damaged shall not be used.

.4 Boards that have been warped, or distorted by manufacture, storage, handling, or exposure to weather shall be rejected.

2 PRODUCTS

2.1 Materials

.1 All Materials for this application shall be reviewed and accepted by The City's Engineer. Materials shall be obtained from the same source of supply or manufacturer for the duration of the Project.

.2 Tack Coat:

.1 Tack coat shall be used in conjunction with the asphalt membrane.

.2 Tack coat shall be primer, cut back with product recommended by the tack coat manufacturer.

.3 The primer shall be compatible with the asphalt membrane.

.3 Rubber Membrane:

.1 Rubber membrane shall be 1.2-millimetre (mm)-thick butyl rubber.

.2 The Material shall be unaffected by the heat generated by the hot mix.

.4 Membrane-reinforcing Fabric:

.1 Membrane-reinforcing fabric shall be a spun-bonded sheet structure composed of 100% continuous filament polyester fibres bonded together at their crossover points.

.2 The membrane-reinforcing fabric shall be supplied in minimum widths of 300 mm.

.3 The membrane-reinforcing fabric shall be unaffected by the heat generated by the waterproofing membrane and the hot mix.

.5 Hot-applied asphalt membrane shall be as per AT Section 16.6 List of Approved Materials sub section 16.6.1 and shall be supplied in cakes ready for melting and application.

.6 Waterproofing Protection Board:

.1 Waterproofing protection board shall be a durable panel of 3 mm thickness specifically designed to provide a protective cushion between the hot-mix asphaltic concrete pavement and the asphalt waterproofing membrane.

.2 It shall have a water absorption property of 5% or less (as defined in OPSS 1215) and shall show not deterioration such as stripping or emulsification or loss of mass.

.3 The waterproofing protection board shall consist of spun glass fibres and shall conform to OPSS 1215.

.4 Cellulose reinforcing fibres are not acceptable.

.7 Subdrain:

.1 Subdrain shall consist of composite polypropylene with a total thickness of 3.6 mm, supplied in 100-mm widths.

.2 Puncture strength shall be a minimum of 182 N measured in accordance with ASTM D4833.

.3 Assembled drain flow discharge at 200 kilopascals (kPa) shall be a minimum 2,800 cubic metres per year (m^3/y) in accordance with ASTM D4716.

.4 Wick drain shall be Nilex MD/7407 or approved equal.

3 EXECUTION

3.1 Equipment

.1 Heating and Mixing Kettle: The kettle used to heat the hot-applied rubberized asphalt membrane shall be of the double boiler oil transfer type, with a built-in agitator and equipped with permanently installed dial-type thermometers to measure and maintain the temperature of the melted compound.

.2 A separate calibrated thermometer with an accuracy of ±2 degrees Celsius (°C) shall be used to verify the Material temperature and shall be available onsite.

.3 The compressed air from the air compressor shall be free from oil and water when tested in accordance with ASTM D4285.

3.2 Installation

.1 Traffic Restrictions:

   .1 Traffic restrictions apply to all traffic other than the construction equipment directly associated with the waterproofing operations and the paving operations that follow.

   .2 After sandblasting and shot blasting operations have commenced, traffic will not be allowed on the sandblasted area until the asphalt concrete pavement (ACP) has been placed and cooled to ambient temperature.

.2 Procedure:

   .1 Waterproofing operations shall be carried out when the air and concrete surface temperatures are 5°C or higher.

   .2 The Contractor shall perform all the operations involved in waterproofing in sequential order, with no delay between operations other than as required by this Technical Specification.

.3 Surface Preparation:

   .1 Any grout tubes shall be cut flush with the deck surface prior to sandblasting and shall be recut flush with the concrete surface if sandblasting results in the tube projecting above the concrete. A 300 x 300 mm piece of Membrane-reinforcing fabric shall be installed as specified herein.

   .2 The deck surface shall be free of ridges, rough spots, and depressions deeper that 2 mm.

   .3 Prior to commencement of shot blasting and sandblasting operations:

      .1 The bridge deck surface shall be inspected by The City's Engineer, the Contractor, and the waterproofing installer.

      .2 Measurements and photos of the bridge deck shall be collected for review by The City's Engineer to assess the level of desired surface preparation.

.4 The surface of the concrete shall be completely sandblasted or shot blasted to expose sound, laitance-free concrete.

.5 All dirt and debris shall be removed and disposed of, leaving a prepared surface satisfactory for tack coating.

.6 Sandblast concrete areas to be waterproofed as shown on the Drawings.

.7 Tack coating and waterproofing shall not commence until The City's Engineer has reviewed all surface preparation work.

.4 Tack Coat:

.1 Deck concrete, including barriers, sidewalks, and medians, must be completely dry and cured at least 14 Days before application of tack or membrane can proceed.

.1 Fog testing, using a poly sheet sealed to the deck surface, may be used to confirm the deck surface dryness.

.2 Immediately prior to application of the tack coat, the concrete surface shall be air-blasted with oil- and water-free compressed air to remove dust and other foreign materials.

.3 Application of tack coat material shall be uniformly at a rate of 0.25 l/m^2 or as required by the manufacturer of the tack coat material.

.4 The application rate shall be such that the tack material will be absorbed into the concrete, resulting in a surface that is dull and black in appearance.

.5 The application of an excessive amount of tack as indicated by a shiny, black surface shall be avoided.

.6 Tack coat material shall be applied with the equipment that is proven to provide uniform application at the required rate or approved by the manufacturer of the tack coat material.

.7 Waterproofing equipment or Materials shall not be permitted on the tack coat until it has fully cured and is completely tack-free. Drying of the concrete surface shall not be expedited by use of a torch or any other means.

.5 Waterproofing of Joints and Cracks:

.1 Special attention shall be paid to waterproofing over all construction joints, lift hook pockets, patches and any cracks that would not be bridged by the asphalt membrane as determined by The City's Engineer.

.2 Prior to the application of the asphalt membrane to the whole deck, a coat of hot asphalt membrane at least 4 mm thick (no thicker than 6 mm) and wide enough to extend 200 mm on either side of the joint or crack shall be applied to the tack-coated concrete surface in accordance with Clause 3.2.7.

.3 A strip of membrane reinforcing fabric wide enough to extend 150 mm on either side of the joint or crack shall be applied over the joint or crack while the asphalt membrane is still hot.

.6 Waterproofing of Curbs and Barrier Walls

.1 Along all curbs and barrier walls the hot asphalt membrane shall be applied to the height of the top of the hot-mix surface course, and 150 mm onto the deck when a lap cannot be avoided.

.2 The rubber membrane shall extend 40 mm up the vertical faces, and 110 mm onto the deck surface.

.7 Waterproofing Around Deck Drain Tubes:

.1 Special attention shall be paid to waterproofing around the deck drain tubes. The asphalt membrane shall be carefully applied around the deck drain tubes so that a positive seal is obtained.

.2 Deck drain tubes shall be temporarily plugged prior to waterproofing to prevent the entrance of hot membrane.

.3 After application of hot membrane, deck drain tubes shall checked to ensure they allow free drainage of water.

.8 Application of Hot-Applied Asphalt Waterproofing Membrane:

.1 Cakes of asphalt membrane shall be melted in the mechanically agitated heating and mixing kettle specified. This unit shall keep the contents continuously agitated until the Material can be drawn free-flowing and lump-free from the mixing units at a temperature not exceeding that recommended by the manufacturer.

Membrane shall not be applied until the tack coat has cured completely and is free from surface moisture and dirt.

.2 The membrane shall be applied within the temperature range recommended by the manufacturer, to the clean, tack-coated concrete deck, to form a uniform film having a thickness of 5 mm ±1 mm.

.3 The Contractor shall measure to verify during placement that the asphalt membrane thickness conforms to the specified requirement prior to placing the protection board. Measurement frequency and locations for measurement shall be agreed upon by the Contractor and The City’s Engineer prior to commencement of application asphalt waterproofing membrane.

.4 The laying of the membrane shall be continuous. The laying operation shall be such that discontinuities in the membrane are avoided. If unavoidable, joints must be lapped a minimum of 150 mm.

.5 Wick drains shall be placed the full length of the deck along gutters on top of the membrane when the membrane is still hot and tacky. Special attention shall be given to waterproofing and wick drain connections at deck drain tubes to ensure proper function in the final condition.

.9 Application of Protection Board:

.1 Protection boards shall be laid on the asphalt membrane while the surface is still tacky and laid transverse to the centreline of the deck. The protection boards shall be placed with all edges overlapping a minimum of 25 mm both longitudinally and transversely.

.2 The protection board edge shall be placed within 5 mm of all curbs, wick drains, deck drain tubes, and concrete paving lip edges.

.3 Protection boards shall be placed such that the joints in the direction of traffic flow shall be staggered a minimum of 150 mm. Protection boards shall be placed from the low end up to create a “shingling effect” and prevent water from flowing to the underside.

.4 Protection boards shall be rolled by means of a linoleum or lawn-type roller while the membrane is still warm to provide good contact with the membrane.

.5 In instances where edges of the protection board curl up, the edges shall be cemented down using hot membrane material to the satisfaction of The City’s Engineer.

.6 Protection boards that are warped, distorted or damaged in any way, by manufacturer, storage, handling and exposure shall not be used included in the Work.

.7 Binder course pavement shall be placed within 7 days of waterproofing.

4 MEASUREMENT AND PAYMENT

4.1 Measurement

.1 The quantity measured for payment of this section shall be on a unit price basis per square metre (m^2) or a lump sum basis, as tendered.

.2 For unit price payment, the quantity measured for payment will be the area of deck waterproofing acceptably installed, measured to the nearest 0.1 m^2. Vertical faces will not be measured.

4.2 Payment

.1 Payment for the Work of this section shall be as tendered and will be full compensation for the following:

 .1 Traffic control

 .2 Preparation of concrete surfaces, including sandblasting and shot blasting

 .3 Supply and application of the asphaltic primer

 .4 Supply and installation of asphalt membrane, membrane reinforcing fabric, rubber membrane, wick drain, and protection board

 .5 All labour, Materials, Construction Equipment, inspection and testing necessary to complete the Work, including all subsidiary and incidental items thereto

.2 All costs associated with waterproofing of vertical faces will be considered incidental to the Work, and no separate or additional payment will be made.

.3 Contractors Quality Control documentation must be submitted to The City's Engineer before payment will be issued.

END OF SECTION

1 GENERAL

1.1 Work Included

.1 This section outlines the requirements for shop and field coating of new Structural Steel.

.2 This section does not cover the requirements for hot dip galvanizing or coating over top of galvanized surfaces.

.3 This section does not cover the requirements for coatings of concrete surfaces.

1.2 Related Work Specified in Other Sections

.1	Structural Steel Supply, Fabrication, and Erection	Section 05120
.2	Metal Fabrications	Section 05500
.3	Bridge Bearings	Section 05650
.4	Expansion Joint Assemblies	Section 05820

1.3 Reference Standards

.1 Perform the Work of this section in accordance with the latest edition of the following standards available at the Effective Date. Provide one copy of each reference standard onsite in either hard copy or digital format.

.2 ASTM International (ASTM):

- .1 ASTM D523, Standard Test Method for Specular Gloss
- .2 ASTM D562, Standard Test Method for Consistency of Paints Measuring Krebs Unit (KU) Viscosity Using a Stormer-Type Viscometer
- .3 ASTM D610, Standard Practice for Evaluating Degree of Rusting on Painted Steel Surfaces
- .4 ASTM D660, Standard Test Method for Evaluating Degree of Checking of Exterior Paints
- .5 ASTM D661, Standard Test Method for Evaluating Degree of Cracking of Exterior Paints
- .6 ASTM D714, Standard Test Method for Evaluating Degree of Blistering of Paints
- .7 ASTM D772, Standard Test Method for Evaluating Degree of Flaking (Scaling) of Exterior Paints
- .8 ASTM D2244, Standard Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates
- .9 ASTM D3363, Standard Test Method for Film Hardness by Pencil Test
- .10 ASTM D3960, Standard Practice for Determining Volatile Organic Compound (VOC) Content of Paint and Related Coatings

.11 ASTM D4285, Standard Test Method for Indicating Oil or Water in Compressed Air

.12 ASTM D4417, Standard Test Methods for Field Measurement of Surface Profile of Blast Cleaned Steel

.13 ASTM D4541, Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers

.14 ASTM D7091, Standard Practice for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to Ferrous Metals and Nonmagnetic, Nonconductive Coatings Applied to Non-Ferrous Metals

.15 ASTM F3125/F3125M, Standard Specification for High Strength Structural Bolts and Assemblies, Steel and Alloy Steel, Heat Treated, Inch Dimensions 120 ksi and 150 ksi Minimum Tensile Strength, and Metric Dimensions 830 MPa and 1040 MPa Minimum Tensile Strength

.16 MNL17-2ND, Paint and Coating Testing Manual, 15th Edition of the Gardner-Sward Handbook, Joseph Koleske, ed.

.3 CSA Group (CSA):

.1 CAN/CSA S6, Canadian Highway Bridge Design Code

.2 CSA S16, Design of steel structures

.4 The Society for Protective Coatings (SSPC):

.1 SSPC Good Painting Practice, Volume 1

.2 SSPC PA 1, Shop, Field, and Maintenance Painting of Steel

.3 SSPC PA 2, Determining Compliance to Required DFT

.4 SSPC QP 1, Field Application to Complex Industrial and Marine Structures

.5 SSPC QP 3/AISC 420, Qualification of Paint Shops

.6 SSPC QP 5, Inspection Company Qualification

.7 SSPC SP 1, Solvent Cleaning

.8 SSPC SP 2, Hand Tool Cleaning

.9 SSPC SP 3, Power Tool Cleaning

.10 SSPC SP 8, Pickling

.11 SSPC SP 11, Bare Metal Power Tool Cleaning

.12 SSPC-Vis 1, Guide and Reference Photographs for Steel Surfaces Prepared by Dry Abrasive Blast Cleaning

.13 SSPC-Vis 3, Guide and Reference Photographs for Steel Surfaces Prepared by Hand and Power Tool Cleaning

.5 SSPC and NACE International (NACE) Joint Publications:

.1 SSPC-SP 5, White Metal Wet Abrasive Blast Cleaning (NACE No. 1)

.2 SSPC SP 6, Commercial Blast Cleaning (NACE No. 3)

.3 SSPC SP 10, Near-White Metal Blast Cleaning (NACE No. 2)

.6 United States (U.S.) Federal Standards

.1 Aerospace Material Specification Standard 595 (AMS-STD-595-COLOR) – published by US General Services Administration

.7 RAL gGmbH (RAL)

.1 RAL Standard Colours

1.4 Definitions

.1 **Dry Film Thickness (DFT)** means the thickness of a Coating after it has dried throughout, after all the solvent has evaporated, and the Coating has cured.

.2 **Extended Warranty Period** means a period of 5 years from the date of issuance of The City's Substantial Completion Certificate.

.3 **Faying Surface** means the mating surface of a member that is in contact with the mating surface of another member when joined together.

.4 **Final Surface Preparation** means surface preparation as specified in the Agreement.

.5 **Interim Surface Preparation** means an incomplete surface preparation that does not meet the requirements for the Final Surface Preparation.

.6 **Low-VOC** means a Paint Coating material that contains not more than 340 grams per litre (g/L) of volatile organic compounds (VOCs) when tested according to ASTM D3960.

.7 **Marginally Prepared Surface** means a steel surface prepared by power tool cleaning according to SSPC SP 3.

.8 **Paint Coating** means a liquid or mastic composition that, upon drying or curing, is converted to a solid protective, decorative, or functional adherent film after application as a thin layer.

.9 **Paint Coating System** means a number of coats of paint separately applied in a predetermined order at suitable intervals to allow for setting, drying, or curing.

.10 **Pot Life** means the length of time a multicomponent material is usable after all components are mixed in the recommended portions.

.11 **Recoat Time** means the time recommended by the manufacturer for drying, curing, or setting of Paint Coating prior to application of a subsequent coat.

.12 **Slip Critical Connection** has the meaning given in CSA S6.

.13 **Structural Steel** means the steel components of a structure, including lighting poles, traffic signal poles, bearing assemblies, deck drains, piles, and all other steel appurtenances and connections, excluding railing systems.

.14 **Surface Profile** means the surface contour of a blast or power tool cleaned substrate, when viewed from the edges of the surface.

1.5 Permits

.1 The Contractor shall obtain the necessary permits and approvals, and conform to all requirements of environmental screening reports, municipal bylaws, and provincial and federal environmental protection laws, for all Work carried out. The Contractor shall be familiar with and comply with all regulations, such as, but not limited to, Environmental permits, the Worker's Compensation Act, Workplace Safety and Insurance Act, and the Occupational Health and Safety Act, Regulation and Code which control the exposure of workers to chemical hazards.

1.6 Qualifications

.1 The Contractor performing the work of this section shall have certification in good standing with the Society for Protective Coatings (SSPC) under SSPC-QP1, SSPC-QP2, SSPC-QP3, and SSPC-QP5 (for inspection) or approved equivalent.

1.7 Submittals

.1 Submit to The City, required Paint Coating System information and colour samples of top coat(s) for acceptance 20 Business Days prior to ordering. Paint Coating System shall conform to the requirements specified in the Materials section of this Technical Specification. The submittal shall include the following:

.1 Sample drawdowns and a completed Paint Coating information sheet for each component of the Paint Coating System.

.2 Materials Safety Data Sheet (MSDS) for each Paint Coating to be used.

.3 Manufacturer's instructions for use and material information including documentation on laboratory and field tests carried out to establish the Pot Life, physical characteristics, and chemical composition, as shown in the Paint Coating information sheet.

.4 Proof of the coating Contractor's qualifications

.2 Where field coatings or touch-ups for Paint Coatings are applied on newly erected structures and would require a containment structure, scaffolding, platforms, or swing stages to be employed, the Contractor shall submit the following:

.1 20 Business Days prior to proceeding, submit plans to The City's Engineer for review including temporary works, structural loadings, and evaluation of bridge, as well as detailed calculations and notes sealed by an Engineer, retained by the Contractor detailing the Contractor's containment structure, scaffolding, platforms, or swing stages. All scaffolding, platforms, swing stages, and material equipment shall be designed and operated in accordance with the current CSA standards. The design of any enclosures, including temporary supports, shall be according to CSA S16 and all other applicable codes, standards, legislation, and requirements. Such works are incidental to completion of the Work and are entirely within the Contractor's responsibility.

.2 After verification of the actual field condition of the structure for application, submit Shop Drawings with the statement that the bridge, including all components that the Contractor requires to support the enclosure system, can safely support all loads, including construction loads, according to CAN/CSA S6 and shall bear the seals and signatures of two (2) Engineers retained by the Contractor.

.3 Submit a detailed description of the environmental protection to be employed, including details of the enclosure, erection of the enclosure, and relocation procedure for the enclosure and equipment.

.3 Product Data:

.1 Submit the manufacturer's product data sheets for each Paint Coating showing the following:

.1 Recommended maximum Dry Film Thickness (DFT)

.2 Mixing and thinning directions

.3 Recommended spray nozzles and pressures

.4 Acceptable humidity levels and temperature range for application

.5 Minimum acceptable Recoat Time for temperatures in the intervals of 5 degrees Celsius (°C) from 0° to 30°C, including the acceptable range of relative humidity (RH) for each temperature interval

.6 Required recoat conditioning agents or surface roughing between coats

.4 Before commencement of the Paint Coating application, supply The City's Engineer with written certification from the Paint Coating manufacturer stating that all materials supplied are as specified in the Agreement and the manufacturer's current product data sheets.

.5 Written certification from the Contractor performing the work is required at the following stages:

.1 Upon completion of surface preparations prior to applying coatings

.2 Upon completion of all shop coating and prior to delivery of any Structural Steel, including DFT of each coat

.3 Upon completion of field coating, including all QC records

1.8 Quality Control, Quality Assurance, and Inspection and Testing

.1 Quality Control and Quality Assurance

.1 The Contractor shall be responsible for Quality Control (QC) and Quality Assurance (QA) testing required to verify the Work meets the design parameters and Technical Specification requirements; and shall include all methods, means, materials, equipment, and labour necessary to accomplish the requirements identified within this Technical Specification.

.2 The Contractor's plan for QA/QC shall be included in the Quality Management Plan (QMP) and submitted to The City's Engineer for review prior to starting any Paint Coating work.

.3 All QA/QC, including testing as part of the Contractor's QMP, shall be paid for by the Contractor.

.2 Inspection and Testing

.1 Testing provided by the Contractor:

.1 The Contractor shall engage an independent testing agency, certified in accordance with NACE, to perform QC testing. A NACE Level 3 Inspector shall conduct all required inspection and testing.

.2 Additional testing made necessary by Material substitutions, repair of Deficient work, and additional unspecified Material touch-ups shall be paid for by the Contractor.

.3 All test records produced in the course of QC shall be submitted to The City's Engineer within the Contractor's QA review documentation for review and acceptance.

.2 Testing provided by The City:

.1 In addition to the Contractor's responsibility for QA/QC, The City may appoint a testing agency to perform independent QA testing as deemed necessary by The City.

.2 These inspections will be performed by testing agencies appointed by and paid for by The City.

.3 This testing is independent of the Contractor's QMP and shall not replace the Contractor's QC testing and QA review documentation.

.3 The Contractor shall notify The City's Engineer no less than 48 hours prior to commencement of shop or field work.

.4 No protective treatment shall be applied to the Work until the appropriate inspection and testing has been carried out.

.5 Written documentation of measurements taken, including DFT measurements, shall be provided to The City's Engineer on a weekly basis, at a minimum, or more often as requested by The City's Engineer.

.6 The Contractor is responsible for ongoing QC of cleaning and Paint Coating application operations, including measurements of temperature, humidity, dew point, Surface Profile, and Coating thickness.

.7 The Work may be randomly tested by The City's QA independent tester for cleanliness to determine contamination of surfaces by presence of visible dust, oils, grease, or other foreign matter. Random testing of ambient and surface temperature, RH, and dew point may also be conducted by The City's QA independent tester and would be done by means of a thermometer, surface thermometer, or recording hygro-thermograph and digital or sling psychrometer with recognized psychometric tables.

.8 Surface Profile Measurements:

.1 Surface Profile shall be verified using a spring micrometer and an extra-coarse, pressure-sensitive replica tape according to ASTM D4417, Method C.

.2 Surface Profile measurements may be made by The City's QA independent tester on a random basis according to ASTM D4417, Method C.

.9 Dry Film Thickness Measurements:

.1 DFT shall be verified with a Type 2 constant pressure probe gauges according to ASTM D7091 and SSPC PA 2.

.2 The gauge shall be calibrated according to procedures in SSPC PA 2. To facilitate the calibration procedure, mask off a 75-millimetre (mm) by 75-mm area of the prepared steel at a location selected by The City's Engineer. After all tests are completed, the masked off area shall be coated as specified.

.3 As an alternative to calibrating the Type 2 gauge on prepared surfaces, the Contractor may provide an uncoated 300-mm by 300-mm reference plate sample of steel of similar composition; thickness, ±10%; and surface preparation for gauge calibration.

.4 Paint Coating thickness measurements may be made by The City's QA independent tester, and the Contractor shall be present when the gauges are being calibrated for this purpose.

.5 Minimum DFT for Paint Coating Systems as per Table A. Inform the City's Engineer in the case where the minimum DFT values in Table A exceed the recommended maximum dry film thickness stated by the product manufacturer.

Table A – DFT Requirements Acceptable Paint Coating Systems

System	Coat	Material	Minimum DFT (µm)
1	Prime	Epoxy-zinc	90
	Mid	Water-based acrylic	90
	Top	Water-based acrylic	90
2	Prime	Epoxy-Zinc	90
	Mid	Epoxy	100
	Top	Polyurethane	50
3	Prime	Inorganic-zinc	75
	Mid	Water-based acrylic	90
	Top	Water-based acrylic	90
4	Prime	Inorganic-zinc	75
	Mid	Epoxy	100
	Top	Polyurethane	50
5	Prime	Zinc-Rich Moisture-cured polyurethane	90
	Mid	Moisture-cured polyurethane	100
	Top	Moisture-cured polyurethane	50

.10 Adhesion and Hardness Testing:

.1 Performance testing of the Paint Coating System shall be conducted on test samples for adhesion per ASTM D4541, and hardness per ASTM D3363.

.2 Coating shall meet the minimum adhesion and hardness values as stated by the product supplier.

.3 Coatings may be subjected to additional tests for adhesion and hardness at the discretion of The City's Engineer or The City's QA independent tester.

.11 Colour, gloss and formulation

.1 For each batch of paint used on the Project, the Contractor shall have QC tests completed for colour, gloss, and formulation.

.2 Colour testing for the mixed top coat shall be carried out in accordance with ASTM D2244 with a CIE 1976 L8A8B, 2 degree observer, and a D65 illuminate.

.3 Gloss testing for the mixed top coat shall be carried out in accordance with ASTM D523 at 60 degrees observer angle.

.4 Infrared Spectroscopy (IR) shall be conducted on all individual components of the Coating prior to mixing, to confirm that the formulation conforms to that which was originally approved. A minimum 32 scans shall be taken with a Fourier transform infrared spectrometer between 4000 and 400 wave-numbers (CM-1) using the salt plate sandwich technique. The salt plate may be made from potassium bromide for non-aqueous paints. If the formulation contains water; appropriate, non-water soluble plates shall be used. Plate material shall be reported with each individual spectrum. The spectra shall be taken of vehicle portion of the coating without the pigment. For single component materials, a representative sample of the material shall be centrifuged to remove pigment and then analyzed. For plural component materials, each of the individual components shall be centrifuged to remove pigment and then analyzed separately. IR analysis of the mixed components is not required. The IR plots shall be completed with transmittance (0 – 100%) on the y-axis and Wave-numbers (4000 – 400; non-linear) on the x-axis. All peaks shall be labelled with the corresponding wave-number. The spectra shall be taken such that the largest peaks are at 50 – 0%T and the baseline is greater than 80%T. Materials with IR plots indicating a change in formulation from that which was originally approved will be rejected.

.5 Submit test results to the City's Engineer for review and acceptance a minimum of 10 business days prior to the anticipated commencement of coating operations.

.12 Paint Batch Testing by City:

.1 Each batch of paint may be subjected to additional testing by The City or The City's Engineer.

.2 If requested, the Contractor shall provide four 250-millilitre (mL) samples of paint from a pail or barrel chosen by The City or The City's Engineer.

.3 Samples shall be placed in suitable new, clean, metal containers, and be sealed to avoid contamination of the paint.

1.9 Acceptability

.1 Failure to comply with the requirements of this Technical Specification will result in the Paint Coating being considered potentially deficient.

.2 The following shall be a cause for rejection of some or all of the Paint Coating or Paint Coating System:

.1 Failure to conform to the requirements of Section 2.1, Materials, or changes made in the formulation after acceptance

.2 Inability to maintain production quality

.3 Unsatisfactory field performance of Paint Coatings or Paint Coating Systems

.3 Acceptability of surface preparation shall be based on the applicable SSPC surface preparation specifications and pictorial standards given in SSPC-Vis 1 and SSPC-Vis 3.

.4 Determination of acceptability of DFT of each coat shall be made according to SSPC PA 2, Coating Thickness Restriction Level 3. For areas with multiple intersecting steel members, Level 4 may be used with approval of the Engineer.

.5 Specified maximum DFT used to determine acceptability of Paint Coating thickness according to SSPC PA 2 shall be the manufacturer's recommended maximum, as shown in the submitted product data sheets.

.6 Additional testing, inspection, and evaluation may be required where evidence points to a potentially Deficient work and shall be paid for by the Contractor. The Contractor shall be responsible for the costs and schedule implications for any corrective action required.

.7 The Contractor shall pay all costs for additional testing, inspection, and analysis required to demonstrate the adequacy of Paint Coatings that do not meet the requirements of the Agreement. The Contractor shall be responsible for any Project costs associated with schedule delays related to demonstrating the adequacy of Paint Coatings.

.8 The Contractor shall replace at their own expense, including all direct and indirect costs, all Paint Coatings judged inadequate by testing and inspection at any time up to the end of the Extended Warranty Period.

.9 The City’s Engineer may order further testing, inspection, and analysis at any time. If additional testing is outside the scope of this Agreement, The City will pay for those tests, inspections, or chemical analysis that meet the specified requirements; and the Contractor will pay for those that do not.

2 PRODUCTS

2.1 Materials

.1 The Paint Coating System for steel surfaces shall be a three-coat system composed of a zinc primer, epoxy mid-coat, and polyurethane top coat with system compatible touch-up material.

.2 A single Paint Coating System shall be used throughout the entire project unless specified otherwise. The Contractor shall not change to another Paint Coating System once the initial system has been applied to any portion of the Work.

.3 Use only one of the approved Paint Coating Systems as per Table B.

Table B – Approved Paint Coating Systems

System	Coat	Material	Product
Carboline System	Primer	Inorganic Zinc	Carbozinc 11 HS
	Mid	Epoxy	Carboguard 893
	Top	Polyurethane	Carbothane 134 HG
PPG Amercoat System	Primer	Organic Zinc	Amercoat 68 HS – C
	Mid	Epoxy	Amercoat 370 Fast Dry Multi-Purpose Epoxy
	Top	Polyurethane	Amercoat 450H Aliphatic Polyurethane
Devoe System	Primer	Organic Zinc	Catha-Coat 302
	Mid	Epoxy	Bar-Rust 231
	Top	Polyurethane	Devthane 379
Sherwin Williams	Primer	Organic Zinc	Zinc Clad III
	Mid	Epoxy	Macropoxy 646
	Top	Polyurethane	Acrolon 218

.4 All paint Material shall be compatible with the surface to which it is being applied.

.5 Only Paint Coatings contained in the original containers sealed by the manufacturer shall be used.

.6 Compressed air used during all Work operations shall be clean, dry, and free from oil residues, when tested according to ASTM D4285.

.7 Chloride remover used during surface preparation of steel components shall be compatible with the Paint Coating System being used.

.8 Caulking used to seal joints in steel components shall be compatible with the Paint Coating System being used.

2.2 Paint Colour

.1 For atmospheric corrosion-resistant (ACR) steel within 3 metres (m) of the girder supports, the finish colour of the top coat for all systems shall be AMS-STD-595-10045 (brown), AMS-STD-595-30045 (brown), or RAL equivalents.

.2 For all other Structural Steel, the Contractor shall use RAL colours as specified on the IFC Drawings.

.3 Each coat shall be formulated to show a distinct colour difference as to assist in distinguishing the different coats.

.4 The prime coat shall be of such a colour as to assist the applicator in distinguishing between primed areas and the uncoated cleaned steel or other prepared surfaces.

3 EXECUTION

3.1 General

.1 The extent of work, cleaning requirements, surface preparation, environmental protection requirements, and type of Paint Coating System shall be as specified in the Agreement.

.2 All Paint Coating Systems shall be stored, thinned, handled, mixed, and applied according to SSPC PA 1 and the recommendations on the manufacturer's written product data sheets. Where there is a conflict between the manufacturer's recommendations and the Agreement, the more stringent requirements shall apply as determined by The City's Engineer.

.3 The City's Engineer shall be informed when the surface preparation and each subsequent phase of work of Paint Coating application are completed and ready for inspection. Subsequent work shall not commence until The City's Engineer has complete the inspection of the work and given permission in writing to proceed.

.4 For new structural steel, all coats of the specified Paint Coating System shall be shop applied.

.5 The Contractor shall protect and maintain the coated surfaces until acceptance of the Work.

3.2 Limits of Paint Coating Work

.1 Apply the entire Paint Coating System to all steel surfaces as described on the IFC Drawings except for:

- .1 Steel surfaces which will be cast into concrete
- .2 Sliding metal to metal contact bearing surfaces and mating surfaces of spherical bearings
- .3 Metal surfaces within 50 mm of any edge to be welded. Provide unprotected steel with one coat of boiled linseed oil or other approved protective coating.
- .4 Contact surfaces of slip-critical connections. At slip critical connections the surface within the bolt pattern and for a distance of 50 mm beyond the splice plates shall receive only the prime coat prior to assembly.
- .5 Exterior surfaces of the bolted connections within a distance of 25 mm around the edge of bolt holes and against which the bolt head or washer is going to be bearing shall receive only the prime coat prior to assembly.

.2 Bare or prime coated surfaces that are exposed after final assembly are to receive all remaining Paint Coatings after cleaning of surfaces according to manufacturer's recommendations.

3.3 Repair of Damaged Coatings

.1 Damaged areas of coated surfaces shall be prepared to the original surface preparation standard specified and by feathering the edges of sound coatings. For damaged areas of less than 100 square centimeters (cm^2), power tool cleaning to

SSPC-SP 11 may be used for surface preparation. The prepared surface shall be recoated with the originally applied materials. The dry film thickness of all three coats in the repair area shall be as specified for the initial application.

3.4 Containment System

1. The Contractor must prevent debris generated during surface preparation from entering into the environment and to facilitate the controlled collection of debris for disposal through the use of a containment system.
2. When abrasive blast cleaning is used to clean and prepare the steel surface, the Contractor shall contain the paint chips, abrasive particles, and debris resulting from the operation. The containment system may include cover panels, screens, tarps, scaffolds, supports. Shrouds and ground sheets used to enclose the entire work area, and equipment to clean, transport, collect, and store blast media.

3.5 Packaging and Delivery of Coating Products

.1 Paint shall be delivered in the manufacturer's originally sealed containers. Paint containers shall be leak-free, provided with triple-tight lids, and constructed so that the contents can be thoroughly and completely mixed. Containers 4 litres (L) or larger shall have wire bail handles.

.2 Each container and shipping case shall be permanently marked with the Paint Coating batch number to show the following information:

  .1 Identification of the Paint Coating System

  .2 The contents of the container (that is, prime coat, mid-coat, top coat)

  .3 The colour and colour code

  .4 The manufacturer's name and address

  .5 The quantity of the contents in litres

  .6 The date of filling the container (that is, yyyy-mm-dd)

  .7 The manufacturer's code and coating batch numbers

.3 Paint shall be safely stored by the Contractor, in a location which keeps its temperature between 10 °C to 25 °C.

3.6 Protection of Surfaces

.1 The Contractor shall take due precaution against damaging or disfiguring any portion of the Work with blast media, spatter, spray fog, splashes, smirches of paint or associated coating materials including the fuel and lubricants used with his equipment. Tarps, polyethylene or other covering material shall be used to protect deck, sidewalks, piers, abutments, slope protection and other portions of the Work adjacent to areas being painted and subject to paint or other damage.

.2 Completely protect mechanical and electrical components and working surfaces of bearings from sand, dust, grit, and other debris and damage. Any cleaning of these components necessary as a result of inadequate protection will be performed by the Contractor at no additional cost to The City.

.3 The Contractor shall protect the coated areas of the structure coming into contact with rollers, clamps, and other parts of the scaffolding and access facilities using rubber or other material to prevent damage to the Paint Coating.

.4 Any inadvertent damage or disfigurement shall immediately be repaired to the satisfaction of The City's Engineer at the Contractor's expense.

.5 Protect surfaces not to be coated; and if damaged, clean and restore such surfaces as directed by The City's Engineer.

.6 Protect all components coated offsite from handling and/or shipping damage by plastic shrink-wrapping all components or assembles; use padded slings, separators, and tie-downs or other similar devices. Loading procedures shall protect coated surfaces from possible damage.

3.7 Surface Preparation

.1 Perform surface preparation in accordance with the Paint Coating manufacturer's instructions and this Technical Specification.

.2 Remove fins, slivers, burrs, sharp edges, weld spatter, and slag by power grinding prior to the surface preparation and Paint Coating application.

.3 Grind all sharp edges of Structural Steel specified to be coated to a smooth radius of at least 3 mm using hand or power tools prior to cleaning.

.4 Clean Faying Surfaces of new Structural Steel components to be connected by bolts to the surface preparation standard required for the Paint Coating System specified.

.5 Abrasive blast clean Structural Steel specified to be coated, other than ACR steel, to the requirements of SSPC SP 10 / NACE No. 2. The abrasive blast cleaning shall provide a Surface Profile height of a minimum of 40 μm and a maximum of 75 μm.

.6 Abrasive blast clean all ACR steel components according to SSPC SP 6 / NACE No. 3 to completely remove mill scale, rust, coatings, oxides, corrosion products, oil, grease, dust, dirt, and other foreign matter.

.7 Final surface preparation for coating application shall only be carried out when the temperature, moisture, and humidity satisfy the criteria specified in SSPC-PA 1 for coating application.

.8 Remove traces of blast products from surfaces, pockets, and corners to be coated by brushing with clean brushes, by blowing with clean, dry, compressed air, or by vacuum cleaning. Confirm compressed air is free of water and oil before reaching nozzle.

.9 Verify that prepared surfaces are free of blast products, dust, and other contaminates prior to the application of Paint Coatings. Prevent contamination of cleaned and prepared surfaces before prime coat is applied and between applications of remaining Paint Coatings.

.10 Provide certificate of conformance prepared by a NACE Level 3 inspector for all surface preparations prior to applying prime coat.

.11 Difficult to Access Areas:

.1 Surfaces not in contact with other steel surfaces, but that are inaccessible after assembly shall have all Paint Coatings applied prior to assembly.

.2 Surface inaccessible for coating after erection shall be coated prior to erection.

.3 The Contractor shall identify difficult to access areas to The City's Engineer. Surface preparation of these areas shall be carried out to the extent practical as detailed on the Contractor's submission for methods, procedures, and sequence of work. The surface preparation standard for these areas shall be based on reasonable effort demonstrated in the field acceptable to The City's Engineer.

3.8 Mixing of Paint Coatings

.1 Do not dilute or thin coat for brush application unless indicated by the manufacturer's written instructions.

.2 Mix ingredients in a container free of deleterious materials before and during use; and confirm breaking up of lumps, complete dispersion of settled pigment, and uniform composition.

.3 Do not mix or keep Paint Coatings in suspension by means of air bubbling.

.4 Mix thin Paint Coatings for spraying according to the manufacturer's written instructions. If directions are not on the container, obtain instructions in writing from the manufacturer, and provide a copy to The City's Engineer.

3.9 Application of Paint Coating System

.1 Prior to commencing Paint Coating application, confirm degree of cleanliness of surfaces is in accordance with SSPC-Vis 1 and that surfaces have no dust.

.2 Notify The City's Engineer no less than 48 hours prior to mixing and applying Paint Coating. Notify The City's Engineer when surface preparation and each subsequent phase of Work of Paint Coating application is completed and ready for inspection.

.3 Do not commence subsequent work until The City's Engineer and the Contractor's NACE Level 3 inspector have completed inspection of Work and given authorization in writing to proceed.

.4 Paint Coatings shall be applied by spraying, brushing, rolling or a combination of these methods. On all surface which are inaccessible for brushes or rollers and where spraying cannot be employed, the paint may be applied with sheepskin mitts specifically manufactured for this purpose.

.5 Apply Paint Coating System to all steel surfaces in accordance with the IFC Drawings, Technical Specifications, and manufacturer's instructions. When required the coating manufacturer's representative shall be available to provide guidance and solve problems.

.6 Paint Coatings shall be smooth, continuous and free of runs and sags. Applied coatings shall have no pinholes, holidays, bubbles, or craters. Brush out all runs and sags as application progresses.

.7 Keep Paint Coating ingredients properly mixed in spray pots or containers during application either by continuous mechanical agitation or by intermittent agitation. The paint shall be agitated often enough during application to keep the pigment in suspension.

.8 Correct application-related failures in Paint Coatings, as described in the coating failures chapter of the SSPC Painting Manual, prior to application of a subsequent Paint Coating and, in case of top coat, after application of the top coat.

.9 Where excessive coating thickness produces mud cracking in coating materials, scrape back and sand to soundly bonded coating, then recoat the area to required thickness,

.10 Remove all dry spray by sanding, and reapply the Paint Coating as specified.

.11 Apply each coat as a continuous film of uniform thickness. Recoat thin spots or bare areas before application of the next Paint Coating.

.12 Apply Paint Coatings within the temperature and RH restrictions specified by the manufacturer.

.13 All portions of the Paint Coating shall be within the range of DFTs which was originally approved. Bolts, rivets, edges of members and other changes in surface contour shall also receive the required DFTs.

.14 Spray Application:

  .1 Provide and maintain equipment suitable for the intended purpose, capable of properly atomizing Paint Coating to be applied, and equipped with suitable pressure regulators and gauges.

  .2 Provide traps or separators to remove oil and water from compressed air, and drain periodically during operations.

  .3 Apply Paint Coatings in a uniform layer, with overlapping at edges of spray pattern. Direct initial pass of the spray gun at outside edges of the steel work prior to completely coating all surface for each coat of paint.

.15 Do not apply the next coat before the undercoat has sufficiently cured in accordance with the manufacturer's written instructions.

.16 Paint Coatings shall not be applied when the air and/or steel temperatures are at or below 4 °C, nor when the metal has absorbed sufficient heat (above 50 °C) to cause the paint to blister and produce a porous film, nor when it is possible the air temperature may drop below 0 °C before the paint is dry. Variances from these requirements, due to paint supplier’s recommendations or requirements, require The City Engineers acceptance prior to usage. Remove Paint Coatings from areas that have been exposed to unsuitable temperature, humidity, moisture, or other damaging conditions. Prepare surface again and recoat.

.17 Shop Coating:

.1 Limit the time between Final Surface Preparation and prime coat application inside shop to 24 hours or less. Prime coat Structural Steel subjected to outdoor exposure after Final Surface Preparation within 10 hours, or as directed by the manufacturer.

.2 Leave at least 100 mm of bare metal and 100 mm of each coat of the Paint Coating System exposed for lapping of subsequent coats, where the continuous application of coat or Final Surface Preparation is interrupted in a section.

.3 Perform shop coating after fabrication and before damage to surface occurs from weather or other exposure.

.4 Remove weld spatter, weld slag, and flux before Coating.

.5 Protect machine-finished or similar surfaces that are not to be coated but that do require protection with coating of rust-inhibitive petroleum, molybdenum disulphide, or other Coating approved by The City's Engineer.

.6 Copy previous erection marks and weight marks on areas that have been shop coated.

.7 Allow access by The City's Engineer and The City's QA independent tester to the Paint Coating shops where components are being cleaned and coated during all hours of Work.

.18 Field Coating:

.1 Applying Paint Coatings to Structural Steel in the field should be limited to repairs, touch-ups, and difficult to access areas only.

.2 Limit the time between Final Surface Preparation and the prime coat application to 10 hours or less, unless otherwise directed by the manufacturer.

.3 Coat steel structures as soon as practical after erection.

.4 If concreting or other operations damage the Paint Coating, clean and recoat the damaged area. Remove concrete splatter and droppings before Paint Coating is applied.

.5 Touch-up:

.1 Touch-up steel that has been shop-coated with the same type of Paint Coating and to the same thickness as the shop coat.

.2 This touch-up shall include cleaning and coating of field connections, welds, nuts, washers, bolts, and damaged or defective coat and rusted areas.

.6 Wash surfaces subject to chlorides prior to erection shall be washed in preparation of impending field coating.

.7 Provide cover when Paint Coatings must be applied in damp or cold weather.

.8 Protect, shelter, or heat surface and surrounding air to comply with specified temperature and humidity requirements.

.9 Protect until Paint Coating is dry or until weather conditions are suitable.

.10 Where Paint Coating does not meet with requirements of this Technical Specification, and when so directed by The City's Engineer, remove defective Paint Coating, thoroughly clean affected surfaces, and recoat in accordance with this Technical Specification.

.19 Handling Coated Steel:

.1 Do not handle coated steel until Paint Coating has cured, except for necessary handling for coating or stacking for drying.

.20 Application of Coating of Areas Difficult to Access:

.1 Prior to assembly, apply all three coats to surfaces not in contact with other steel surfaces but that are inaccessible after assembly.

.2 Prior to erection, apply all three coats to surfaces inaccessible for coating after erection.

.3 Paint coating of areas specified in the Agreement as difficult to access shall be done from access openings, as detailed in the Contractor's submission for methods, procedures, and sequence of work.

.4 Quality of Paint Coating application for these areas shall be based on reasonable effort demonstrated in the field acceptable to The City's Engineer.

3.10 Coating of Bolts, Nuts, and Washers

.1 Apply prime coat and finish coat by both spray and brush to all bolts, nuts, and washers when specified to be coated as per the IFC Drawings. Brush apply the finish coat prior to spray application of the finish coat.

.2 When inorganic zinc primer is specified, carry out the brush application with an epoxy-zinc primer from the same manufacturer after the spray application of the prime coat.

3.11 Guarantee

.1 The Contractor is to Warranty, in writing, the performance of the Paint Coating and Paint Coating System for the duration of the Extended Warranty Period.

.2 The Contractor, Paint Coating supplier, and Paint Coating installer are required to complete an Extended Warranty Form that guarantees the replacement of Paint Coatings at no cost to The City in the event that the Paint Coating(s) do not perform satisfactorily under normal environmental exposure. The Contractor will verify the coated components are installed in a manner that will not void the Warranty.

.3 Paint Coating System Inspection:

.1 An inspection of the Paint Coating System shall be carried out a minimum of 40 Business Days prior to the expiration of the Extended Warranty Period.

.2 The Contractor shall be notified prior to and may be present during this inspection.

.3 The Contractor shall provide traffic accommodation and inspection equipment, as required, at the Contractor's cost. Traffic accommodation shall be coordinated with The City.

.4 The Paint Coating System shall be considered defective if any of the following conditions exist, as defined by the SSPC Painting Manual, Volume 1, Good Painting Practice:

.1 Visible corrosion products, except at locations defined in the Agreement as difficult to access, as well as blistering, bubbling, checking, cracking, wrinkling, delaminations, dry spray, pinholes, sagging, flaking, mud cracking, peeling, scaling, or undercutting

.2 Any debonding or failure of adhesion of the Paint Coating either to the Structural Steel or lack of intercoat adhesion

.3 Any loss of normal gloss or rapid change of colour of the Paint Coating

.4 Paint Coating applied over dirt, debris, blasting debris, corrosion products not removed during surface preparation, or steel projections

.5 Incomplete Paint Coating

.6 Damage to the Paint Coating caused by the Contractor's operations or excessive blast dust on the finish coat

.5 Damage to the Coating due to vehicle impact or snow removal equipment will not constitute failure of the system.

.4 Repair under Warranty shall include all Permits, Licenses and Approvals, traffic accommodation, containment systems, labour, Materials, Construction Equipment, tools, and incidentals necessary to restore the Coating to a condition acceptable to The City at no cost to The City.

.5 Warranty Work shall be completed within 60 Days of notification of defects, or, in the event this would place the repair work period in winter weather conditions, by the following June 30th.

4 MEASUREMENT AND PAYMENT

4.1 Measurement

.1 The quantity measured for payment of this section shall be on a unit price or lump sum basis as per the Agreement.

4.2 Payment

.1 Payment for the Work of this section shall be full compensation for all labour, materials, engineering services, temporary structures, lead abatement, ventilation systems, heating and hoarding, environmental protections, fish habitat protection, and equipment necessary to complete the Work, including all subsidiary and incidental items thereto for which separate payment is not elsewhere provided.

.2 Payment for this Work shall be issued upon 100% completion, including submission of all documentation per this Technical Specification.

END OF SECTION

APPENDIX D – WARRANTY FORMS

D1 **BEARINGS**

D2 **EXPANSION JOINTS**

D3 **GALVANIZING**

D4 **COATINGS (PAINTINGS included)**

EXTENDED WARRANTY FORM

TO: The City of Calgary

Bridge Engineering Section
P.O. Box 2100, Stn.M
MC #8481
Calgary, Alberta T2P 2M5

Project Name:

Tender Number:

Re: BEARINGS

Bridge File Number:

We the undersigned, hereby guarantee The City of Calgary against defects in the said Bearings or workmanship or both related to their installation for a period of **five (5) years** from the date of issuance of The City's Substantial Completion Certificate (the "Extended Warranty Period"). We guarantee for the **Five (5) year** period that the said Bearings will perform satisfactorily within the project specifications, design range of movement and under the design loads.

In the event the Bearings do not perform satisfactorily, the replacement or repairs or both will be done at no cost to The City of Calgary.

Bridge File Number: ________________ **Tender Number:** ______________

Type of Bearings: ____

Installation Date: ____

Warranty Commencement Date:
(Issuance date of Substantial Completion Certificate) ______________________________

Warranty Termination Date: ______________________________________

GENERAL CONTRACTOR

Name of Corporation: ____

Name and Position of Signing Officer: ______________________________

Signature of Signing Officer: _____________________________________

SUPPLIER

Name of Corporation: ____

Name and Position of Signing Officer: ______________________________

Signature of Signing Officer: _____________________________________

INSTALLER

Name of Corporation: ____

Name and Position of Signing Officer: ______________________________

Signature of Signing Officer: _____________________________________

Receipt of this document is acknowledged this______day of_____________, 20___.

The City of Calgary per: _________________________

EXTENDED WARRANTY FORM

TO: The City of Calgary

Bridge Engineering Section
P.O. Box 2100, Stn.M
MC #8481
Calgary, Alberta T2P 2M5

Project Name: ____________________

Tender Number: ____________________

Re: EXPANSION JOINTS

Bridge File Number: ____________________

We the undersigned hereby guarantee The City of Calgary against defects in the said Expansion Joints or workmanship or both related to their installation for a period of **five (5) years** from the date of issuance of The City's Substantial Completion Certificate (the "Extended Warranty Period"). We guarantee for the **five (5) year** period that the said Expansion Joints will perform satisfactorily within the project specifications, design range of movement and under the design loads.

In the event the Expansion Joints do not perform satisfactorily, the replacement or repairs or both will be done at no cost to The City of Calgary.

Bridge File Number: ________________ **Tender Number:** ______________

Type of Joints: ____

Installation Date: ____

Warranty Commencement Date:
(Issuance date of Substantial Completion Certificate) ______________________________

Warranty Termination Date: ______________________________________

GENERAL CONTRACTOR

Name of Corporation: ______________________________________

Name and Position of Signing Officer: ______________________________

Signature of Signing Officer: ______________________________________

SUPPLIER

Name of Corporation: ______________________________________

Name and Position of Signing Officer: ______________________________

Signature of Signing Officer: ______________________________________

INSTALLER

Name of Corporation: ______________________________________

Name and Position of Signing Officer: ______________________________

Signature of Signing Officer: ______________________________________

Receipt of this document is acknowledged this_______day of_____________, 20___.

The City of Calgary per: __________________________

EXTENDED WARRANTY FORM

TO: The City of Calgary

Bridge Engineering Section
P.O. Box 2100, Stn.M
MC #8481
Calgary, Alberta T2P 2M5

Project Name:

Tender Number:

Re: GALVANIZING

Bridge File Number:

We, the undersigned acknowledge and agree that, subject to the exception described below, we are jointly and severally responsible for any and all costs of repairs reasonably required in connection with any failure or defect in the coating system described due to the coating system itself or the workmanship in the application of such coating system, for a period of **five (5) years** from the date of issuance of the City's Substantial Completion Certificate (the "Extended Warranty Period").

To the extent that any problem is due to ordinary wear and tear, damage caused by third parties, or damage caused by the negligence or wilful misconduct by or on behalf of The City or its employees, the undersigned will not be responsible.

In the event of any failure or unsatisfactory performance of the coating system during the Extended Warranty Period, except to the extent of the exception described above, the undersigned or any of them will perform any and all replacement or repair work reasonably required. If the undersigned are unable or unwilling to proceed with and complete reasonable required replacement or repair work within a reasonable period, the City may have the required replacement or repair work carried out by another contractor or by its own forces, and the undersigned or any of them will indemnify and save harmless the City from all reasonable costs in connection with the replacement or repair work, including any legal costs reasonably incurred.

Bridge File Number: ________________ **Tender Number:** ______________

Type of Coating: ____

Installation Date: ____

Warranty Commencement Date:
(Issuance date of Substantial Completion Certificate) ______________________________

Warranty Termination Date: ____________________________________

GENERAL CONTRACTOR

Name of Corporation: ____

Name and Position of Signing Officer: ______________________________

Signature of Signing Officer: ____________________________________

SUPPLIER

Name of Corporation: ____

Name and Position of Signing Officer: ______________________________

Signature of Signing Officer: ____________________________________

INSTALLER

Name of Corporation: ____

Name and Position of Signing Officer: ______________________________

Signature of Signing Officer: ____________________________________

Receipt of this document is acknowledged this_______day of_____________, 20___.

The City of Calgary per: _________________________

EXTENDED WARRANTY FORM

TO: The City of Calgary

Bridge Engineering Section
P.O. Box 2100, Stn.M
MC #8481
Calgary, Alberta T2P 2M5

Project Name: ______________________________

Tender Number: ______________________________

Re: COATING SYSTEM

Bridge File Number: ______________________________

We, the undersigned, acknowledge and agree that, subject to the exception described below, are jointly and severally responsible for any and all costs of repairs reasonably required in connection with any failure or defect in the coating system described due to the coating system itself or the workmanship in the application of such coating system, for a period of **five (5) years** from the date of issuance of The City's Substantial Completion Certificate (the "Extended Warranty Period").

To the extent that any problem is due to ordinary wear and tear, damage caused by third parties, or damage caused by the negligence or wilful misconduct by or on behalf of The City or its employees, the undersigned will not be responsible.

In the event of any failure or unsatisfactory performance of the coating system during the Extended Warranty Period, except to the extent of the exception described above, the undersigned or any of them will perform any and all replacement or repair work reasonably required. If the undersigned are unable or unwilling to proceed with and complete reasonable required replacement or repair work within a reasonable period, the City may have the required replacement or repair work carried out by another contractor or by its own forces, and the undersigned or any of them will indemnify and save harmless the City from all reasonable costs in connection with the replacement or repair work, including any legal costs reasonably incurred.

Bridge File Number: ________________ **Tender Number:** ______________

Type of Coating: ____

Installation Date: ____

Warranty Commencement Date:
(Issuance date of Substantial Completion Certificate) ____________________________

Warranty Termination Date: ____________________________________

GENERAL CONTRACTOR

Name of Corporation: ____________________________________

Name and Position of Signing Officer: ____________________________

Signature of Signing Officer: ____________________________________

SUPPLIER

Name of Corporation: ____________________________________

Name and Position of Signing Officer: ____________________________

Signature of Signing Officer: ____________________________________

INSTALLER

Name of Corporation: ____________________________________

Name and Position of Signing Officer: ____________________________

Signature of Signing Officer: ____________________________________

Receipt of this document is acknowledged this_______day of_____________, 20___.

The City of Calgary per: __________________________

ISC: Protected

APPENDIX E – TYPICAL DETAILS

BRIDGE BARRIER AND DECK, TYPICAL SECTIONS AND DETAIL

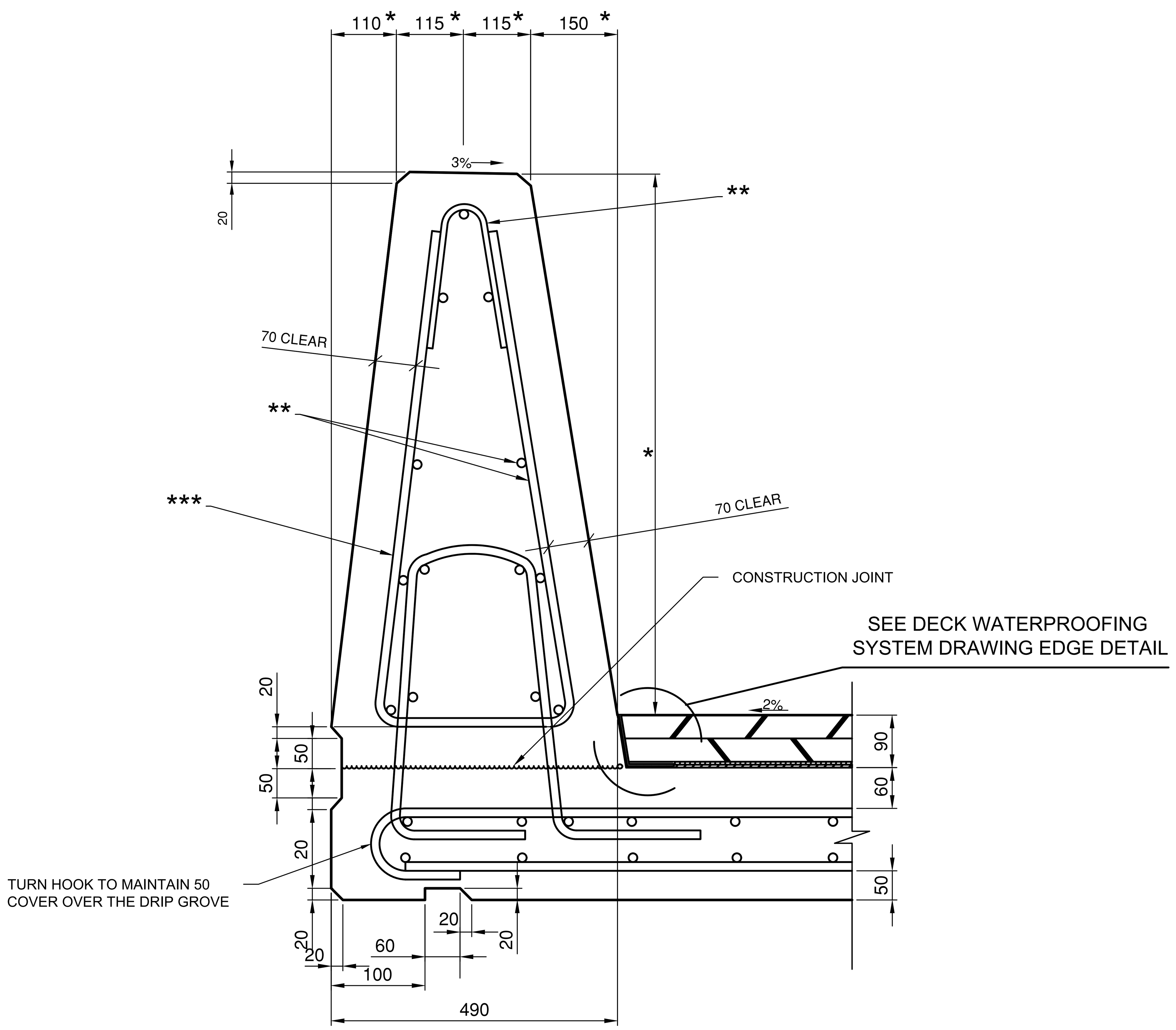
INTEGRAL AND SEMI-INTEGRAL ABUTMENT, TYPICAL APPROACH SLAB END SECTION AND DETAILS

SEMI-INTEGRAL ABUTMENT WINGWALL, TYPICAL SECTIONS AND DETAIL

DECK WATERPROOFING SYSTEM, TYPICAL SECTIONS AND DETAILS

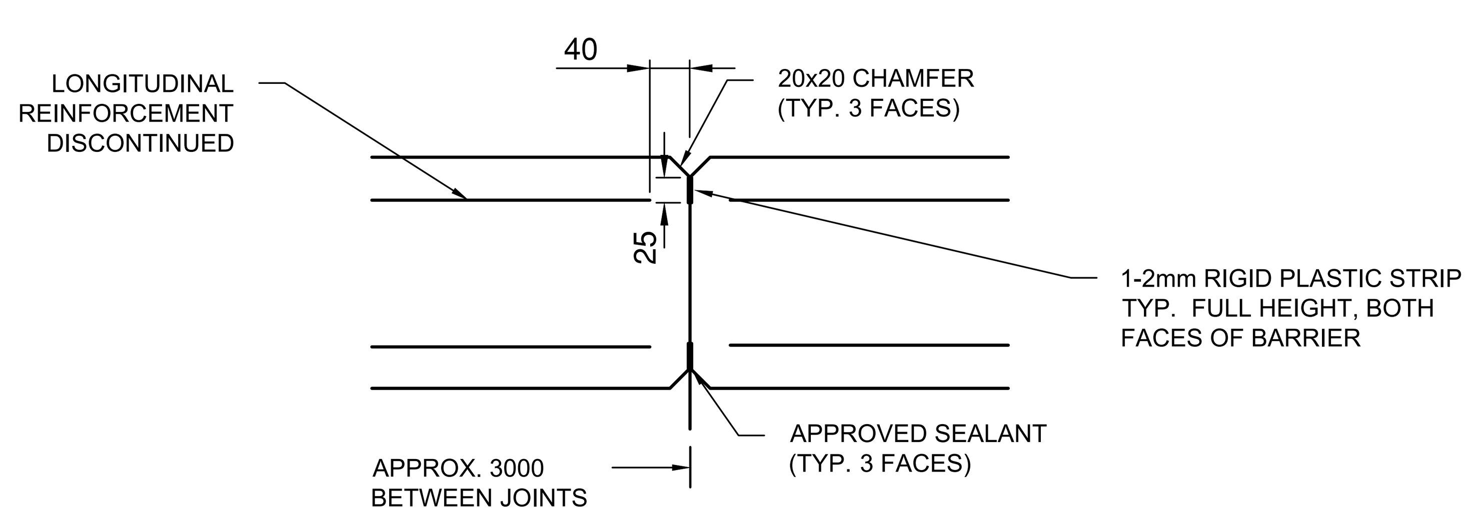
NOTES

- * DIMENSION AS PER PROJECT SPECIFIC DESIGN
- ** DIAMETER AND SPACING OF REINFORCEMENT AS PER PROJECT SPECIFIC DESIGN
- *** DECREASE SPACING TO 100mm WITHIN 1000mm OF BARRIER CONTROL JOINTS AND EXPANSION JOINTS (TYPICAL)
- 1. REINFORCEMENT MATERIAL AND PROTECTIVE COATING IS PROJECT SPECIFIC



A – BRIDGE BARRIER SECTION

SCALE NTS

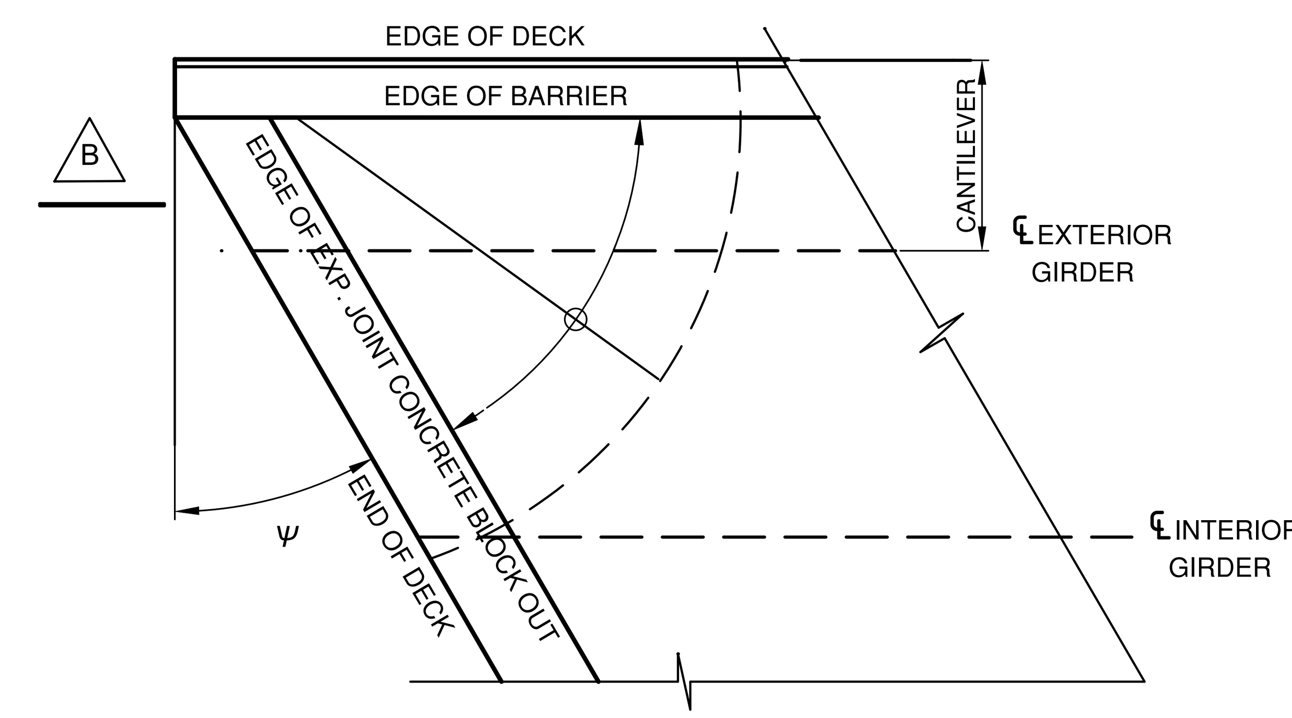


BARRIER CONTROL JOINT (CJ)

SCALE NTS

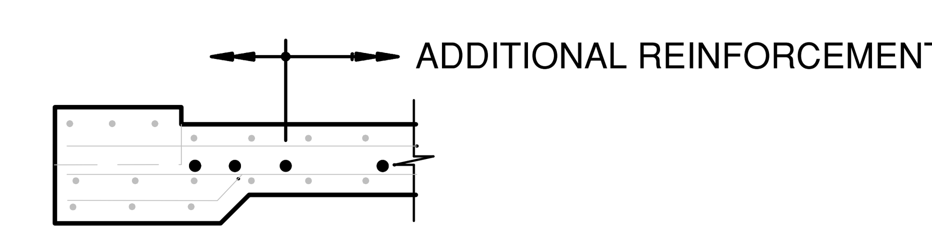
SKEW Ψ	CANTILEVER	ADDITIONAL REINFORCEMENT
20° - 35°	0.6m - 1.2m	6 - 20M
20° - 35°	1.2m - 1.6m	6 - 25M
35° - 45°	0.6m - 1.2m	8 - 20M
35° - 45°	1.2m - 1.6m	8 - 25M

LESS THAN 0.6m CANTILEVERS DO NOT REQUIRE THIS ADDITIONAL REINFORCEMENT



PLAN

SCALE NTS



B – DECK END SECTION AT ACUTE CORNERS

SCALE NTS

STANDARD REQUIRED ADDITIONAL RADIAL REINFORCEMENT FOR SKEWED DECKS (CANTILEVER BETWEEN 0.6m AND 1.6m)

NAD 83 COORDINATES

ISSUED FOR REVIEW

NO.	DESCRIPTION	DATE (YYYY-MM-DD)	BY	APPD

PERMIT | SEAL

	BY	DATE (YYYY-MM-DD)
DESIGNED		
DRAWN		
CHECKED		

SCALE

CONSULTANT'S LOGO

PROJECT

THE CITY OF CALGARY CONSTRUCTION DRAFTING STANDARDS AND TEMPLATES

SEC: -- - TWP: --- RGE: -- W -th M

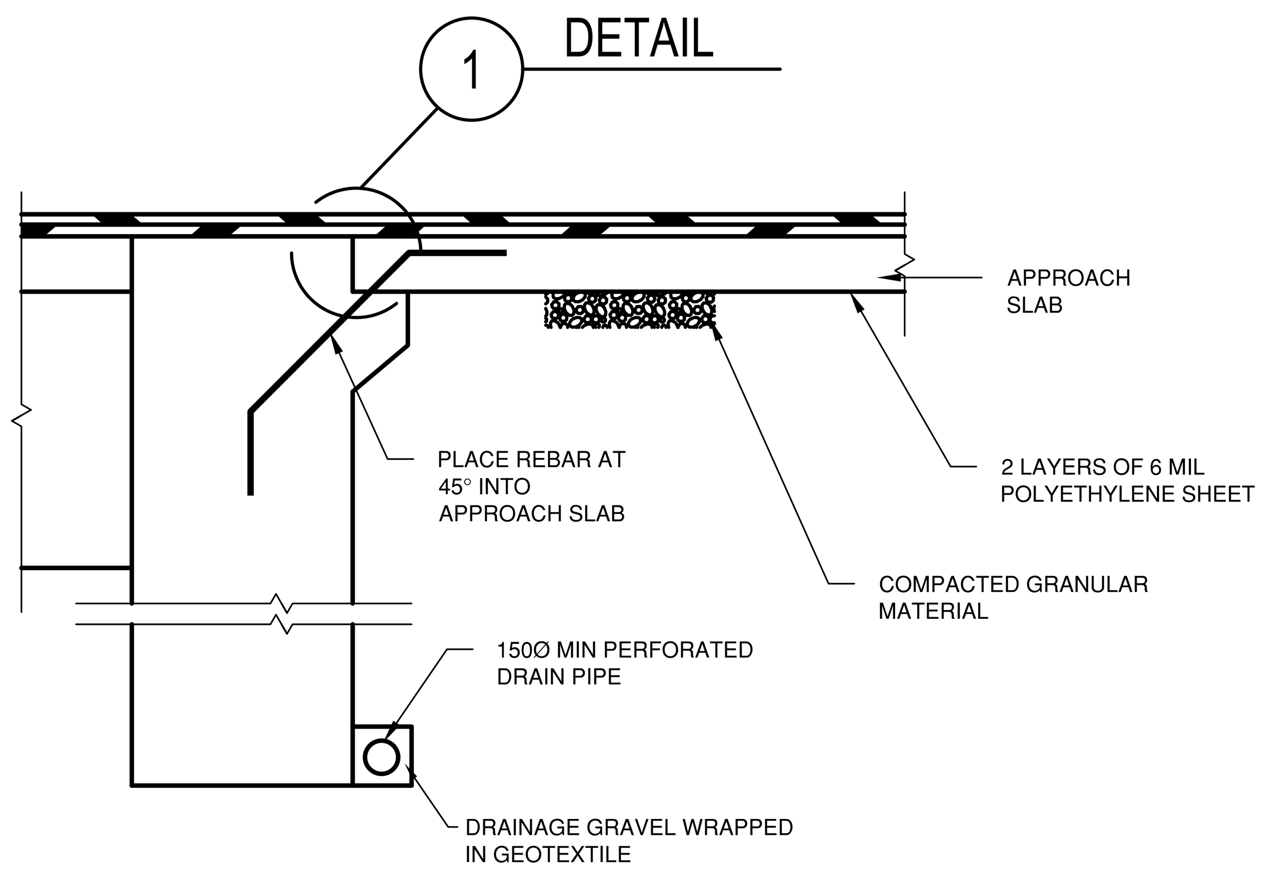
SHEET TITLE

BRIDGE BARRIER AND DECK STANDARD SECTIONS AND DETAIL

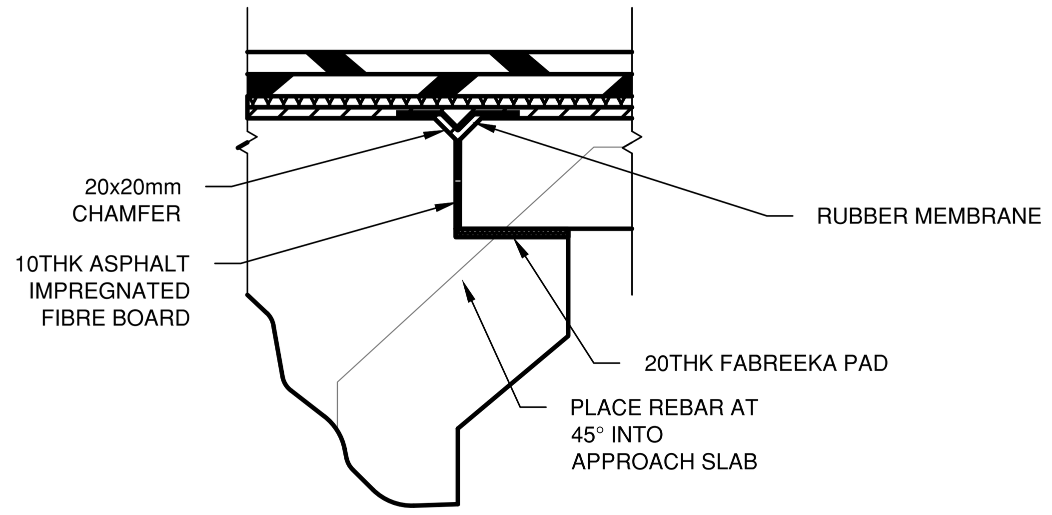
FILE NO. -- | ENG DWG NO. --

SHEET ID. --- | SHEET COUNT -- of --

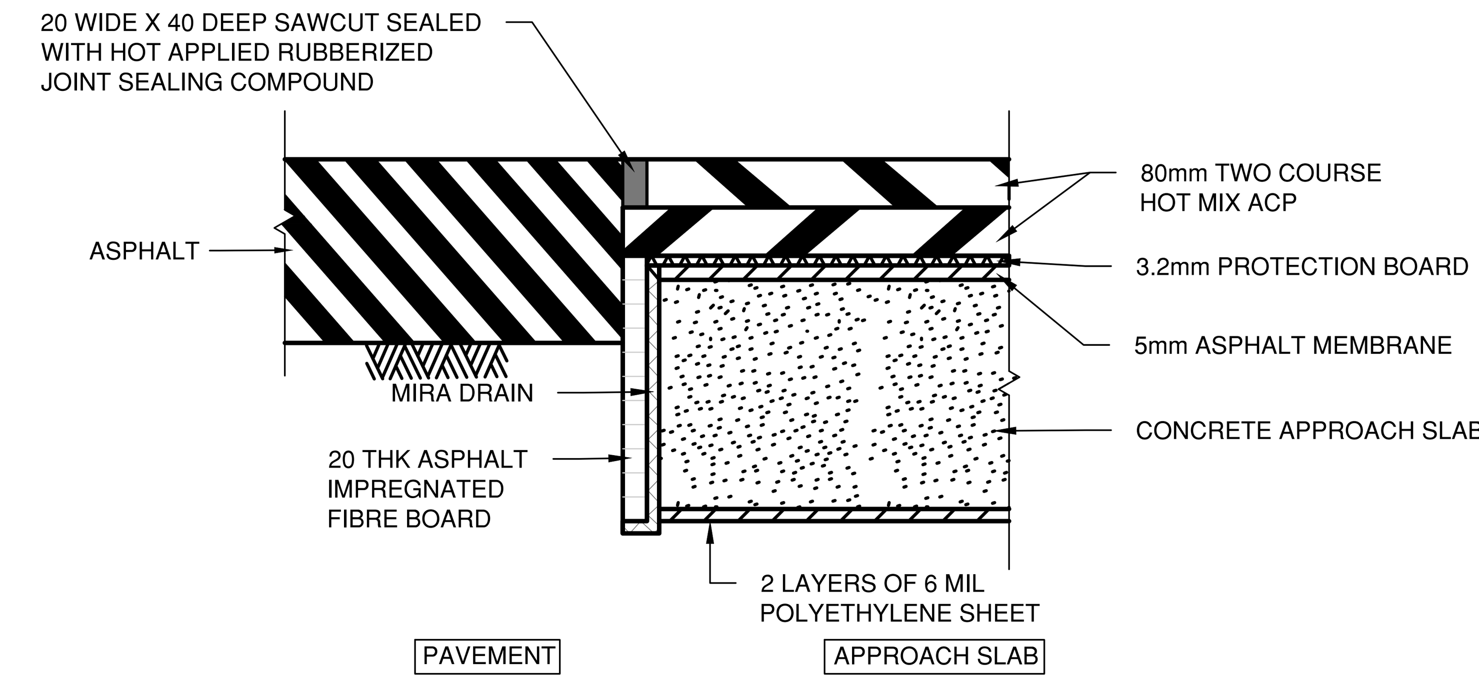
SHEET SIZE ANSI D 25 mm 0



A -- APPROACH SLAB INTERFACE SECTION
SCALE NTS

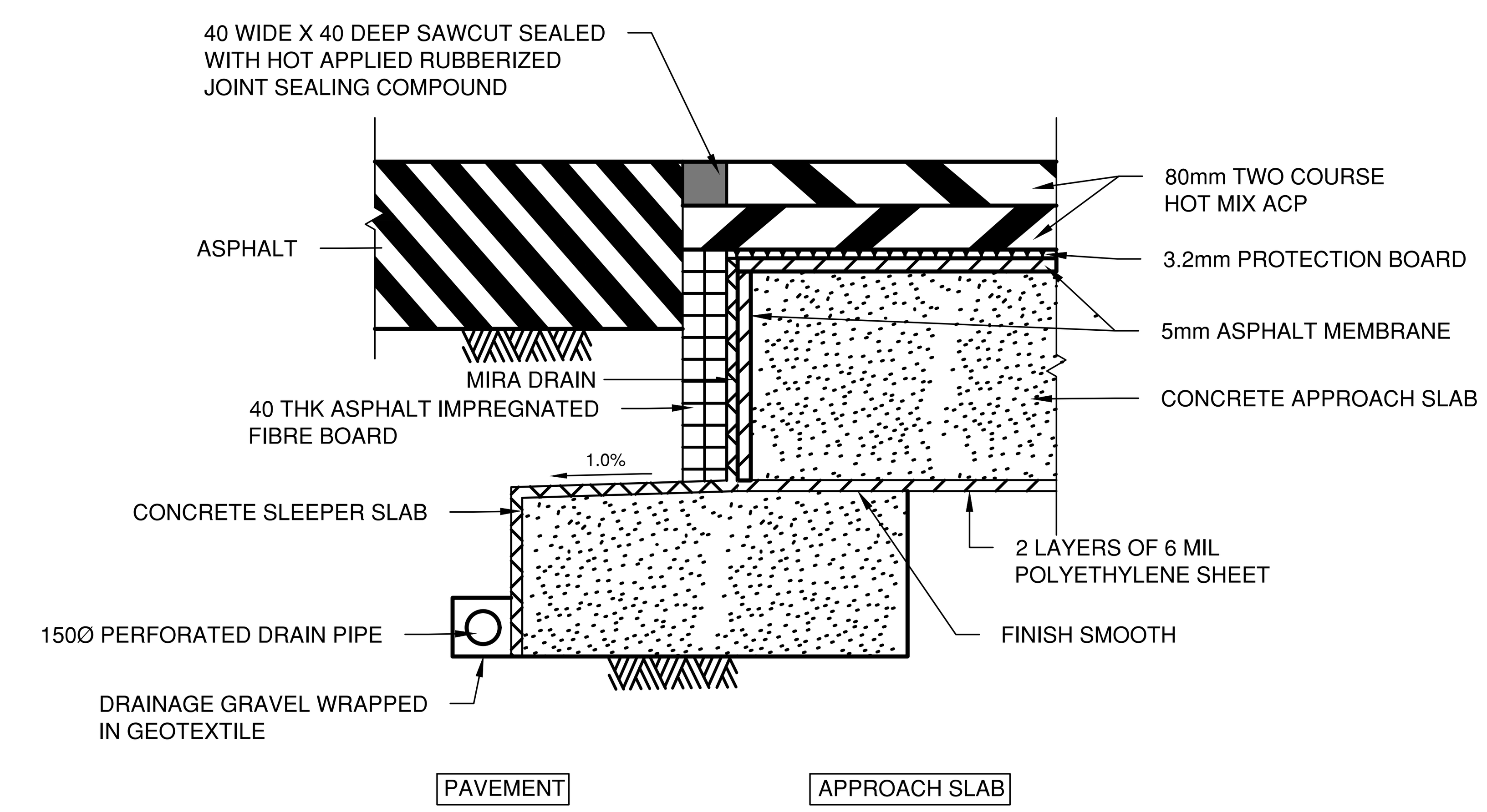


1 -- DETAIL
SCALE NTS



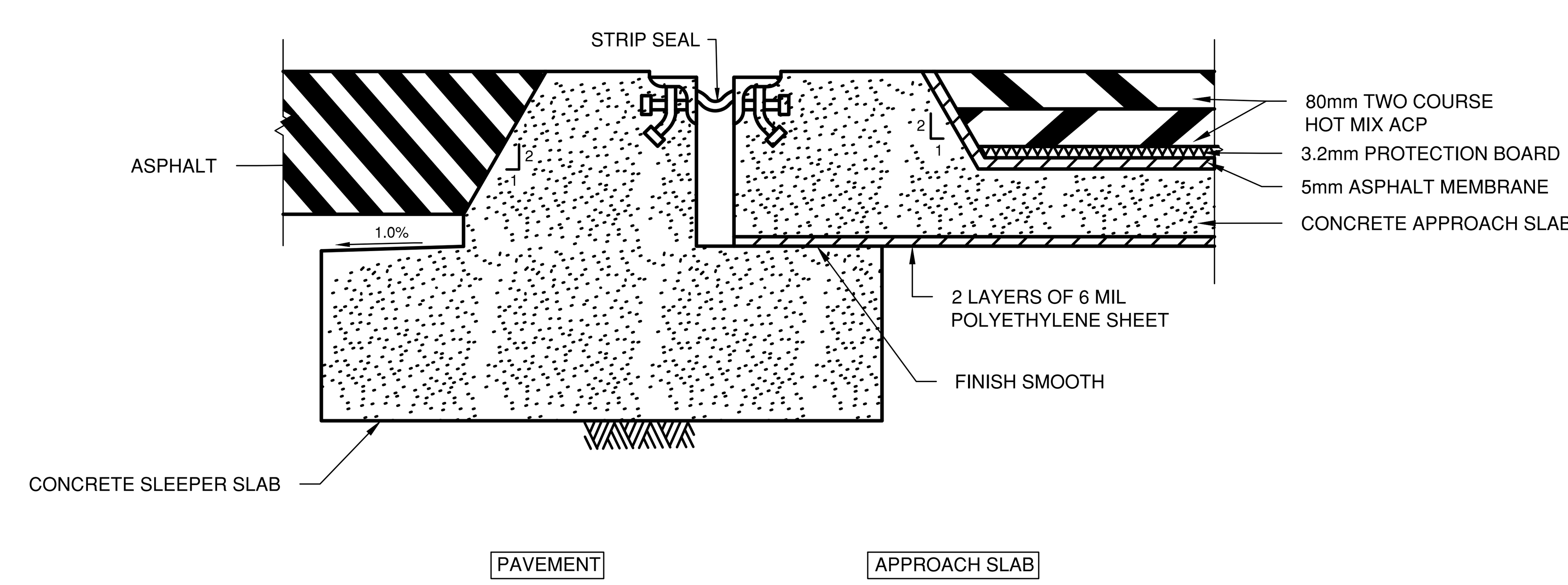
2 -- DETAIL
SCALE NTS

CONCRETE STRUCTURES < 50m LONG, STEEL STRUCTURES < 40m LONG (< 15mm EXP)



3 -- DETAIL
SCALE NTS

CONCRETE STRUCTURES 50m-100m LONG, STEEL STRUCTURES 40m-75m LONG (15mm-30mm EXP)



4 -- DETAIL
SCALE NTS

CONCRETE STRUCTURES > 100mm LONG, STEEL STRUCTURES > 75m LONG (> 30mm EXP)

NOTES

1. DIMENSION AS PER PROJECT SPECIFIC DESIGN
2. DIAMETER AND SPACING OF REINFORCEMENT AS PER PROJECT SPECIFIC DESIGN
3. HOT APPLIED RUBBERIZED JOINT SEAL COMPOUND TO ACCOMMODATE STRUCTURE MOVEMENT

LEGEND

80mm TWO-COURSE HOT-MIX ASPHALTIC CONCRETE PAVEMENT
3.2mm PROTECTION BOARD
5mm ASPHALT MEMBRANE
MEMBRANE REINFORCING FABRIC
1.2mm RUBBER MEMBRANE
3.6mm WICK DRAIN

NAD 83
COORDINATES

ISSUED FOR REVIEW

NO.	DESCRIPTION	DATE (YYYY-MM-DD)	BY	APPD
A	ISSUED FOR REVIEW			

PERMIT
SEAL

	BY	DATE (YYYY-MM-DD)
DESIGNED		
DRAWN		
CHECKED		
SCALE		

CONSULTANT'S LOGO

PROJECT
THE CITY OF CALGARY CONSTRUCTION DRAFTING STANDARDS AND TEMPLATES

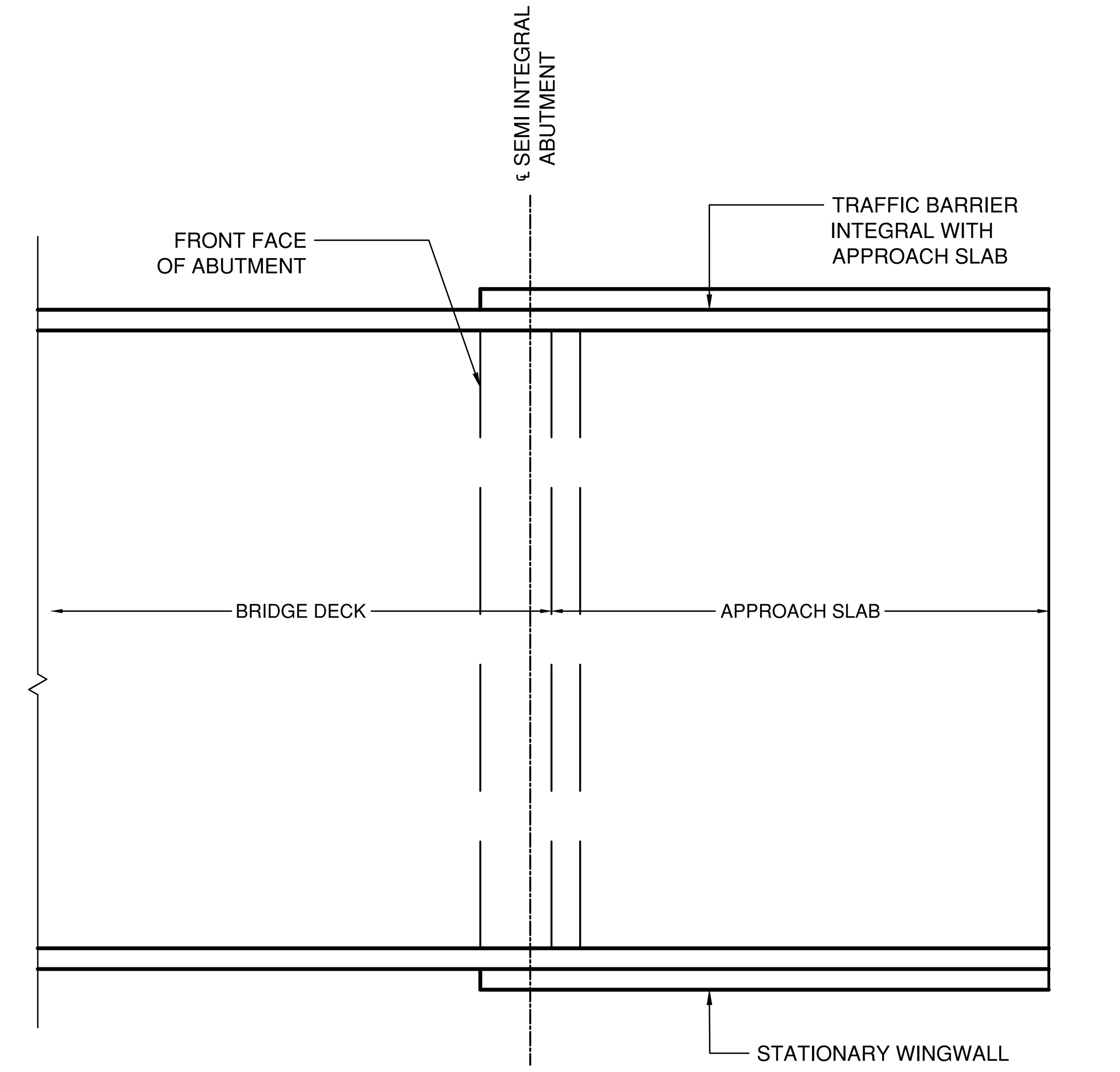
SEC: -- - TWP: --- RGE: -- W -th M

SHEET TITLE
INTEGRAL AND SEMI-INTEGRAL ABUTMENT STANDARD APPROACH SLAB END SECTION AND DETAILS

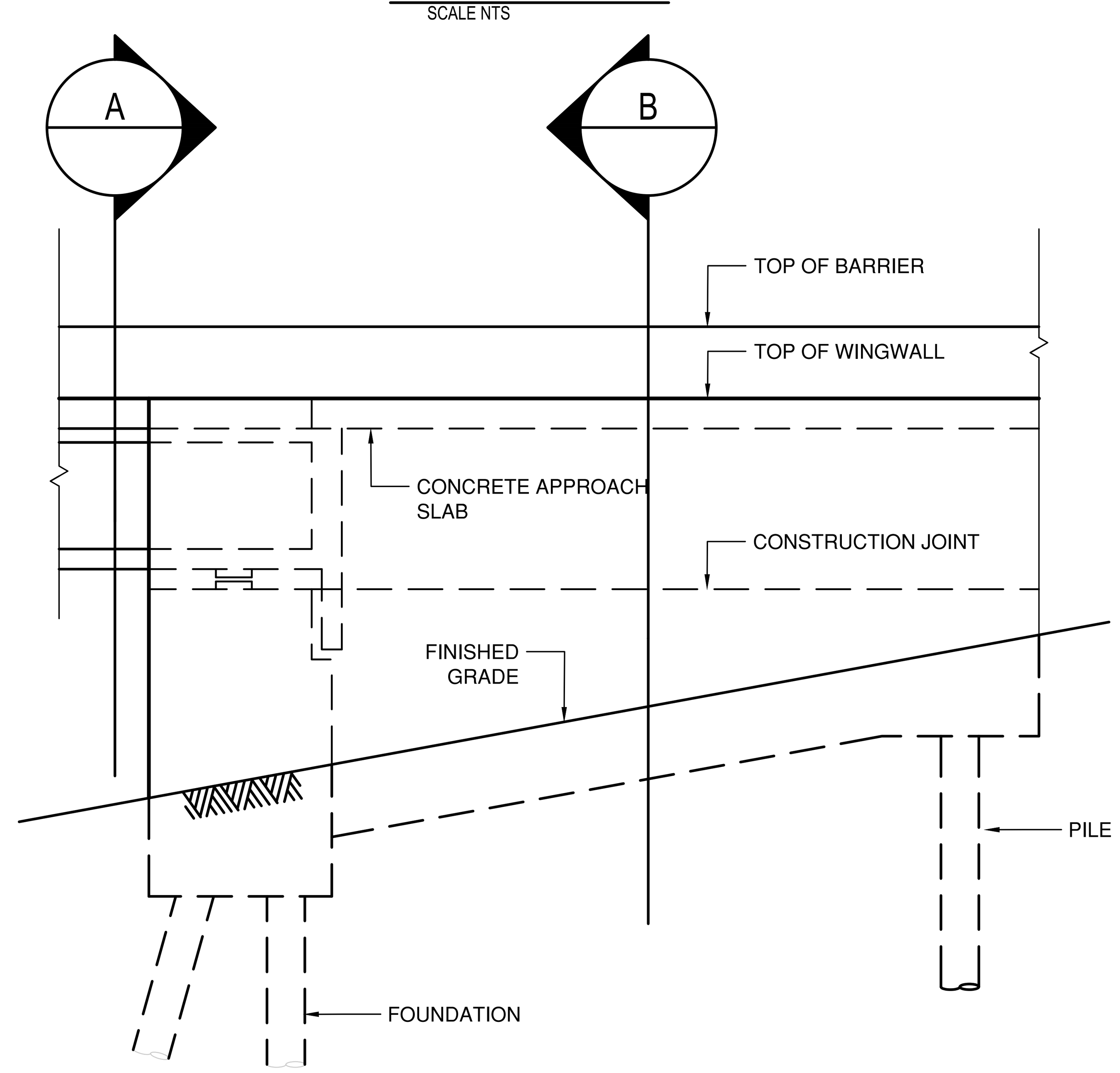
FILE NO. --
ENG DWG NO. --
SHEET ID. ---
SHEET COUNT -- of --

SHEET SIZE ANSI D 25 mm 0

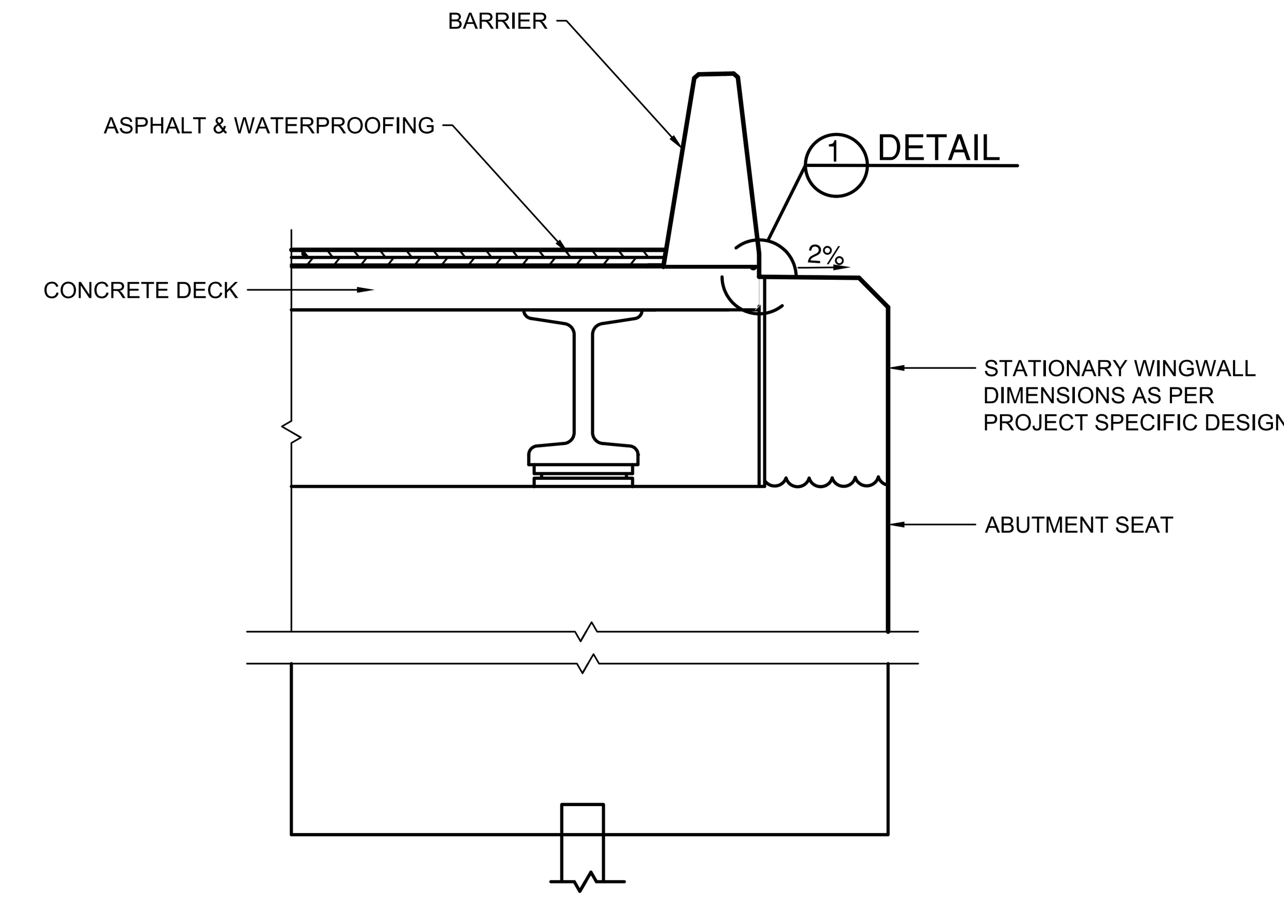
FILE: Z:\SPECIAL\2017_TI_SPECIALREQUESTS\02171539_TI_INTERNALSUPPORTSERVICES_2017\GEORGEVAYALI\INTEGRALSEMI_INTEGRAL.DWG | DATE: Friday, January 04, 2019 6:47:55 AM | ISC: UNRESTRICTED



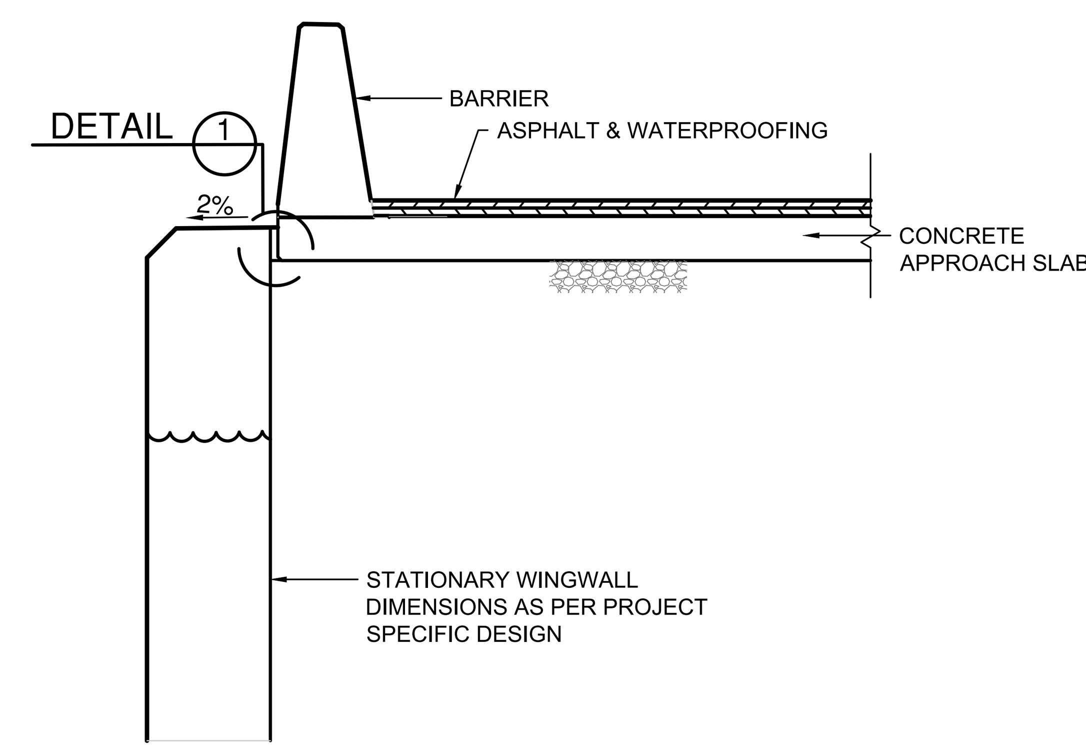
PLAN VIEW
SCALE NTS



ELEVATION
SCALE NTS



A -- SECTION
SCALE NTS



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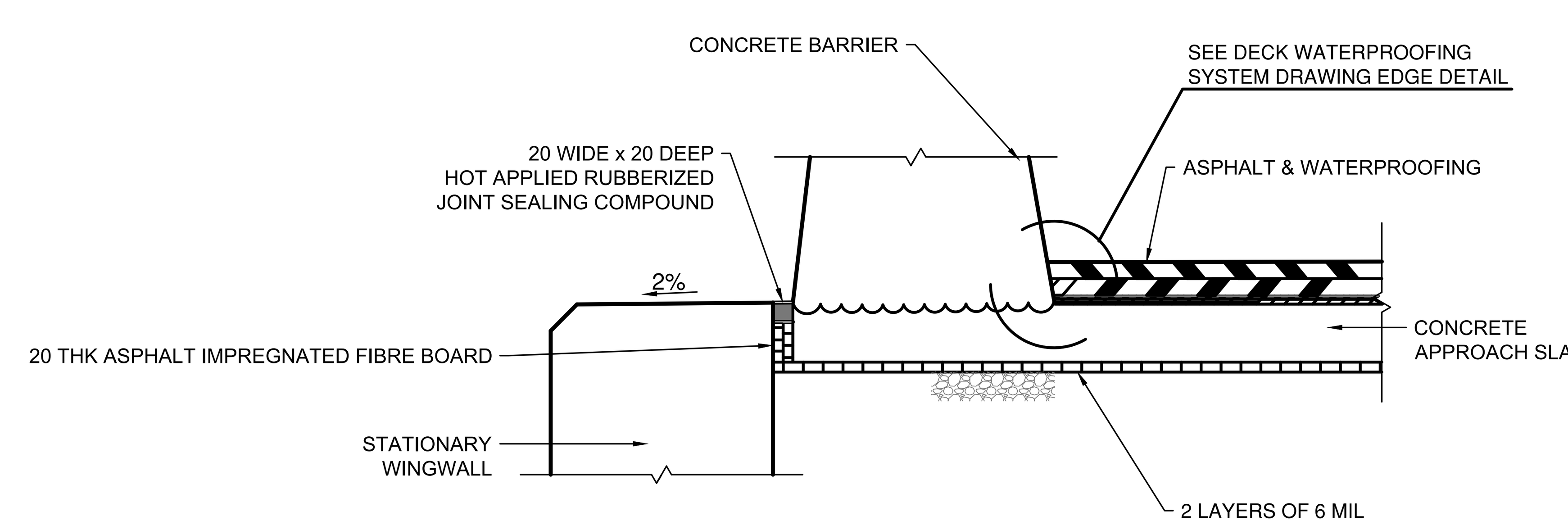


1 -- DETAIL
SCALE NTS

NOTES

1. DIMENSION AS PER PROJECT SPECIFIC DESIGN
2. DIAMETER AND SPACING OF REINFORCEMENT AS PER PROJECT SPECIFIC DESIGN
3. HOT APPLIED RUBBERIZED JOINT SEAL COMPOUND TO ACCOMMODATE STRUCTURE MOVEMENT

LEGEND

- 80mm TWO-COURSE HOT-MIX ASPHALTIC CONCRETE PAVEMENT
- 3.2mm PROTECTION BOARD
- 5mm ASPHALT MEMBRANE
- FIBRE BOARD

NAD 83
COORDINATES

ISSUED FOR REVIEW

NO.	DESCRIPTION	DATE (YYYY-MM-DD)	BY	APPD
A	ISSUED FOR REVIEW			

PERMIT

SEAL

	BY	DATE (YYYY-MM-DD)
DESIGNED		
DRAWN		
CHECKED		

SCALE

CONSULTANT'S LOGO

PROJECT

**THE CITY OF CALGARY
CONSTRUCTION DRAFTING STANDARDS
AND TEMPLATES**

SEC: -- - TWP: --- RGE: -- W -th M

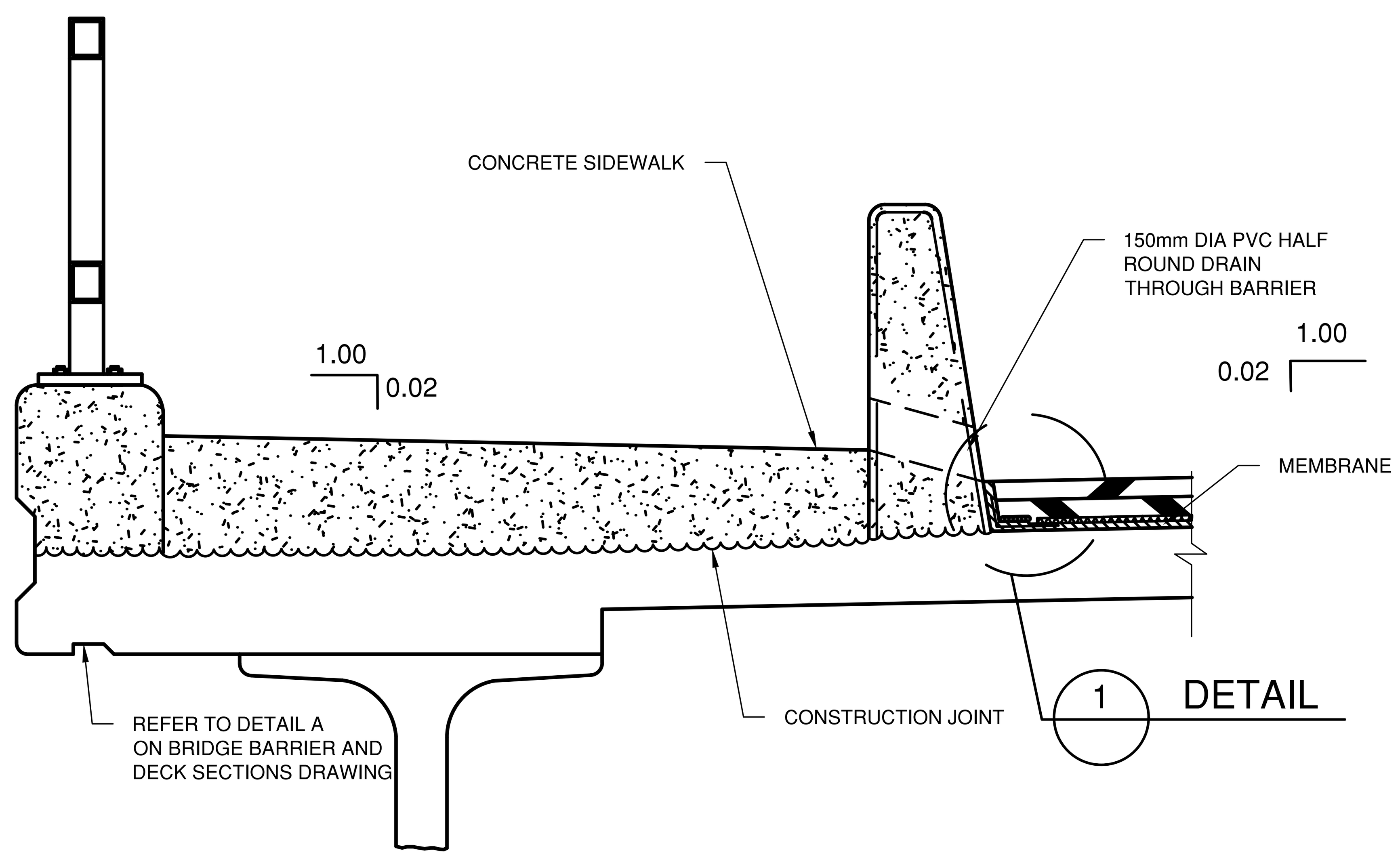
SHEET TITLE

**SEMI-INTEGRAL ABUTMENT WINGWALL
STANDARD SECTIONS AND DETAIL**

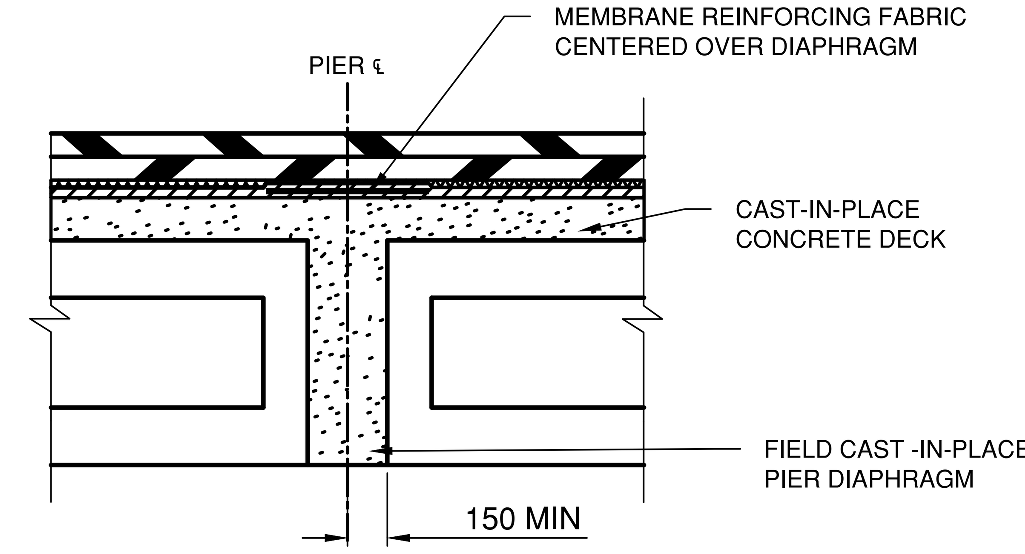
FILE NO.	ENG DWG NO.
--	--
SHEET ID.	SHEET COUNT
---	-- of --

SHEET SIZE ANSI D 25 mm 0

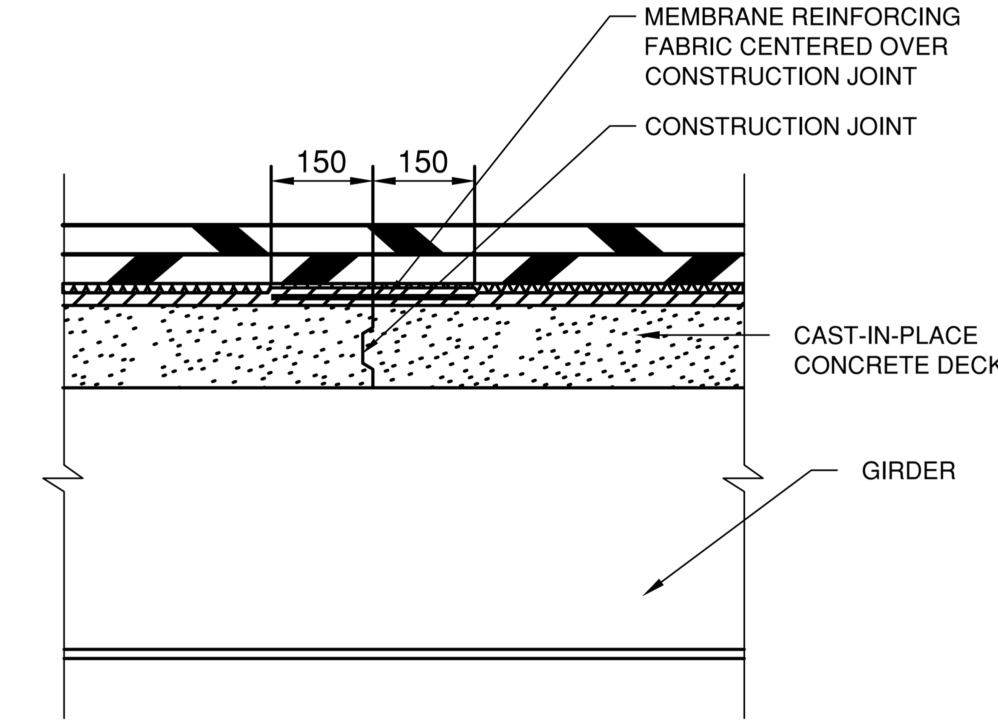
FILE: Z:\SPECIAL\2017_TI_SPECIALREQUESTS\02171539_TI_INTERNALSUPPORTSERVICES_2017\GEORGEVAYA\SEMI-INTEGRAL\SEMI-INTEGRAL_V1.DWG | DATE: Friday, January 04, 2019 6:44:13 AM | ISC: UNRESTRICTED



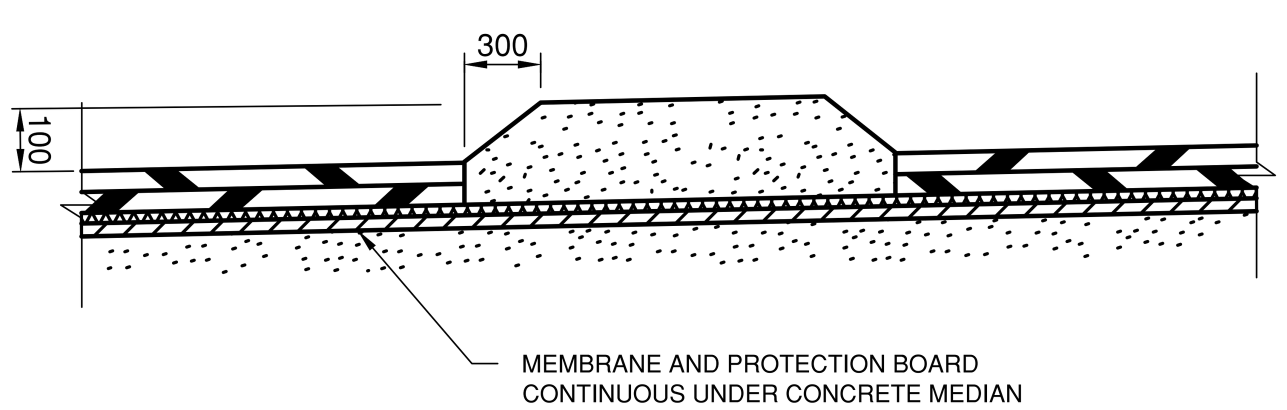
A SIDEWALK SECTION
SCALE NTS



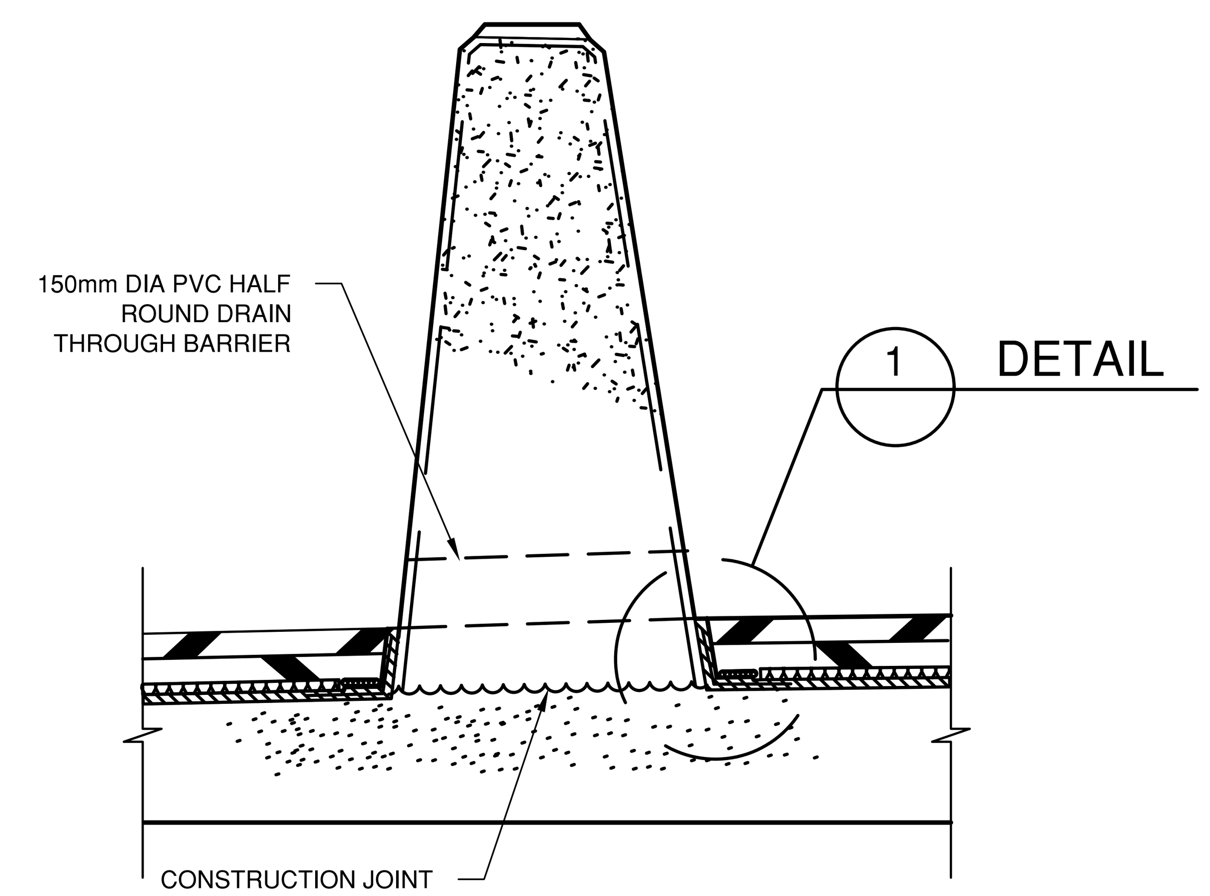
D CAST-IN-PLACE PIER DIAPHRAGMS PRECAST GIRDERS
SCALE NTS



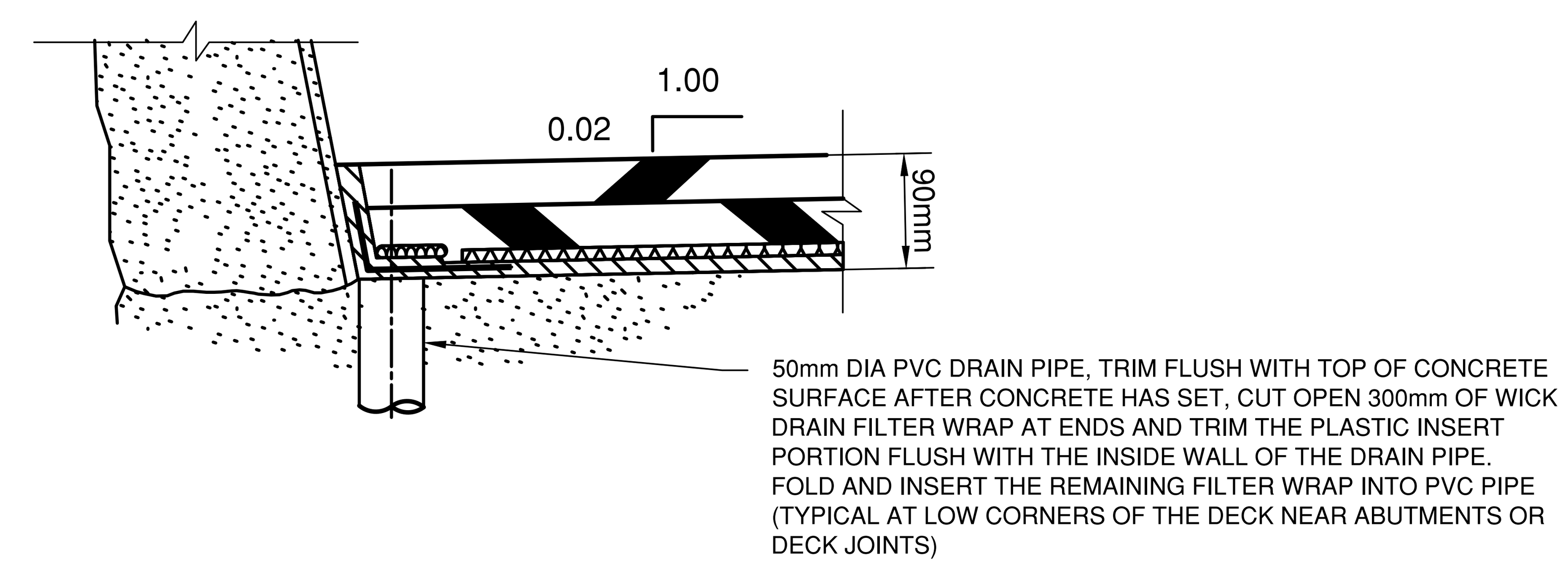
E CAST-IN-PLACE DECK CONSTRUCTION JOINTS SECTION
SCALE NTS



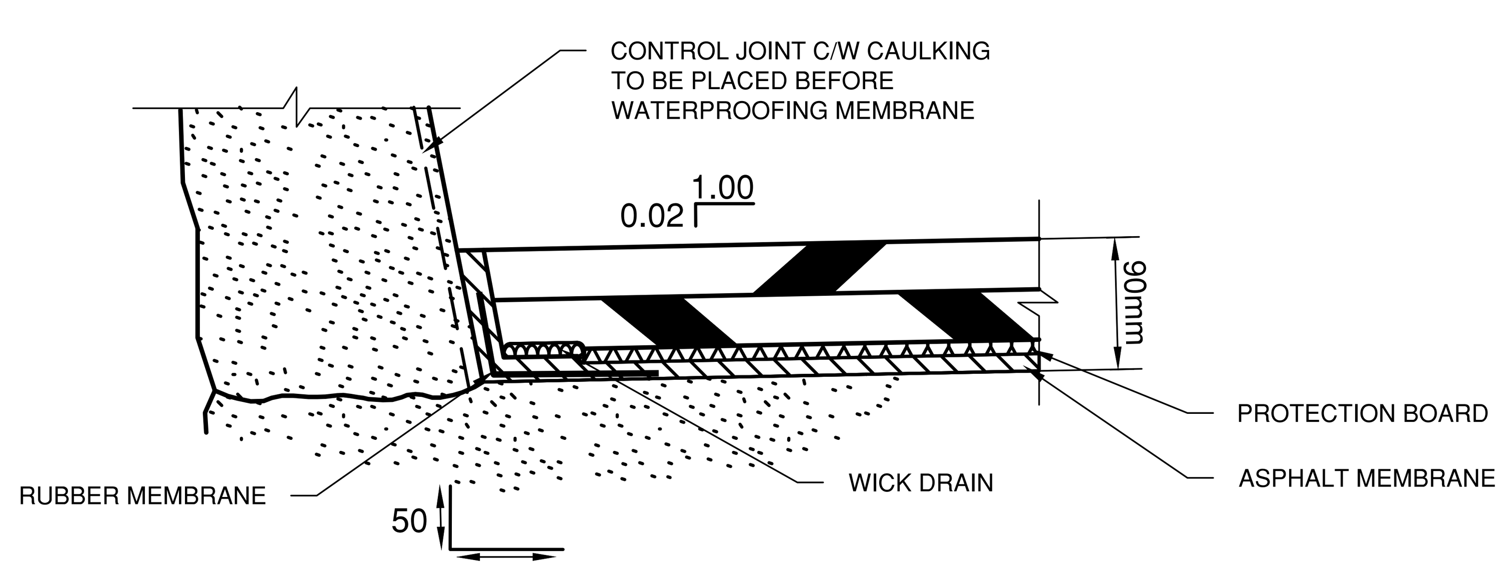
B MEDIAN ON DECK
SCALE NTS



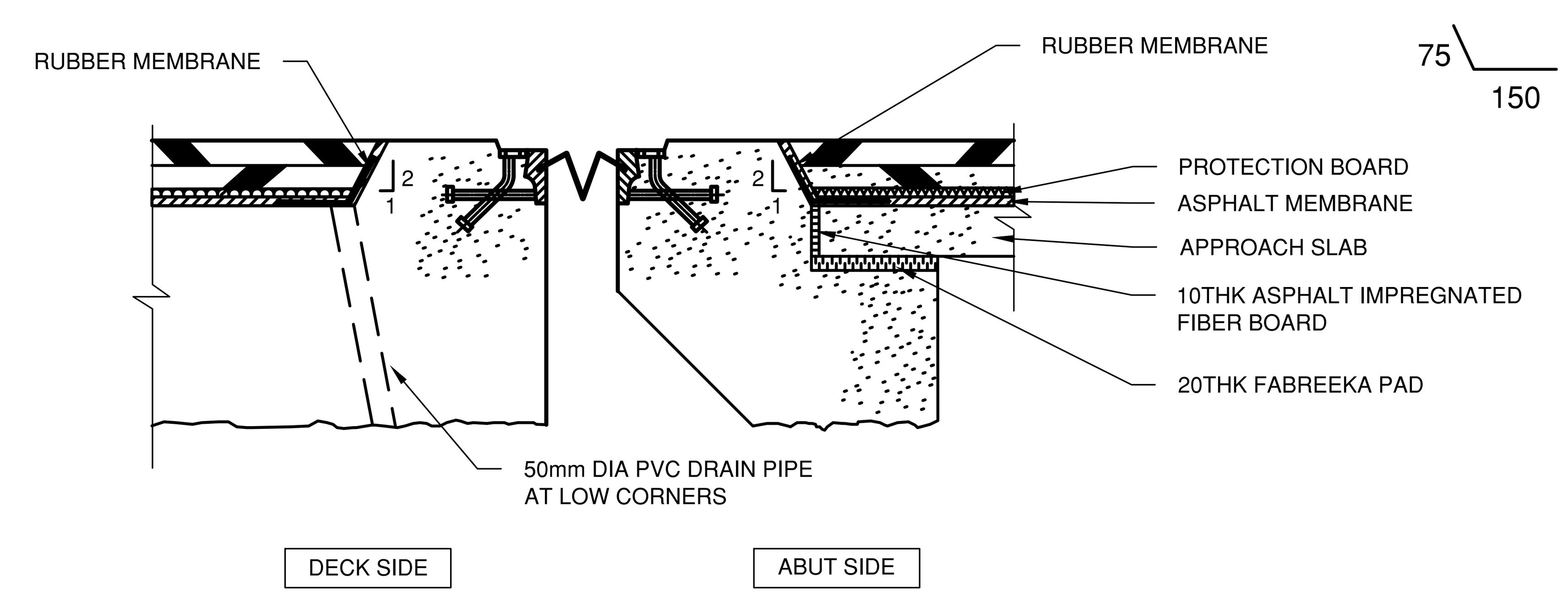
C BARRIER ON DECK
SCALE NTS



2 PVC DRAIN PIPE DETAIL
SCALE NTS



1 EDGE DETAIL
SCALE NTS



3 DETAIL AT DECK JOINTS
SCALE NTS

NOTES

1. DIMENSION AS PER PROJECT SPECIFIC DESIGN
2. BARRIER REINFORCEMENT INTO DECK SHALL BE AS PER PROJECT SPECIFIC DESIGN.

LEGEND

- 80mm TWO-COURSE HOT-MIX ASPHALTIC CONCRETE PAVEMENT
- 3.2mm PROTECTION BOARD
- 5mm ASPHALT MEMBRANE
- MEMBRANE REINFORCING FABRIC
- 1.2mm RUBBER MEMBRANE
- 3.6mm WICK DRAIN

ALBERTA ONECALL

NAD 83
COORDINATES

ISSUED FOR REVIEW

NO.	DESCRIPTION	DATE (YYYY-MM-DD)	BY	APPD
A	ISSUED FOR REVIEW			

PERMIT

SEAL

	BY	DATE (YYYY-MM-DD)
DESIGNED		
DRAWN		
CHECKED		

SCALE
AS SHOWN

CONSULTANT'S LOGO

PROJECT

THE CITY OF CALGARY
CONSTRUCTION DRAFTING STANDARDS AND TEMPLATES

SEC: -- - TWP: --- RGE: -- W -th M

SHEET TITLE

DECK WATERPROOFING SYSTEM
STANDARD SECTIONS AND DETAILS

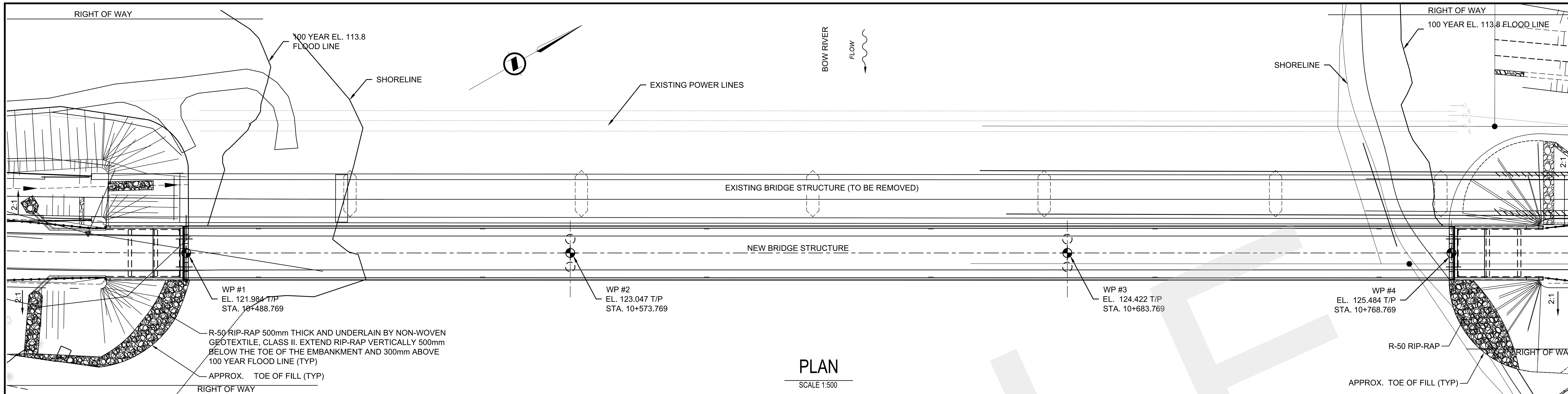
FILE NO.	ENG DWG NO.
--	--
SHEET ID.	SHEET COUNT
---	-- of --

SHEET SIZE ANSI D 25 mm 0

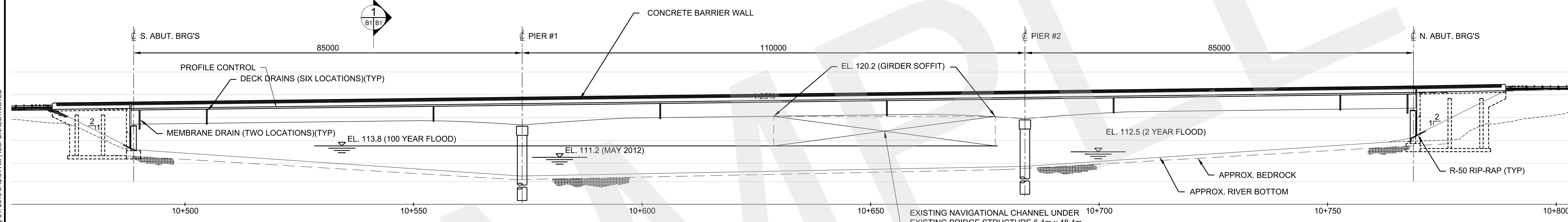
FILE: Z:\SPECIAL\2017_TI_SPECIALREQUESTS\02171539_TI_INTERNALSUPPORTSERVICES_2017\GEORGEVAYAL_BRIDGES\DECK_WATERPROOFING.DWG | DATE: Wednesday, March 13, 2019 7:28:33 AM | ISC: UNRESTRICTED

APPENDIX F – SAMPLE DRAWING

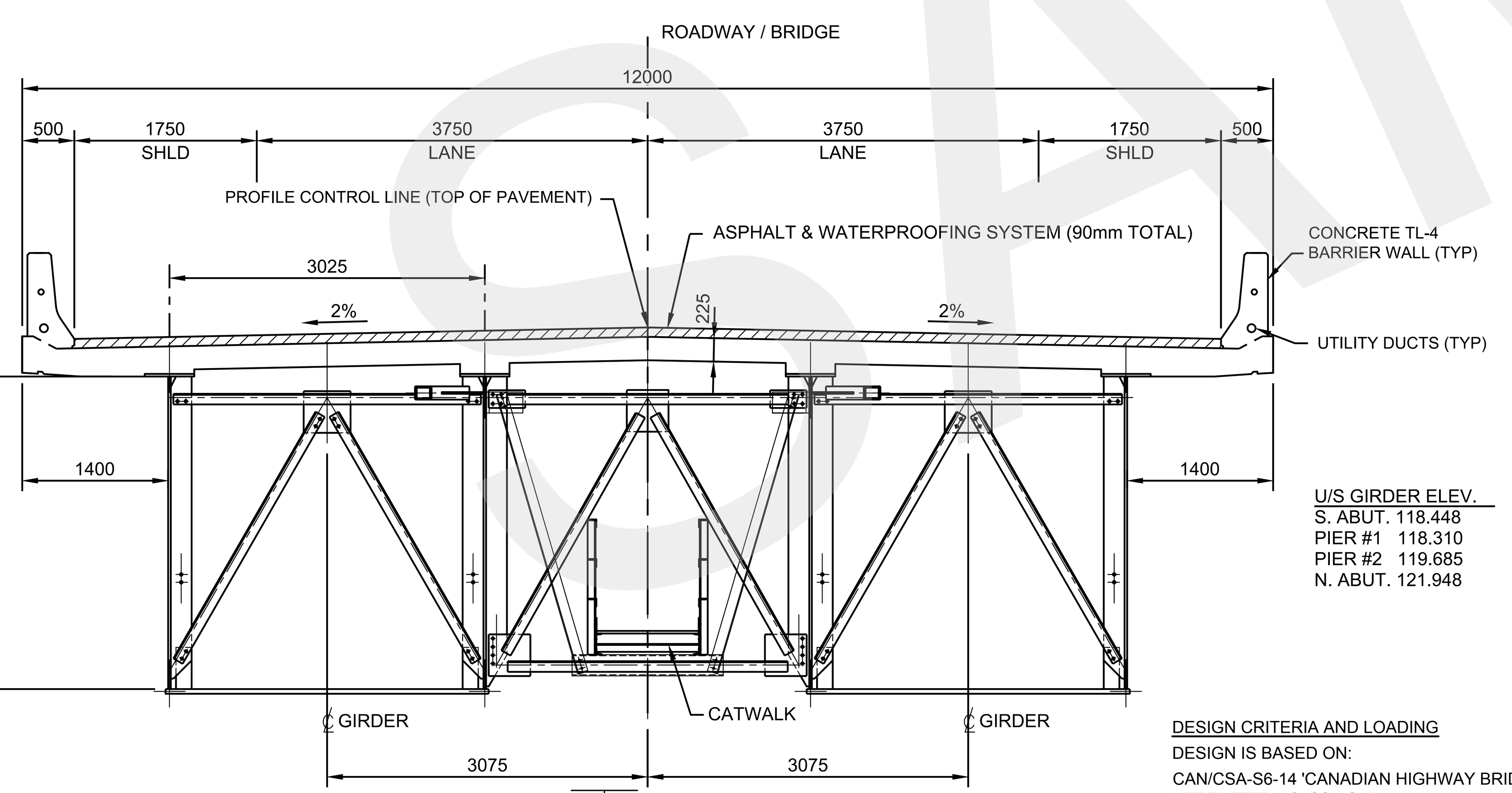
GENERAL ARRANGEMENT



PLAN
SCALE 1:500

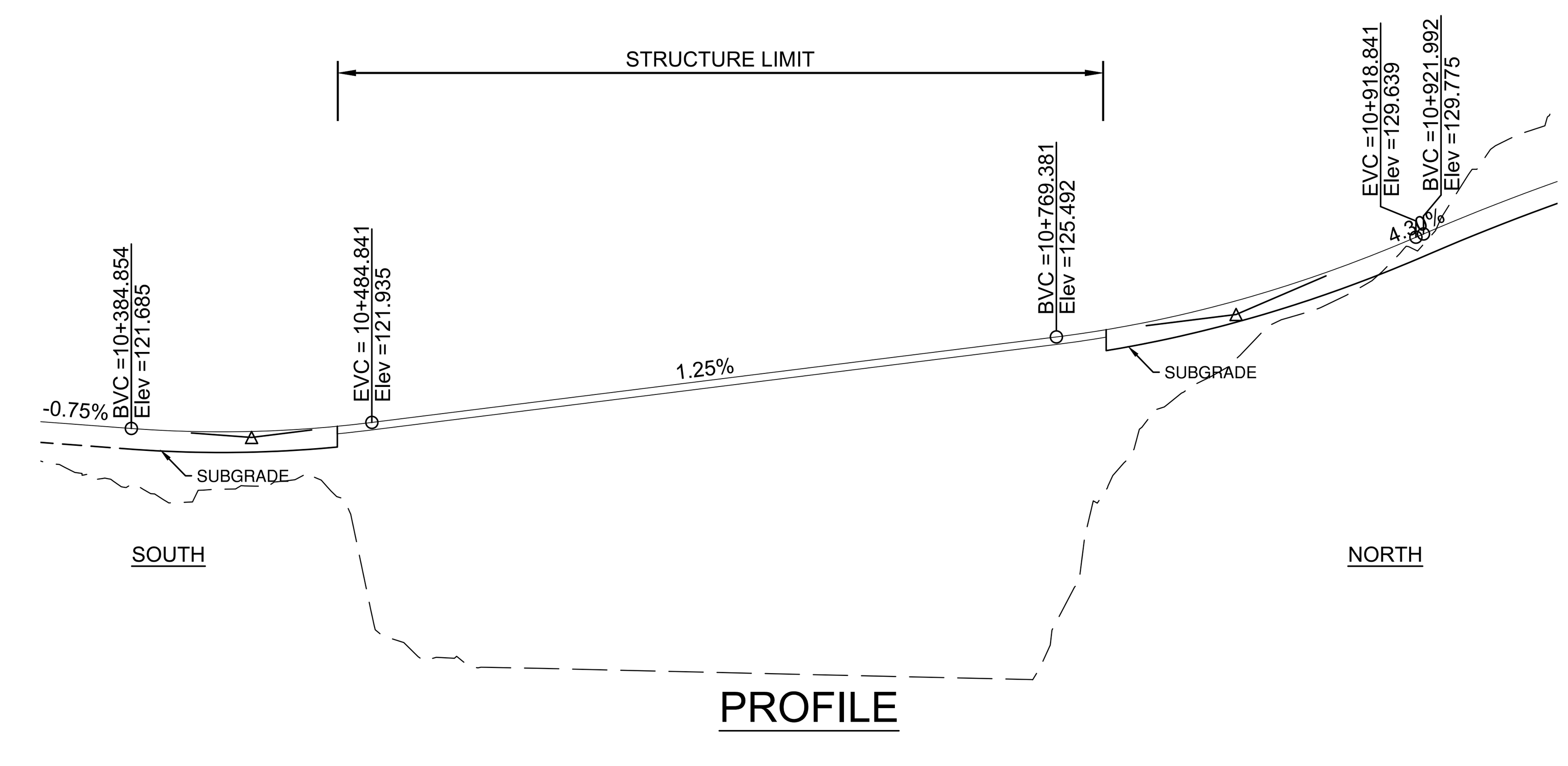


ELEVATION
SCALE 1:500



U/S GIRDER ELEV.
S. ABUT. 118.448
PIER #1 118.310
PIER #2 119.685
N. ABUT. 121.948

SECTION
SCALE 1:50



PROFILE

DESIGN CRITERIA AND LOADING

DESIGN IS BASED ON:

CAN/CSA-S6-14 'CANADIAN HIGHWAY BRIDGE DESIGN CODE' (REFERRED TO HEREAFTER AS 'CSA S6').

CITY OF CALGARY 'DESIGN GUIDELINES FOR BRIDGES AND STRUCTURES', SEVENTH EDITION, 2019

DESIGN LIVE LOAD IS CL-800 PLUS DYNAMIC LOAD ALLOWANCE PER CSA S6.

DESIGN TRUCKS: CL-800 PLUS DYNAMIC LOAD ALLOWANCE PER CSA S6 AND CITY OF CALGARY MAINTENANCE TRUCK (ASPEN UB50ER) WITH G.V.W. OF 62,985 kg (TWO AXLE LOADS OF 148 AND 131 kN WITH 6.48 m DISTANCE BETWEEN AXLES).

BARRIERS DESIGNED FOR PERFORMANCE LEVEL TL-4.

ASSUMED WEIGHT OF ABUTMENT BACKFILL = 21 kN/m³

MINIMUM AND MAXIMUM DAILY MEAN TEMPERATURES = -38 AND 28 °C

MINIMUM AND MAXIMUM EFFECTIVE TEMPERATURES = -33 AND 41 °C

LONGITUDINAL BRAKING FORCE = 385 kN

MEAN WIND PRESSURE FOR 100 YEAR RETURN PERIOD = 0.540 kPa

MEAN WIND PRESSURE FOR 10 YEAR RETURN PERIOD (DURING CONSTRUCTION) = 0.395 kPa

DESIGN HORIZONTAL WIND PRESSURE = 2.70 kPa

DESIGN VERTICAL WIND PRESSURE = 1.35 kPa

DESIGN ICE PRESSURE = 700 kPa

CONSIDERING A MAXIMUM ICE THICKNESS OF 500 mm APPLIED TO THE TOP OF THE BANK ELEVATION

WATER DESIGN SPEED (VELOCITY) = 1 m/s

DESIGNED FOR THE REQUIREMENTS OF SEISMIC PERFORMANCE ZONE 1 AND ZONAL ACCELERATION RATIO A=0.0. RESTRAINING ELEMENTS DESIGNED FOR MINIMUM 20% OF TRIBUTARY DEAD LOAD. MINIMUM SUPPORT LENGTHS PROVIDED IN ACCORDANCE WITH CLAUSE 4.4.10.5 OF CSA S6.

CONSTRUCTION LOADING

MAXIMUM FACTORED SCREED MACHINE TRAVELING WHEEL LOAD PER SIDE OF BRIDGE NOT TO EXCEED 20kN.

DECK FORMWORK DEAD LOAD: 0.72 kPa.

DECK LIVE LOAD: 3.0 kPa.

600mm CANTILEVER WALKWAY DEAD LOAD (ONE PER BOX GIRDER): 0.72 kPa.

600mm CANTILEVER WALKWAY LIVE LOAD (ONE PER BOX GIRDER): 2.4 kPa.

BENCHMARK

ALBERTA, HCM# 00819670351
ELEVATION: 122.151
STATION: 10+468.776
OFFSET = 5.513m LEFT
N: 5074141.523 E: 262525.924

REFERENCE DATA

SURVEYS CARRIED OUT BY:
SURVEY'S SPOT ON

SITE SEISMIC NOTES

LOCATION: CALGARY, ALBERTA
VELOCITY RELATED SEISMIC ZONE: Z_v = 1
ZONAL VELOCITY RATIO: V = 0.05
ACCELERATION - RELATED SEISMIC ZONE: Z_a = 0
ZONAL ACCELERATION RATIO: A = 0.00
SITE COEFFICIENT: S = 1.0 (TYPE 1 SOIL PROFILE) Si = 1.0
STRUCTURE IMPORTANCE CATEGORY: MAJOR ROUTE
SEISMIC PERFORMANCE ZONE: 1

NOTES

1. READ THESE GENERAL NOTES IN CONJUNCTION WITH THE PROJECT SPECIFICATIONS AND OTHER CONTRACT DOCUMENTS. THESE NOTES HIGHLIGHT ONLY A LIMITED SELECTION OF THE SPECIFIED REQUIREMENTS.
2. OBTAIN CLARIFICATION FROM THE ENGINEER IN THE EVENT THAT INFORMATION CONTAINED ELSEWHERE IN THE CONTRACT DOCUMENTS APPEARS TO CONFLICT WITH THESE GENERAL NOTES.
3. DO NOT SCALE DRAWINGS.

CONSTRUCTION NOTES

1. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE.
2. CHAINAGES AND ELEVATIONS ARE IN METRES.
3. RIVER BOTTOM AND BEDROCK ELEVATIONS AND OR PROFILE ARE APPROXIMATE. ELEVATIONS ARE EXTRACTED FROM THE BOREHOLE LOGS AND REFLECT THE ELEVATIONS AT THE BOREHOLES ONLY. CONFIRM RIVER BOTTOM AND BEDROCK ELEVATIONS FOR ALL CAISSONS AND FOOTINGS.
4. VERIFY ALL EXISTING CONDITIONS AND ALL DETAILS ON SITE AND IMMEDIATELY NOTIFY THE ENGINEER OF ALL DISCREPANCIES.
5. ESTABLISH THE BEARING SEAT ELEVATIONS BY DEDUCTING THE ACTUAL BEARING THICKNESSES FROM THE UNDERSIDE OF GIRDER ELEVATIONS. IF THE ACTUAL THICKNESSES ARE DIFFERENT FROM THOSE GIVEN WITH THE BEARING DESIGN DATA, ADJUST THE REINFORCING STEEL TO SUIT.
6. MAINTAIN FULL NAVIGATIONAL CLEARANCE THROUGHOUT CONSTRUCTION.
7. CHAMFER ALL EXPOSED CONCRETE EDGES 20 mm x 20 mm, UNLESS NOTED OTHERWISE.
8. ALL STATIONS, ELEVATIONS, EASTINGS, NORTHINGS AND OFFSETS ARE IN METRES (m OR M) U.N.O.
9. STATIONS, NORTHINGS AND EASTINGS ARE GIVEN IN GRID COORDINATES, ALL OTHER DIMENSIONS ARE 'GROUND' VALUES UNLESS NOTED OTHERWISE.
10. ELEVATIONS ARE REFERENCED TO GEODETIC SURVEY OF CANADA (GSC) DATUM (NAD 83 USING 3TM GRID PROJECTION).
11. ALL LENGTHS ARE SHOWN IN HORIZONTAL PLANE AND MEASURED AT 20°C.
12. SUBMIT STEEL SHOP DRAWINGS TO THE ENGINEER FOR REVIEW AT LEAST 28 CALENDAR DAYS PRIOR TO START OF FABRICATION. CONTRACTOR SHALL REVIEW AND STAMP EACH SHOP DRAWING PRIOR TO SUBMISSION TO THE ENGINEER AS PER THE STANDARD GENERAL CONDITIONS. DRAWINGS SUBMITTED WITHOUT THE CONTRACTOR'S REVIEW STAMP WILL NOT BE REVIEWED BY THE ENGINEER. ANY WORK EXECUTED BEFORE THE ENGINEER'S REVIEW OF ANY SHOP DRAWINGS WILL BE AT THE CONTRACTOR'S OWN RISK.
13. ENSURE THE STABILITY OF ALL COMPONENTS DURING HANDLING, TRANSPORTATION AND ERECTION AND UNTIL THE STRUCTURAL STEEL IS IN ITS FINAL LOCATION WITH ALL PERMANENT BRACING. CONNECTIONS AND SUPPORTS IN PLACE AND THE CONCRETE IN THE DECK HAS REACHED 75% OF ITS SPECIFIED STRENGTH.

LEGEND

WP DENOTES WORKING POINT
T/P* DENOTES THEORETICAL TOP OF PAVEMENT AT PROFILE CONTROL
U/S DENOTES UNDERSIDE
U/G DENOTES UNDERSIDE OF GIRDER
N.F. DENOTES NEAR FACE
F.F. DENOTES FAR FACE
E.F. DENOTES EACH FACE
E.W. DENOTES EACH WAY
N.S. DENOTES NEAR SIDE
F.S. DENOTES FAR SIDE

NAD 83
COORDINATES

ISSUED FOR REVIEW

NO.	DESCRIPTION	DATE (YYYY-MM-DD)	BY	APPD
A	ISSUED FOR REVIEW	2018-01-05	DEF	GHI

PERMIT

SEAL

	BY	DATE (YYYY-MM-DD)
DESIGNED	ABC	2018-01-05
DRAWN	DEF	2018-01-05
CHECKED	GHI	2018-01-05

SCALE
AS SHOWN

CONSULTANT'S LOGO

PROJECT

THE CITY OF CALGARY CONSTRUCTION DRAFTING STANDARDS AND TEMPLATES

SEC: -- - TWP- - RGE: - - W -th M

SHEET TITLE

GENERAL ARRANGEMENT

FILE NO. --
ENG DWG NO. --
SHEET ID. --
SHEET COUNT -- of --

SHEET SIZE ANSI D 25 mm 0