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300.0 CONSTRUCTION

300.1 INTRODUCTION

This Section covers the construction requirements applicable to roadways and bridge structures in the New Bypass Infrastructure.

300.2 CONSTRUCTION – GENERAL

Project Co's responsibility includes but is not limited to the supply of all management, professional and technical services, supervision services, construction quality control and quality assurance services, labour, materials, and equipment for performing all of the duties and obligations necessary for delivering all of the requirements of the Project. Project Co shall be responsible for obtaining and complying with requirements of all permits and other authorizations required for the construction of the New Bypass Infrastructure.

Project Co shall ensure that construction conforms to the requirements of the design. All construction is to reflect a high degree of workmanship and all materials incorporated into the New Bypass Infrastructure shall meet long-term safety, durability and functionality requirements.

Project Co shall be responsible for reclaiming all areas that have been disturbed during construction of the Project. All such work shall meet the Technical Requirements.

300.2.1 Site Office Requirements

300.2.1.1 General Requirements

Project Co shall provide 5,000 square feet of office space on the site (the "**Site Office**"), which desirably shall be co-located with Project Co's office space, for the Ministry's exclusive use during the carrying out of the Works and for an additional 12 months following Substantial Completion.

Project Co shall be responsible for maintenance and operational costs associated with the Site Office during the carrying out of the Works and for an additional 12 months following Substantial Completion.

The Site Office shall include the following:

- A partitioned heated space that has a walled separation and a lockable door between Project Co and Ministry personnel, including a separate entrance for each of Project Co and Ministry personnel;
- A finished and furnished office area with specific requirements to be agreed in consultation with the Ministry; and
- Internet, IT, and voice connectivity with specific requirements to be agreed in consultation with the Ministry.

300.2.1.2 Site Vehicles

Project Co shall provide two site vehicles for the Ministry's exclusive use during the carrying out of the Works.

The vehicles provided by Project Co shall be hybrid, half-ton, crew cab pick-up trucks that are to be stationed at the co-located offices of Project Co and the Ministry.

300.2.2 Traffic Management

Project Co shall take all necessary measures to safely and expeditiously accommodate traffic using the Provincial Highway within the Project Limits and using all roads open to the public and affected by the Construction Activities.

Requirements for the accommodation of traffic during construction and operation until the end of the Project Term are set out in Sections 100 (General), 200 (Design) and Section 401 (Operations and Maintenance).

If Project Co elects to truck haul materials over roads outside the Site Project Co shall be responsible for obtaining written approval from the Local Authority and the Ministry for use of proposed haul routes within their respective jurisdictions.

Construction Activities shall be carried out so as not to interfere unnecessarily with the convenience of the public in respect of and the access of the public to and use ofany public or private roads or footpaths or highways or other transportation infrastructure (other than the Bypass) whether under the control of the Ministry, Local Authority or any other person.

Project Co shall ensure that traffic on existing roadways and intersections continues to operate at the existing standards and level of service throughout the Construction Activities. Any Service Roads required to replace an existing access shall be completed and open to public traffic prior to removing existing access roads from service. Project Co shall be responsible for removal, and coordination of any required road removals and closures within the Project Limits with the Local Authority.

Project Co shall be responsible for maintaining all existing accesses whether vehicular or pedestrian on all roadways and for all properties affected by the Construction Activities until alternative access is provided. The extent of all detours shall be constructed entirely within the Project Limits.

Project Co shall submit detour plans showing geometry, traffic accommodation, signing, and a Temporary Traffic Accommodation On-Site Road Safety Audit, to the Ministry in accordance with Schedule 9 - Review Procedure. Project Co shall not implement any detour until it has had its proposal endorsed "Reviewed" or "Reviewed As Noted". Project Co shall advise the Local Authority at least 5 days before implementing any detour. Project Co shall also conduct an in-

service road safety audit of each detour immediately after opening to traffic, and implement any required modifications.

The City of Regina Dispatch System and Ministry's Highway Hot Line shall be integrated with Project Co's public communications process. Project Co shall contact these agencies as required, to provide timely traffic information, so the public has access to current and accurate information. Project Co may also establish protocols with the City of Regina to use their variable message board system if the City of Regina so agrees.

Project Co shall be responsible for ensuring flag persons, detour signage, barriers, markings, lighting, safety devices, and other appurtenances are installed and maintained for the duration that the detour is in use. Any existing overhead or ground-mount guide signs that display information contrary to the intended operation of the detours shall be covered up or removed for the duration that the detour is in place.

If Project Co's detour requires the alteration of traffic signals or traffic signal timing on signals owned by the Local Authority, Project Co shall coordinate any changes with the Local Authority, and shall hire the Local Authority to make the necessary signal revisions on signals owned by the Local Authority. In addition, Project Co shall confirm that the signal alteration will not result in a reduction of capacity during the a.m. and p.m. peak periods.

300.2.3 Demolition

Notwithstanding Section 16.2(a) of the Project Agreement Project Co shall, at its own cost and expense, demolish and dispose of all retaining walls, existing bridge structures and other structures as required within the Lands to complete the Project. Burial of the demolition materials within the Lands is not permitted except concrete materials that are less than 150 mm in any dimension and located at greater than 1 metre below the subgrade surface.

Project Co shall be responsible for demolition of existing bridge structures carrying Highway 11 over the Courtney Street near the proposed Bypass grade separation structure, and the existing service road bridge over Boggy Creek northeast of the new Highway11 interchange. Project Co shall obtain all required permits and provide copies to the Ministry at least 30 days in advance of demolition. All components of the demolished structure and substructure shall be removed to a minimum depth of 1 m below final grade. Project Co shall supply the Ministry with plans showing all bridge components left below grade, together with a description of the components, approximate dimensions and depths as extracted off "as-built" drawings, and surveyed coordinates. Where these components are within 20 m of any bridge that forms part of the New Bypass Infrastructure, they shall be identified and shown in the bridge set.

Project Co shall submit the following information in respect of a demolition to the Ministry:

- Proposed demolition sequence and schedule;
- Proposed disposal location;
- Construction limits;
- Demolition methods;

- Depth of removal;
- Traffic Accommodation Plan;
- Safety plan; and
- Protection measures for Existing Bypass Infrastructure and environment.

All removed asphalt, soil cement and concrete pavement is the property of Project Co. All operations necessary for the removal of any structures which might adversely impact the new construction shall be completed prior to the construction of the new work.

Project Co shall locate any abandoned Utilities which impact construction of the New Bypass Infrastructure. Project Co shall remove and/or decommission any such abandoned utilities in accordance with industry practice and in accordance with any Applicable Laws.

300.2.4 Railways

The construction of at-grade railway crossings shall, at a minimum, meet the requirements set out by Transport Canada in the *Grade Crossing Standards* and *Grade Crossing Regulations*, and the railway in the crossing agreement.

Flagging and Permits

All Railway Companies have indicated flagging protection will be provided for a maximum 8 hours per day, 40 hours per week, including travel. Project Co shall be required to match work schedules within the railway right of way to this schedule unless otherwise agreed to in writing with the Railway Company.

Project Co shall be responsible for coordination and payment of all documents and fee's related to railway flagging or railway work permits.

The Railway Company may allow Project Co provided flagging personnel to provide flagging protection during construction. Arrangements may be made with the individual railway at the time of construction. No additional payment will be made for Project Co provided railway flagging.

Notice of Works

Project Co shall submit a "Notice of Works" pursuant to section 8 of the *Railway Safety Act* prior to commencing construction.

Construction by Railways

It is anticipated that the lead time for design and procurement of crossing warning system equipment is least 12 months from the date of submission to, and approval of, the final crossing design drawings to the railway.

Approvals

Project Co shall obtain all necessary approvals, including payment of any fees, in accordance with and in addition to that established in the railway agreements. Such approvals include but are not limited to those required for construction activities on or adjacent to railway lines, construction of temporary at-grade crossings, temporary railway closures, and temporary clearance boxes used during construction.

Construction Staging and Inspection

Project Co shall coordinate all railway construction work with the railway and carefully stage the work so as to minimize impact to railway operations.

The railway, at their discretion, may conduct interim inspections of any portion of the Work within the railway right-of-way.

Acceptance By The Railway

Work completed within the railway right of way shall be subject to acceptance by the railway.

Detailed Safety Assessment

Project Co shall complete a detailed safety assessment as part of a Road Safety Audit and correct all deficiencies noted in the crossing safety assessment prior to opening the crossing to traffic.

Information Sharing

Project Co shall submit as part of the As-Built Roadway Construction Report, all information to be shared by the "Road Authority" listed in the *Grade Crossing Regulations* and as-built drawings containing information required on the at grade crossing design drawings in Section 200.

300.2.5 Road Closures

Project Co shall be responsible for the physical closure of existing roads at locations shown on drawings in the Reference Concept

Project Co shall be responsible for obtaining all permits and approvals for the physical road closures and removals, construction of the required turnarounds, installation of appropriate

signage, installation of barricades and disposal of all materials and restoration of the closed road to a natural landscaped area, including the restoration of drainage to its original lines. The roadway structure shall be obliterated in accordance with this Section then topsoiled and seeded in accordance with this Section.

Project Co shall be responsible for coordination of all removals and closures with the Ministry and Local Authority. Project Co shall apply to the Ministry for road closure permits a minimum three months prior to the planned date of the road closure. The Ministry will be responsible for obtaining legal road closure and Project Co shall cooperate with the Ministry in the supply of information for legal road closure.

Project Co shall not close any road until such time as permanent alternative access to affected properties is available and in full operation. Project Co shall also coordinate communications with the Ministry's Communications Branch.

Project Co shall construct turnarounds as shown in the Reference Concept and at locations shown on the drawings in Appendix A. When specified or shown on the drawings, turnarounds shall be designed and constructed to accommodate a WB-20 design vehicle.

300.2.6 Hours of Work / Work Restrictions

In general, construction work on the Project, including starting and running of equipment, shall be restricted to the period from ½ hour before sunrise to sunset (no work in the dark).

Project Co will be allowed to undertake construction work on defined areas of the Project between sunset and 1/2 hour before sunrise, provided the following conditions are met:

- Project Co shall submit to the Ministry for review in accordance with Schedule 9 – Review Procedure, a plan (or plans) showing physical limits of, and anticipated start and end dates for construction for, each defined area. Project Co shall not start construction in any defined area until the Ministry has returned the plan (or plans) marked "Reviewed" or "Reviewed As Noted".
- Project Co shall obtain Ministry approval to carry out Construction Activities overnight. Detours and construction operations shall have lighting designed to TAC guidelines for traffic lighting, with no hazards to traffic caused by construction lighting (specifically no glare from construction lighting, or contrast between bright and dark areas, in excess of TAC guidelines). All flag person stations shall be lit in accordance with Ministry practice.

Project Co may also be allowed to undertake short-term construction activities between sunset and 1/2 hour before sunrise, where traffic would be severely impacted otherwise, provided all of the conditions in this section have been met except those relating to noise. This could include:

- Overhead sign structure or traffic signal structure installation;
- Girder erection;

- Concrete pours for bridge construction; and
- Line painting.

Other "night" activities may be allowed with the prior written approval of the Ministry subject to the review and evaluation of the predicted levels of impact to surrounding residents.

Project Co shall not commence Construction Activities on the portion of north Service Road between Pilot Butte Access Road and Gravel Pit Road designated as After-Acquired Lands until such After-Acquired Lands have been acquired by the Ministry. Project Co shall construct and commission the Service Road pursuant to Schedule 16, Commissioning, within 12 months of receiving notice from the Ministry that it has acquired the After-Acquired Lands portion of the north Service Road between Pilot Butte Access Road and Gravel Pit Road.

300.2.7 Coordination with Local Authority

Project Co shall be responsible for coordinating all operations on crossroads, service roads, or other Local Authority roads, with the Local Authority during construction.

Refer to Section 200.5.9 of Schedule 15-2 –Design and Construction, for Local Authority contacts.

Project Co shall obtain and pay for any required permits from the Ministry and/or Local Authority for haul or any other operations outside the Project Limits. The following relevant documents are available for viewing in the Data Room:

- A briefing note that gives some background to the rates that the Local Authorities can charge haulers.
- Ministry's current haul road agreement template where the Local Authority maintains the road.
- An example of a haul road agreement where the Local Authority maintains the road.
- Ministry's current haul road agreement template where the hauler maintains the road.
- An example of a haul road agreement where the hauler maintains the road.
- "Detours and construction operations shall have lighting designed in accordance with Section 200.5.8.6 of Schedule 15-2 – Design and Construction, with no hazards to traffic caused by construction lighting.

300.2.8 Police, Fire and other Emergency Services

Police, fire and other emergency services for any area of the Bypass Infrastructure within the boundaries of a Local Authority will be provided by and under the jurisdiction of the Local Authority and obtained by 911 call.

Project Co shall take all such actions, or refrain from all such actions, as are necessary to enable the police, Local Authority, and others with statutory duties or functions in relation to the Infrastructure or adjoining roads to fulfil those duties and functions. Without limiting the generality of the foregoing, Project Co shall permit the police, Local Authority, and others with

statutory duties or functions in relation to the Infrastructure, to carry out "Check Stops" and speed enforcement activities.

For any follow-up response necessary as a direct result of the emergency, Project Co shall be responsible for all costs for such follow-up responses incurred as a direct result of the emergency including the placement and removal of barricades and timely removal of debris, which may be deposited on the Infrastructure.

300.2.9 Work By Other Forces

Project Co shall coordinate all construction activities with any work that may be undertaken by utility stakeholders or Local Authorities on their plants or facilities within the Project Limits or as permitted by the Ministry.

300.2.10 Environmental Requirements

In addition to the reports given in Section 200.6.13 of Schedule 15-2 – Design and Construction, Project Co shall carry out and fulfill all of the requirements in the table entitled "Mitigation Measures for All Valued Ecosystem Components to be performed by Project Co" (VECs) given in this Section 300.2.10 of Schedule 15-2 – Design and Construction. This table has been developed as a summary of the environmental protection requirements and includes but is not limited to the requirements in the Section 200 reports, with some additional requirements, information, or clarifications.

Project Co shall be responsible for all of the environmental protection requirements. Project Co shall incorporate the mitigation measures into the Integrated Management System (IMS) environmental section, as outlined in Schedule 14. The mitigation measures shall also be incorporated into the Project Environmental Protection Plan (EPP), which will form part of the IMS. Regular reporting by Project Co on the status of the VECs listed below shall commence from the date of Commercial Close of the Project Agreement and continuing as required by the IMS. The IMS environmental section reports shall detail, to a level satisfactory to the Ministry, acting reasonably, Project Co's progress as it relates to the mitigation measures.

Project Co shall be responsible for obtaining and complying with all environmental Permits Licences and Approvals , authorizations required by current provincial and federal legislation and regulation. Any reference to an environmental act or regulation within this section is for reference and information only and may not be the only citation applicable to comply with provincial environmental requirements.

Mitigation Measures for Valued Ecosystem Components ("VEC's") to be performed by Project Co

Valued Ecosystem Component (VEC)	Potential Project Effect	Mitigation Measures
Geology, Terrain & Geomorphology - Construction	Slope instability	• Project Co shall incorporate geotechnical data and recommendations into the detailed design phase and implement measures to address identified slope stability issues during construction and post-construction.
Soils - Construction	Soil erosion	• Temporary erosion control measures shall remain in place until vegetation is established. • Appropriate site-specific erosion and sediment control (ESC) measures shall be developed and implemented as part of Project Co's EPP. • Implement, maintain and monitor ESC measures to stabilize disturbed soils until sufficient vegetation is established. • Re-vegetate disturbed areas promptly following topsoil replacement using approved seed mixtures as defined by the *Saskatchewan Guidelines for Native Plants in Roadside Revegetation Pocket Manual* (MHI 2010) and *Seeding- Environmental Practice* (MHI 2013). • Soil erosion by wind and water shall be controlled. In controlling soil erosion, Project Co shall follow best management practices (BMPs) outlined in the *Erosion and Sediment Control Best Management Practices* (MHI, 2012). • Monitor for soil erosion on disturbed areas adjacent to Wascana Creek, other named and unnamed tributaries, and any conservation and development ditches and wetlands. • Soil stockpiles shall be stabilized to prevent erosion and sedimentation using appropriate methods. • Stockpiled soils shall be stabilized by hydro-seeding or another suitable method as soon as possible and no later than two months after stockpiling.

Valued Ecosystem Component (VEC)	Potential Project Effect	Mitigation Measures
		• Soil stockpiles shall be located away from watercourses and slopes. • Avoid soil handling during very windy and/or rainy conditions. Cease soil handling if wind or rain erosion occurs.
		• Monitor and document re-vegetation progress within the Project Limits. Re-vegetate areas with insufficient cover to prevent erosion.
	Admixing of soil and other types of soil quality degradation	• Ensure topsoil is salvaged, stored and replaced appropriately during construction. • Follow standard BMPs for topsoil stripping and replacement consistent with *Saskatchewan Ministry of Highways Topsoil Removal and Replacement Policy* ("CM_302", "DM_726-1", "Standard Plan No. 22023") Develop appropriate site-specific topsoil management measures as part of Project Co's EPP. • Topsoil from landscape borrow areas shall be stockpiled separately and placed back in the same area to ensure better or equal soil quality. Landscape borrow areas on privately owned agricultural land shall be restored to previous land use, or to a new land use as per land owner agreement. • Project Co shall monitor soil handling activities during construction, including soil salvage, storage, and replacement. The thickness of the replaced topsoil shall be equivalent to pre-disturbance conditions and adequate to support plant growth.
	Soil rutting and compaction	• Monitor soil conditions and suspend soil handling and topsoil replacement under wet conditions as appropriate to prevent rutting or compaction. • Using appropriate equipment, subsoil and/or rip compacted soils as needed to alleviate compaction prior to site reclamation. (Note: subsoiling is only effective when the soil is dry enough to break into distinct clods, because subsoiling of wet soils can deform and alter soil structure). • Following topsoil replacement, fine topsoils shall be disked to reduce compaction.

Valued Ecosystem Component (VEC)	Potential Project Effect	Mitigation Measures
		• Stockpile excavated soil and soils salvaged for reclamation purposes in a manner to minimize surface water ponding and maintain surface water drainage. • Re-grade disturbed areas to restore/maintain pre-development drainage patterns.
	Salt leachate impacts	• Develop appropriate site-specific salt management measures as part of Project Co's EPP. Utilize the Ministry's *Salt Management Plan* (2005) and Environment Canada's *Salt Management Guidelines* (2004) as guiding documents. • Store salt impacted fill material in a suitable location and away from natural drainage courses. • Following the removal of the temporary salt impacted stockpile: ▪ Impacted topsoil shall be removed and disposed of at an approved landfill; ▪ Clay samples from the top 450 mm of soil located under and immediately surrounding the stockpile shall be collected and analyzed for salinity parameters; and ▪ Impacted clay materials shall be placed in an overpass embankment. • Project Co shall take baseline salinity measurements of soils in the vicinity of salt storage areas so future measurements can determine any effects of the salt storage on adjacent lands.
	Soil contamination caused by construction activities	• Follow measures, practices, and procedures outlined in the *Spill Management- Environmental Practice* (MHI, 2013). • The EPP shall include measures to prevent spills of hydrocarbons and other fluids and to mitigate effects if a spill occurs. • Implement mitigation measures as described under 'Hydrology – Contaminant Release'. • Excess paving and concrete material shall be recycled when possible or disposed of appropriately.
	Increased surface stones	• Gravelly soils shall be managed separately from non-stony soils.

Valued Ecosystem Component (VEC)	Potential Project Effect	Mitigation Measures
		• Pick stones following topsoil replacement, as needed (up to two years after construction completion) to ensure that the stone content in reclaimed soils is similar to the pre-development conditions.
	Wetland topsoil salvage	• Salvage and stockpile topsoil from any wetlands that will be disturbed. Wetlands soils shall not be mixed with non-wetland soils. Wetland soils shall be used for compensation wetlands, as appropriate.
Soils - Operations	Salt impacts related to seasonal de-icing	• Coordinate the environmental aspects of the EPP with those found in Schedule 15-3 – OM&R and Handback, Section 401.8.4 (Salt Management Plan) • Utilise the TAC *Best Practices for Road Salt Management* (2013) to minimize effects on soils adjacent to roadways. • Refer to items above in the construction section.
	Salt impacts related to leaching from fill material	• Design drainage systems to minimize effects of salt leaching or runoff on native plants and agricultural land.
Vegetation **Native, Riparian and Rare Plant Communities - Construction**	Vegetation clearing	• Follow the measures, procedures, and practices outlined in Section 200-Specification for Clearing and Grubbing (MHI 2011) for all clearing and grubbing activities. • Project Co shall undertake their own detailed rare plant species investigations on affected lands within the Project Limits, and follow recommendations therefrom. The location of any identified rare or other plants of conservation concern shall be marked and either avoided or relocated to suitable habitat outside areas to be disturbed. • Avoid disturbance of native plant communities wherever feasible and adjust clearing limits as necessary to minimize effects on native plants. • Clearly mark clearing limits with snow-fence or highly visible flagging and do not clear outside the limits. • Trees shall not be allowed to fall into a water body. • No equipment is allowed to cross any water body during clearing operations.

Valued Ecosystem Component (VEC)	Potential Project Effect	Mitigation Measures
		• Prohibit equipment storage, maintenance and refuelling in areas that support native plant communities. • Only hand clearing is allowed within 30 m of a water body.
		• Retain an undisturbed vegetation buffer between the construction site and watercourse to reduce the potential for sedimentation. The buffer shall be of a sufficient width so as to filter sediment and maintain riparian function. • Re-vegetate disturbed areas as soon after construction as practicable. • Implement reclamation BMPs for soil handling and replacement, erosion control, and re-vegetation. • Apply suitable seed mixes to re-vegetate disturbed areas. • Native species shall be used for re-vegetation, including roadsides. Utilise Native Plant Society of Saskatchewan's (NPSS) *Guidelines for Use of Native Plants in Roadside Re-vegetation* (2008). • Restoration of areas draining to wetlands shall consider wetland function, utilizing native plants where feasible. • Monitor re-vegetation success within the Project Limits and undertake remedial measures as appropriate.
	Loss of rare plant communities	• The EPP shall include measures to avoid or minimize effects on rare plants. • All rare and tracked plant species referred to in the Environmental Assessment reports shall have site coordinates recorded, and locations marked prior to clearing. • Any S1 and S2 (Saskatchewan) plant species that are impacted by construction shall not be destroyed. S1 and S2 plant species are to be transplanted to a suitable location. Transplants shall be monitored regularly for survival and replaced if survival rates specified in the EPP are not met.

Valued Ecosystem Component (VEC)	Potential Project Effect	Mitigation Measures
		• Avoid or minimize effects on wetlands to protect wetland vegetation communities. Follow mitigation measures under "Wetlands – Construction."
	Dust effects on vegetation	• Avoid excessive migration of airborne dust onto natural areas or agricultural land by following mitigation measures under "Air quality – Construction."
	Road salt	• Coordinate the environmental aspects of the EPP with those found in Schedule 15-3 – OM&R and Handback, Section 401.8.4 (Salt Management Plan). • Utilise the most recent version of Ministry's Salt Management Plan and TAC *Best Practices for Road Salt Management*.
	Weeds control	• Programs and procedures to control weeds within the Project Limits during the Construction Activities and the OM&R Limits during the Operational Term shall be developed in the EPP for prohibited, noxious and nuisance weeds. • All equipment and materials shall be cleaned to be free of dirt, mud, weeds and weed seeds prior to entering the project site. Project Co shall check for, and physically remove, obvious accumulations of weeds and other types of vegetation from their equipment prior to moving onto the Project. • Soils salvaged from any areas that are currently infested with weeds shall be managed to prevent the spread of weeds during site re-vegetation. • Reclaim disturbed areas with appropriate species immediately following construction to minimize potential for colonization by weeds. • Monitoring for and control noxious and other weeds using appropriate methods on an ongoing basis, during the Project Term.
Vegetation **Native, Riparian and Rare Plant Communities - Operation**	Weed control	• Weed control measures shall be addressed in the EPP and may include but are not limited to one or a combination of mowing at appropriate intervals prior to seed dispersal, targeted herbicide application, handpicking, tillage and remedial seeding as appropriate.

Valued Ecosystem Component (VEC)	Potential Project Effect	Mitigation Measures
Wetlands - Construction	Decrease in wetland habitat and wetland function	• The detailed design shall avoid or minimize direct impacts on wetlands wherever feasible. • The detailed design shall include measures to minimize indirect effects on wetlands, including but not limited to drainage, erosion and sedimentation, and restoration of native vegetation.
		• Develop a Wetland Compensation Plan (the "**Wetland Compensation Plan**") to address compensation for wetland loss, as specified in the *Wetland Mitigation Policy: Operational Guidelines* (SMOE, 2013). • Where wetland loss is unavoidable, loss of habitat shall be mitigated through wetland compensation on a one-to-one basis by area. • The Wetland Compensation Plan shall be designed to achieve no net loss of wetland function regionally in accordance with the requirements and objectives of the Environmental Management and Protection Act (2002) confirmed with SMOE. • If suitable wetland compensation sites cannot be identified in the immediate project area, liaise with SMOE and municipal authorities to identify alternative potential wetland compensation sites. • The Wetland Compensation Plan shall consider the Project drainage requirements and be developed in coordination with the detailed drainage design. • Clearly mark clearing limits before construction and avoid incursions into wetlands and riparian areas.
	Alteration of hydrological regime	• Work affecting wetlands shall be conducted during low or no flow conditions. If flowing water is present at the time of construction, the construction site shall be effectively isolated from flows using coffer dams or other measures and pumping stations or a diversion channel to maintain downstream flows. Measures shall be put in place to prevent soil erosion at the site.

Valued Ecosystem Component (VEC)	Potential Project Effect	Mitigation Measures
Wetlands - Operations	General	• Impacted wetlands and any wetland compensation works shall be monitored by Project Co for two years following all construction completion to assess the amount of permanent wetland loss requiring compensation, and to assess changes to wetland functional integrity.
Wildlife - Construction	Habitat loss	• Clearly mark clearing limits. • Ensure compliance with the *Migratory Bird Convention Act* (1994), the *Species at Risk Act* (2002) and *The Wildlife Act* (2007). Complete pre-construction surveys as required to comply with these and any other applicable wildlife legislation. • If Burrowing Owl and/or Northern Leopard Frog presence is confirmed before clearing, SMOE shall be contacted immediately.
		• Vegetation clearing shall not occur between April 15 and August 20 of any given year to avoid the breeding season for migratory birds and prevent disturbance to breeding amphibians unless permission has been given to Project Co to do so by a Professional Biologist upon the results of relevant surveys. • The dens of specified animal species are protected under the *Wildlife Act* (Saskatchewan). The nests of migratory birds are protected under the *Federal Migratory Birds Convention Act*. If a den site or bird nest is found at any time during land clearing or construction, SMOE shall be contacted to determine the appropriate course of action before any work can proceed. Avoidance or mitigation measures may be required to ensure compliance with applicable legislation. • Implement mitigation measures as described under 'Vegetation – Clearing' and 'Wetlands – Decrease in Wetland Habitat'. • Review Regina International Airport's flora and fauna management program to determine if there are any restrictions on storm water pond or wetland construction in the airport vicinity. • To mitigate the loss of Northern Leopard Frog (a special concern species), Project Co shall:

Valued Ecosystem Component (VEC)	Potential Project Effect	Mitigation Measures
		▪ Confirm areas to be cleared and complete pre-construction surveys; ▪ Consult with SMOE to confirm status of Northern Leopard Frog and specific protection and management requirements; and ▪ Adhere to SMOE's development setback distance guidelines for Northern Leopard Frog. • To mitigate for the loss of Burrowing Owl (an endangered species) and Yellow Rail (a special concern species), Project Co shall carry out the following: ▪ Do not clear vegetation in the period of April 15 to August 30; ▪ Clearly mark clearing limits prior to clearing;
		▪ Use native species to re-vegetate catchment draining to wetlands/riparian areas; ▪ Consult with SMOE to confirm status of Burrowing Owl and Yellow Rail mitigation requirements; ▪ Adhere to SMOE's development setback distance guidelines for Burrowing Owl and Yellow Rail; and ▪ If Burrowing Owl nests are observed near the project area the Operation Burrowing Owl (OBO) Coordinator (obo@naturesask.ca) shall be notified.
	Decreased habitat effectiveness	• Implement mitigation measures as described above under 'Air Quality - Dust' to prevent impacts to adjacent breeding and foraging habitat. • Vegetation clearing in natural areas shall occur prior to 15 April or after 20 August to avoid the nesting and breeding season for migratory birds. • Project Co shall comply with the mitigation measures for noise as identified in the VEC category "Noise - Construction" below.
	Mortality risk and wildlife stress	• Vegetation clearing shall not occur between April 15 and August 20 of any given year unless permission has been given to Project Co to do so by a Professional Biologist upon the results of relevant surveys.

Valued Ecosystem Component (VEC)	Potential Project Effect	Mitigation Measures
		• Pre-construction surveys of natural habitat areas shall be conducted to identify areas for construction deferrals during sensitive periods such as the migratory bird nesting period. • If a den site, occupied bird or raptor nest, or injured wildlife is found at any time during land clearing or construction, work shall be halted in the immediate area and SMOE shall be contacted before proceeding further. • The harassment of wildlife during construction is prohibited. • Construction waste (including food waste) shall be managed to prevent wildlife interaction.
Wildlife - Operations	Mortality risk	• Any shrubs planted as part of site restoration shall be placed in accordance with the EPP.
Hydrology - Construction	Contaminant release	• Follow measures, practices, and procedures outlined in the *Spill Management- Environmental Practice* (MHI, 2013) • Spill management procedures ("SMP") shall be included in the EPP. The procedures shall describe measures for spill prevention and emergency spill response including but not limited to spill prevention, control, clean-up, and response measures. • Provide appropriate measures for spill containment in fuel storage and servicing areas and include these measures in the SMP. • Train all personnel working on the Project regarding spill response and ensure appropriate spill kits are available near work areas. • Refuelling, maintenance and hazardous materials storage shall not be permitted near any water body or in areas supporting native plant communities. • Spills shall be reported by calling the 24 hour spill response line at 1-800-667-7525 and the reporting requirements for a discharge or spill shall adhere to the requirements specified by SMOE.
	Sedimentation	• Surface stability shall be promoted by leaving vegetation undisturbed in areas not required for construction.

Valued Ecosystem Component (VEC)	Potential Project Effect	Mitigation Measures
		• Implement mitigation as described above under 'Soil – Soil Erosion'. • Follow applicable mitigation measures under "Fisheries & Aquatic Resources – Construction."
	Alteration of drainage patterns	• Maintain existing hydrologic connections. • Employ measures identified under the "Wetland - Alteration of hydrological regime" section. • Obtain approvals as required from the Saskatchewan Water Security Agency for alteration to natural drainage patterns in areas outside of the Project Limits. • Stream banks shall be protected from erosion as required.
		• Ensure the free passage of water in natural channels and ditches during construction, especially as a result of a storm event.
	Interaction of drainage management with existing Municipality storm water systems	• Communicate with all affected Local Authorities, to confirm design compatibility of all drainage infrastructure.
Hydrology - Operations	Bridge deck runoff	• Run-off from roads and bridge decks shall be designed to prevent erosion and sedimentation of watercourses and wetlands."
Groundwater - Construction	Impacts to groundwater levels due to dewatering activities	• Identify all water supply wells and natural springs within 100 m of the Project Limits. Visibly mark and/or fence off any identified well and spring locations. Record water levels for future reference. • Avoid direct or indirect disturbance of any water supply wells during construction; if other water supply wells or other such features are encountered during construction, limit heavy equipment use and disturbance in proximity to the water supply wells, or other such features to the extent practicable and install appropriate engineering controls to maintain the owner's ability to use the well and to protect water quality.

Valued Ecosystem Component (VEC)	Potential Project Effect	Mitigation Measures
		• If site isolation and dewatering is required, groundwater being discharged to the surface watercourse shall be of equal or better quality (with the exception of total dissolved solids) than that of the water in the watercourse it is being returned to. Monitoring shall be undertaken to ensure that water quality is maintained. • Any borrow areas that penetrate ground water shall be fenced.
	Seepage from cuts	• During detailed design, develop measures to manage potential seepage, such as blanket drains and French drains.
	Contaminated groundwater	• Implement mitigation measures as described above under 'Hydrology – Contaminant Release'. • Project Co shall develop mitigation strategies to ensure the proper management of contaminated soils and/or groundwater, where present.
Groundwater - Operations	Changes to local shallow groundwater flow regime	• Implement appropriate engineering controls such as drains to maintain natural shallow groundwater flow patterns. • Design, locate and construct drainage management facilities so as to maintain surface drainage patterns.
	Changes to groundwater quality	• Implement mitigation measures as found in Schedule 15-3 – OM&R and Handback, Section 401.8.4 (Salt Management Plan) • Implement mitigation measures as described under 'Hydrology – Contaminant Release'. • Implement mitigation measures as described under 'Soils – Soil Erosion' to prevent sedimentation.
Water Quality - Construction	Runoff and sediment transport	• Implement mitigations as described above under 'Hydrology – Sedimentation', and 'Soil – Soil Erosion'. • The EPP shall detail procedures for water quality monitoring during construction, including applicable water quality guidelines and procedures if guidelines are not met.
	Release of contaminants	• Implement mitigation measures as described above under 'Hydrology – Contaminant Release'.

Valued Ecosystem Component (VEC)	Potential Project Effect	Mitigation Measures
		• The Spill Management Procedure shall include detailed responses for each water body located within the Project Limits or downstream form the Project. • Excess paving, concrete, or other construction materials shall be removed from the site and disposed of in an approved facility. Temporary storage areas for such waste, if necessary, shall be stored at least 30 m from waterbodies and 60 m from wells.
Water Quality - Operations	Release of contaminants	• Implement mitigation measures as described above under 'Hydrology Construction – Contaminant Release'. • BMPs shall be used to minimize the chance of spills as well as their potential effect. • All spills (unauthorized discharges of pollutants) shall be reported to the SMOE.
Fisheries and Aquatic Resources - Construction	Sediment release due to erosion	• Implement mitigations as described above under 'Hydrology – Sedimentation' and 'Soil – Soil Erosion' and in accordance with *Erosion and Sediment Control Best Management* (MHI, 2012). • Monitor surface water quality as appropriate for construction activities near water. Establish procedures to be followed if adverse effects on water quality are detected. • Ensure sediment laden water in coffer dams sufficiently settles prior to pumping water back into the watercourse. • Minimize the duration of in-stream work. • In-stream and riparian zone construction should be halted during heavy rains.
	Fish passage at stream crossings	• Fish-bearing watercourse crossings shall be designed to allow for fish passage. • The EPP shall include detailed procedures for stream crossings. Procedures shall meet all Provincial and Federal requirements. Project Co shall be responsible for securing all regulatory permits and authorizations for stream crossings.

Valued Ecosystem Component (VEC)	Potential Project Effect	Mitigation Measures
	Loss of Aquatic and Riparian Habitat	• All approvals and permits (e.g., *Aquatic Habitat Protection Permit, Fisheries Act Authorization*) related to water body crossings or work near water bodies shall be obtained prior to undertaking work in aquatic habitats. • Detailed design and construction procedures shall consider the guidelines in Fisheries and Oceans Canada (2013) Measures to Avoid Causing Harm to Fish and Fish Habitat. • BMPs outlined in Fish Habitat Protection Guidelines, Road Construction and Stream Crossings (SMOE and DFO, 1995) shall be employed.
	Fish mortality during in-stream and near-stream construction	• Prior to construction activities, fish in any areas where stranding may occur or in areas directly impacted by construction activities shall be rescued and released to an area containing sufficient flow and cover.
		• A qualified professional shall be retained to conduct fish salvage in all fish bearing waters prior to any instream work. Fish collection permits shall be obtained from SMOE prior to the fish salvages. All fish salvage methods, timing and techniques shall be reviewed and approved by DFO, SMOE and/or Water Security Agency. • Reports shall be prepared that document all fish salvage operations, including measures taken to attain compliance with applicable regulations. • Ensure that all rescue operations employing effective methods (e.g. electrofishing, seine netting, minnow trapping) are carried out as stipulated in the approvals.
	Damage to channels, banks, and riparian areas	• Disturbance of riparian vegetation shall be kept to a minimum. • During construction and until re-vegetation is sufficient to prevent sediment erosion, effective sediment and erosion control measures shall be in place, functioning properly, and maintained and/or upgraded as required to prevent sediment from entering fish habitat.

Valued Ecosystem Component (VEC)	Potential Project Effect	Mitigation Measures
		• Excavated materials and debris shall be disposed of above the high water mark and located such that they do not enter any watercourse. • No fill material shall be obtained from bed, bank or riparian areas, and not from below the average high water level of any watercourse.
Fisheries and Aquatic Resources - Operation	Deleterious substance release from bridges over fish bearing water bodies	• Project Co shall develop and implement a plan for preventing deleterious substance release from bridges during all maintenance and operations.
Air Quality - Construction	Smoke and other pollutants created by construction activities	• Burning of cleared vegetation is not permitted. • Project specific asphalt and concrete plants shall be situated and designed to operate according to standard procedures applicable to the Project including the *Environmental Guideline for Saskatchewan Asphalt Plants* (Saskatchewan Ministry of Environment, 2014). • Dust shall be controlled using water and other suppressants as practical to minimize off-site migration of dust.
Socio-Economics and Land Use - Construction	Communities (noise and dust)	• Implement mitigation measures as described above under 'Vegetation – Dust' and 'Soil – Soil Erosion'. • Refer to other clauses in the Technical Requirements for hours of work.
	Campsites	• There shall be no campsites or sleeping trailers permitted within the Project Limits during the Construction Activities unless: ▪ Project Co shall obtain all approvals, permits, and written consents required by Applicable Law from local and provincial agencies to establish a work camp; and ▪ Project Co shall comply with all conditions and terms imposed by the local and provincial agencies.
	Pedestrians	• Manage public access to the Project to ensure safety.

Valued Ecosystem Component (VEC)	Potential Project Effect	Mitigation Measures
		• Project Co shall post signage indicating the construction zone and any traffic impediments during construction and shall notify the public and local public safety and protection services of the Project prior to Project commencement in order to reduce inconvenience. • Project Co shall ensure existing pedestrian and cyclist movements are accommodated safely and efficiently.
Historical Resources - Construction	Inadvertent Impacts to unrecorded historical resources during construction	• Project Co shall comply with any conditions specified in the Heritage Resource Impact Assessment for the Project (work done under Saskatchewan Ministry of Parks, Culture and Sport Heritage Conservation Branch `Permit #13-140). • Project Co shall be responsible for obtaining all necessary archaeological or heritage permits or authorizations, and shall comply with all conditions set out in those permits or authorizations.
		• The EPP shall include measures to protect historical resources that meet all guidelines of the Saskatchewan Ministry of Parks, Culture and Sport Heritage Conservation Branch. • In the event any historical, archaeological or paleontological resources are encountered during construction, work shall immediately be suspended and the Heritage Conservation Branch of the Saskatchewan Ministry of Parks, Culture and Sport shall be contacted immediately for its decision on any mitigation that is required.

300.2.11 As-Built Information

300.2.11.1 General

Project Co shall compile and record information on the dimensions and physical characteristics of the New Bypass Infrastructure. Project Co shall compile and retain the As-Built Roadway Construction Report, As-Built Surfacing Information, As-Built Pavement Structural Information, and As-Built Construction Report – Bridge Structures, As-Built Traffic Signal and Street Lighting Information, As-Built Drawings, all as described below (the "As-Built Construction Reports") that include full descriptions of each phase of the work, including, but not limited to, as-built drawings, and inspection and test reports. The maximum time for completion and the

providing of the As-Built Construction Reports to the Ministry shall be six months after Substantial Completion.

300.2.11.2 As-Built Roadway Construction Report

Project Co shall prepare an as-built report known as the "**As-Built Roadway Construction Report**". The As-Built Roadway Construction Report means an as-built report that contains sufficient detail so that an independent reviewer can gain a clear understanding of the Project. The report shall be provided in an electronic PDF format and in hard copy. The As-Built Roadway Construction Report shall contain, but not be limited to the following:

- Project title;
- Scope of the Project, Project description and site plan;
- Project staff, subcontractors, equipment and suppliers;
- Actual Project schedule and key dates;
- Work progress, problems and solutions;
- Innovative and unique aspects of the Project;
- Safety, traffic accommodation and utility relocation;
- Project Agreement extensions, Variations, or supplemental work;
- Environmental issues;
- Photographs of key activities;
- Commentary on and interpretation of the materials testing results; and
- Copies of all correspondence to the Ministry and to Project Co from the Ministry including minutes of meetings.

300.2.11.3 As-Built Surfacing Information

Project Co shall prepare an as-built report known as the "**As-Built Surfacing Information**" which shall include but not be limited to the following:

Project description - A complete description of the Project, including, but not limited to, the following:

- Highway control section number (e.g. 2:02) and linear location (e.g. km 12.5 to 14.0);
- Project title;
- Project description and site plan;
- Project staff, subcontractors, equipment and suppliers;
- Surfacing schedule and key dates;
- Work progress, problems and solutions;
- Innovative and unique aspects of the surfacing;
- Safety, traffic accommodation and utility relocation;
- All asphalt mix designs and job mix formulas;
- Granular base course designs;

- Variations;
- Environmental issues;
- Width and thickness charts;
- Photographs of key activities;
- Commentary, and interpretation and summary of the materials testing results for grading and granular base course;
- Commentary, and interpretation and summary of asphalt pavement testing results;
- Commentary, and interpretation and summary of test results for all asphalt cements and asphalt materials; hydraulic cement and supplemental cementing agents; aggregate (crushed and uncrushed products) and any other mixture additives; and
- Any other information recorded as part of the IMS and required to document material properties or construction details.

300.2.11.4 As-Built Pavement Structural Information

Project Co shall prepare an as-built report known as the "**As-Built Pavement Structural Information**" which shall include, but not be limited to:

Width, cross slope and thickness diagrams - for each homogeneous section greater than 200 m in length, containing:

- Soil classifications;
- Mechanical soil or base course strengthening product and installation details and the applicable plans, annotated to show any deviation from the original design;
- The results of any coring or drilling undertaken on the Project;
- The finished surface width (rounded to the nearest 100 mm);
- The constructed cross section details, including lane and shoulder widths and cross slope;
- The constructed sideslope ratios of pavement structure and subgrade as applicable; and
- The constructed pavement structure thickness (rounded to the nearest 5 mm) including the thickness and cross slope of each layer; and
- The type and grade of asphalt cement.

300.2.11.5 As-Built Construction Report - Bridge Structures

Project Co shall prepare an as-built report known as the "**As-Built Construction Report – Bridge Structures**" which shall contain, but not be limited to the following:

- Shop drawings for bridge material fabrication (see Section 300.4.3.2 in Schedule 15-2 – Design and Construction);
- Weld procedures;
- Mill reports for stressing strand;
- Stress-strain curves for stressing strand;
- Stressing calculations;

- Camber records;
- Construction data sheets for precast concrete girders;
- Mill certificates;
- Test reports for Charpy impact, hardness, radiography, ultrasonic, magnetic particle, and dye penetrant;
- Heat treatment records;
- Concrete and asphalt mix designs;
- Pile driving, pile drilling, foundation records;
- Concrete test results;
- Post-tensioning and stressing records;
- Material testing results including gradation analysis for backfill materials, clay seal, etc.;
- Any other information recorded as part of the IMS and required to document material properties or construction details; and
- All documents listed in Section 200.6.22 of Schedule 15-2 – Design and Construction.

300.2.11.6 As-Built Traffic Signal and Street Lighting Information

Project Co shall prepare an as-built report known as the "**As-Built Traffic Signal and Street Lighting Information**" for all traffic signals and street lights installed. The report shall include, but not be limited to:

- As-built drawings including 1:500 overall site plan, 1:250 plan of underground works, 1:250 plan of aboveground works, 1:500 plan of video detection zones, 1:75 elevation of each pole, PDC, details; details of concrete bases, certification from geotechnical engineer that bases are designed to ground conditions, Pole loading capacity calculations,
- Traffic signal controller database (in both hardcopy format and digital format in native controller database format);
- Shop drawings of all traffic signal and street light poles, PDC, controller cabinet;
- UPS System and cabinet;
- Traffic cabinet wiring drawings (include a second set, laminated and placed inside each cabinet);
- Traffic camera programming files; and
- Traffic camera detection field of view plots.

300.2.11.7 As-Built Drawings

Project Co shall supply the following for the Ministry's record purposes.

Roads

- Two sets of 11x17 stamped and signed drawings (organized per roadway segment and placed in binders);
- One set of the electronic version of the stamped and signed drawings in AutoCAD format; and

- One set of the electronic version of the stamped and signed drawings in .pdf format.
- GPS data in format suitable to Ministry.

Bridges

- Two sets of 11x17 stamped and signed drawings, and record shop drawings, organized by bridge structure and placed in binders;
- One full-size (24x36) stamped and signed set of record drawings on Mylar film;
- Two sets of sign structure drawings for the Project, each submitted together with shop drawings in a single 11x17 binder, and sequenced from one end of the Project to the other. A single drawing showing all signs shall also be included at the front of each of these binders;
- One set of the electronic version of the stamped and signed record drawings in AutoCAD format;
- One set of the electronic version of the stamped and signed record drawings in .pdf format;
- All record shop drawings in electronic form on CD or DVD or flash drive.

300.2.11.8 Bridge Shop Drawing Submission Requirements

Project Co shall supply the following for the Ministry's record purposes.

- One complete set of shop drawings for each bridge for review in accordance with Schedule 9 – Review Procedure, including any shop drawings that are common to more than one bridge.
- Shop drawings for review in accordance with Schedule 9 – Review Procedure shall be provided in electronic file format, for printing in 8 ½" x 11" or 11" x 17" format. Minimum text height to be 2.5 mm. Quality of shop drawings to be such that all details remain clearly legible in the submitted format size after black and white scanning at 200 dpi.
- The review stamp shall be located on the front of each shop drawing, legibly signed and dated, and positioned so that it does not obscure any drawing information.
- The standard shop drawing identification block shall be located close to the bottom right of every shop drawing that contains all information identified in the sample shop drawing identification block below. Position the shop drawing identification block so that it does not obscure any drawing information.
- All supplier design shop drawings shall be authenticated according to the IMS Manual.
- All revised shop drawings shall be resubmitted.

Shop Drawing Identification

Sample Identification Block		Comments on Fields
Regina Bypass		*Project identifier shall go on all shop drawings*
Project Co Structure No.	XXXX	*Supplied by Project Co based on Project Co bridge numbering system*
Design Dwg X-Ref	X	*Supplied by Project Co (this is the design drawing number(s) that the shop drawing relates to)*
Drawing No.	X	*Supplied by Project Co (shall be unique for each sheet, and contain revision numbers where applicable)*
Ministry Bridge File No.	X	*Supplied by the Ministry upon request – see below*
Ministry Plan No.	X	*Supplied by the Ministry upon request – see below*
Sheet No.		*Leave blank for the Ministry to fill in afterwards*

300.3 ROADWAY CONSTRUCTION SPECIFICATIONS

300.3.1 Materials

Project Co shall select the materials to be used for construction and ongoing maintenance to meet the Technical Requirements.

Unless stated elsewhere in the Technical Requirements, except for pavement materials and earthworks all construction materials shall be new materials specifically manufactured for their intended purposes.

300.3.1.1 Aggregates

Aggregates for Portland cement concrete shall be suitable for use in concrete, shall exhibit suitable long-term performance characteristics and shall conform to the requirements of CSA Standard A23.1. Specifically, aggregates for use in appurtenances shall exhibit suitable resistance to alkali-aggregate reactivity.

Aggregates for use in roadways and asphalt concrete shall be selected to provide suitable long term performance. Aggregates shall be composed of sound, hard and durable particles of sand, gravel and rock free from injurious quantities of elongated, soft or flaky particles, shale, loam, clay balls and organic or other deleterious material. For Conveyed Infrastructure roadways, asphalt concrete mixes shall contain 1% hydrated lime by weight of dry aggregate.

300.3.1.2 Portland Cement Concrete

All curbs, gutters, raised medians, traffic islands, sidewalks and related appurtenances shall be constructed with hydraulic cement concrete.

Portland cement concrete for use in roadway elements including barriers or other appurtenances, shall consist of a mixture of hydraulic cement, supplementary cementing materials, fine aggregate, coarse aggregate, water and admixtures where required, in proportions to meet the requirements of the design.

Portland cement concrete designed for any application that will be in contact with winter maintenance materials shall consist of materials shown to provide adequate resistance to scaling and other freeze thaw damage.

The Portland cement used shall meet the requirements of CSA Standard A3001, for the type of cement specified. The Portland cement concrete shall meet all the requirements of CSA Standard A23.1. For A23.1 Section 17.4.2, Air Content of Hardened Concrete, the confirmation of the air-void system shall be on drilled cores obtained from the in-place concrete.

300.3.1.3 Asphalt

Asphalt binders shall meet the requirements of the Ministry's *Specifications for Manufactured Materials*. For Conveyed Infrastructure roadways, only penetration graded asphalt cements will be allowed.

300.3.1.4 Culverts

Approved materials for culverts are specified in Section 614-00 of the Ministry *Hydraulic Manual*. Culvert materials shall have a 75 year design life.

300.3.1.5 Permanent Highway Signs, Post and Bases

300.3.1.5.1 Reflective Sheeting

Reflective sheeting for standard regulatory, warning and side mounted guide signs shall meet or exceed the minimum requirements as specified in ASTM D4956 for Type III and Type IV High Intensity Retro-Reflective Sheeting Material and Section 200 (Design).

For installations of the following signs the reflective sheeting shall meet or exceed the minimum requirements as specified in the ASTM D4956, Performance Requirements Type IX or Type XI Unmetalized Cube Corner Microprismatic Retroreflective Element Material:

- RA-1 "Stop";
- RA-2 "Yield";

- RB-22 "Wrong Way"; and
- RB-23 "Do Not Enter".

For overhead guide signs with sign illumination, the reflective sheeting shall meet or exceed the minimum requirements as specified in ASTM D4956, Performance Requirements Type III or IV, High Intensity Retroreflective Sheeting.

For specific warning signs (roadway alignment, traffic control ahead, hazard, and pedestrian signs), reflective sheeting shall meet or exceed the minimum requirements as specified in ASTM D4956, Performance Requirements Type IX or Type XI Unmetallized Cube Corner Microprismatic Retroreflective Element Material.

For overhead guide signs without sign illumination, the reflective sheeting shall meet or exceed the minimum requirements as specified in ASTM-D4956, Performance Requirements Type IX or Type XI Unmetallized Cube Corner Microprismatic Retroreflective Element Material.

300.3.1.5.2 Sign Posts

Sign posts on rural cross-sections, including but not limited to the mainline facility, shall meet the material and breakaway requirements set forth in Section H8.2 (Sign Post Selection) of the Alberta Transportation Roadside Design Guide. The material and breakaway requirements for sign posts on urban cross-sections may be selected to match adjacent existing urban sign post materials, provided that the material selected for all sign posts is the same.

300.3.1.6 Pavement Marking

Project Co shall supply pavement marking materials that will meet the requirements of the design and the performance requirements in Section 401.10.3 Pavement Marking. Re-application shall meet the same performance requirements.

Transverse lane markings at all signalized intersections shall be permanent or durable pavement markings. These shall include stop lines, crosswalk lines, pavement arrows (in the vicinity of the intersection or within 100 m of the intersection) and left turn guidelines.

300.3.1.7 Flexible Guide Traffic Post Traffic Delineators

Traffic delineators are required on all interchange ramps and shall be spaced appropriately for the design speed and horizontal curvature of the ramps.

300.3.2 Landscaping

Topsoil material shall be uniformly spread to a minimum depth of 75 mm over the prepared areas to facilitate the required seeding and landscaping. In the case of large amounts of surplus topsoil, Project Co shall indicate how the material shall be handled and stored in a manner applicable to relevant regulatory requirements. The handling and storage of topsoil is to be included in Project Co's operational procedures.

Conventional seeding and/or hydro-seeding shall be carried out at Project Co's discretion to meet the requirements of these specifications related to drainage and erosion.

Seeded areas shall show a uniform stand of grass during the calendar year following the year of initial seeding. Areas that do not show a uniform stand of grass shall be reseeded. A uniform stand of grass will show no bare spots greater than 0.5 m^2 in size and provide a minimum of 90% ground cover.

All seed supplied by Project Co shall be certified free of all prohibited noxious weed varieties identified in the Noxious Weeds Act 1984, and the Department of Fisheries and Oceans Act.

In order to maintain consistency in vegetation, Project Co shall develop a seed mixture(s) for the New Bypass Infrastructure that is similar to existing adjacent vegetation, unless adjacent vegetation is deemed unacceptable.

The relocation of trees impacted by the Project shall be done within the Lands and/or drainage facilities if it is safe and technically feasible. These trees shall be relocated where traffic operations, safety, and drainage are not compromised.

300.3.3 Earthworks

Project Co shall refer to DM1 Standard Plans 22010 to 22030. These drawings shall be considered minimum requirements for earthworks construction. The Bypass shall be considered "System 1" for interpreting these drawings.

Topsoil shall consist of a natural, friable surface soil of organic character, suitable for agricultural purposes.

300.3.4 Borrow

All borrow material shall be clean native materials with no contaminants, hazardous materials, or non-native materials. Certain materials such as salt may be allowed in the embankment, provided Project Co has implemented measures to contain such materials to prevent migration.

Project Co shall be responsible for obtaining and paying for any and all required borrow material for this Project from outside the Roadway Right-of-Way, including all investigations, permits, reclamation, fencing, etc.

Deep type borrow pit end slopes shall be 3:1 or flatter to allow egress for animals or persons that enter the pit. Flatter slopes may be required for long-term stability based on Project Co's geotechnical analyses.

Borrow pit layout shall be in accordance with Construction Manual Volume 1 – 200 Surveys – CM 202-04 Borrow Pit Layout.

300.3.5 Temporary Stockpiles

Temporary stockpiles shall have 2:1 or flatter sideslopes and any other measures deemed necessary by Project Co for public safety.

300.3.6 Cleaning of Roadways

Project Co shall not track material from the construction site onto roadways used by the public. If tracking should occur, Project Co shall immediately remove all tracked material from the affected roadway.

300.3.7 Roadway and Other Infrastructure Obliteration or Removal

All roadways, ramps, and access roads designated for removal, as indicated on the Reference Concept or as required by Project Co's design, shall have the road structure removed, filled with clean material native to the surrounding land, landscaped neatly with slopes flatter than 5 horizontal to 1 vertical within the Roadway Right-of-Way and flatter than 6 horizontal to 1 vertical outside the Roadway Right-of-Way, culverts removed and existing drainage patterns maintained, then topsoiled and seeded in accordance with Section 300

Project Co shall assume ownership of all debris and salvaged materials, such as culverts, except as otherwise identified. All materials having salvage value shall be carefully removed to avoid damage to Existing Bypass Infrastructure that is to remain. The old pavement structures shall be removed to an existing joint or cut to a true vertical face at the tie-in locations to Existing Bypass Infrastructure. After removal, Project Co shall store on site any existing lighting systems owned by the Local Authority and shall provide the Local Authority with written notice, and the Ministry with a copy of such notice concurrently, that any materials to be salvaged are to be removed by the Local Authority within 30 days. If the Local Authority has not removed the materials within 30 days from notice, the lighting systems become the property of Project Co.

Any hazardous or contaminated materials shall not be left or buried within the Project Limits, and shall be dealt with in accordance with all Ministry practice and satisfying all environmental requirements. For example, Project Co's attention is drawn to the Ministry's *Construction Manual Volume 1,* Section 400 Grading – CM 450-22, for proper disposal of creosote materials at a certified site.

300.4 STRUCTURES CONSTRUCTION SPECIFICATIONS

300.4.1 Materials

All materials incorporated into the bridge structures for the Project shall be new. Timber materials shall only be used for approach guardrail posts and blocking.

300.4.2 Cast-In-Place Concrete

300.4.2.1 General

The specification is for the supply, placement and quality management of cast-in-place Portland cement concrete.

Metric versions of references are inferred, when available and relevant.

300.4.2.2 Reference Drawings and Standards

The following reference drawings shall apply:

- Standard Concrete Joints Drawing, SK-3
- Standard Construction Joints, S-1412-99
- Deck Water Proofing System With 80 mm Two Course Hot-Mix ACP Drawing, SK-4

Reference Standards

CSA Standard A23.1	Concrete Materials and Methods of Concrete Construction
CSA Standard A23.2	Test Methods and Standard Practices for Concrete
CSA Standard A3000	Cementitious Materials Compendium
CSA Standard S269.3	Concrete Formwork
CSA Standard A283	Qualification Code for Concrete Testing Laboratories

300.4.2.3 Submittals

Project Co shall submit concrete aggregate tests and concrete mix designs to the Ministry for each type of concrete proposed pursuant to Schedule 9 – the Review Procedure. Submittals shall comply with Section 300.4.2.5. of Schedule 15-2 – Design and Construction and to be made not less than 2 weeks prior to proposed use. All concrete trial mix results shall be included.

Project Co shall provide notice to the Ministry prior to concrete placing.

In the event that the Ministry requests any of the following information, it shall be submitted within the timelines noted below:

- Five days prior to placing concrete:
    - Data showing conformance of the fly ash to the requirements of CSA Standard A3001 for Type “F” fly ash

- Aluminum content of steel fibres used in Type DC with steel fibres

- Two days prior to blast cleaning operations:
  - Concrete crack measurements for Type DC and Type DC with steel fibres concrete
- Within seven days of request by the Ministry:
  - Concrete core strength results
  - Concrete cylinder strength test results
  - Type of machine proposed for grinding of deck, if required

300.4.2.4 Materials

Material properties used in concrete production shall conform to CSA Standard A23.1, unless otherwise specified in these specifications. Laboratory testing shall be carried out by a testing laboratory certified in accordance with the requirements of CSA Standard A283. Field test procedures shall be undertaken by personnel certified under an industry-recognized program.

All accepted admixtures shall be compatible with all other admixtures and constituents used in the mix

Cement - Portland cement shall conform to the requirements of CSA Standard A3001. General use (Normal), Type GU, or high sulphate resistant, Type HS, shall be supplied unless otherwise specified.

- A mill test report and a manufacturer's certificate of compliance for each delivered shipment representing each type of cementitious material shall be submitted to the Ministry.
- The total alkali content [Na_2O equivalent, (Na_2O + (0.658 x K_2O))] of the Portland cement shall not exceed 0.60% by mass.
- Blended hydraulic cement shall not be used.

Concrete intended for placement in sulphate environments may be produced with combinations of Type GU cement and supplementary cementing materials provided CSA Test Method A3004-C8 test data demonstrating compliance with CSA Standard A3001 requirements for high sulphate resistance is submitted.

Water - Water to be used for mixing concrete or mortar shall conform to the requirements of CSA Standard A23.1 and shall be free from injurious amounts of alkali, organic materials or deleterious substances. Project Co shall not use water from shallow, stagnant or marshy sources.

Aggregates -All aggregates are to be natural, processed or manufactured granular material composed of hard, sound and durable particles, free of adherent coatings, shale, clay, organic materials and other soft or disintegrated pieces.

Fine and coarse aggregates shall conform to the requirements of CSA Standard A23.1 and shall be stockpiled separately.

Admixtures - All admixtures, such as water-reducing agents, air-entraining agents and superplasticizers, shall conform to ASTM Specification C494 and be compatible with all other constituents including cement, silica fume and fly ash. Type F high range water reducer (super plasticizer) shall be used when concrete contains silica fume. The addition of calcium chloride, accelerators or air-reducing agents is not permitted. If requested, a written statement from the manufacturer stating that the admixture contains no intentionally added calcium chloride shall be provided to the Quality Manager and the Ministry.

Hydration stabilizing admixtures (HSA's) shall meet ASTM Specification C494 requirements for Type D water reducing and retarding admixtures. The maximum allowable time of set retarding shall be three hours, as measured from the time of mixing. The appropriate dosage rates are to be verified with trial batch tests. The use of HSA's requires the approval of the Ministry and their usage is limited to those situations where haul times are expected to exceed the specified times and/or projects which require retardation due to structural considerations.

Type B, retarding or Type D, water-reducing and retarding (hydration stabilizing) admixtures shall not be incorporated into the mix design and/or added to the concrete without the acceptance of the Engineer of Record and the Ministry Representative.

Silica Fume - Condensed silica fume shall conform to the requirements of CSA Standard A3001 for a Type SF supplementary cementing material, with a SiO_2 content of at least 70%, a maximum loss on ignition of 10%, and a SO_3 content not more than 1%.

Silica fume application rates shall not exceed 8% by mass of Portland cement.

Air Entraining Agent - Air entraining agent shall be added to all concrete and shall conform to the requirements of ASTM Specification C260.

Steel Fibres - Steel fibres shall meet the requirements of ASTM Specification A820 Type 1 cold drawn high tensile deformed steel fibres. A mill certificate showing compliance with ASTM Specification A820 shall accompany each delivered lot. Steel fibres shall be Xerox 1 or Novocon or an alternate acceptable to the Engineer of Record and the Ministry.

Fly Ash - All fly ash shall conform to the requirements of CSA Standard A3001 for Type "F" fly ash with a maximum CaO content of 8%, a maximum SO_3 content of 5%, and a maximum 8.0% ignition loss.

Fly ash application rates shall be limited to a maximum of 25% by mass of Portland cement in substructure concrete. For concrete for bridge decks, approach slabs and concrete overlays, the maximum application rate shall be 15% by mass of Portland cement.

300.4.2.4.1 Storage of Materials

The storage and handling of all materials used in the production of concrete shall conform to CSA Standard A23.1, unless otherwise specified herein. Project Co shall store all cement, silica fume, fly ash and steel fibres in weather tight buildings to protect such materials from dampness. Cement, silica fume and fly ash shall be free of lumps at all times during their use in the work and shall have a maximum temperature of 50°Celsius Steel fibres shall be free from balls and clumps at all times during their use in the work.

Project Co shall handle all aggregates so as to prevent segregation and to obtain uniformity of materials. The separated aggregates, and aggregates secured from different sources, shall be piled in separate stockpiles. The site of the stockpiles shall be cleared of all foreign materials and shall be reasonably level and firm. If aggregates are placed directly on the ground, material shall not be removed from the stockpile within 150 mm of the ground level. This material shall remain undisturbed to avoid contaminating the aggregate being used with the ground material.

Access shall be provided to the storage facilities to allow for inspection and sampling. Where applicable, materials shall be identified by MSDS sheets. All admixtures shall be stored in manufacturers' original labeled containers with clearly legible labels and be kept above freezing at all times and in accordance with the manufacturers' technical data sheets. Tanks used for storing and/or hauling, concrete mixing and curing water shall be free from contamination by oil, acid, alkali, organic matter, sediment, rust or other deleterious substances. Other materials, such as steel fibres, etc. shall be stored and handled in accordance with the manufacturer's recommendations and instructions

300.4.2.5 Type and Composition of Concrete

300.4.2.5.1 Concrete Type
Concrete Mix Design and Requirements

Type	Minimum Compressive Strength at 28 Days (MPa)	Nominal Maximum Size of Coarse Aggregate (mm)	Air Content (%)	Slump (mm)	Maximum W/C Ratio By Mass
Type DC concrete: Cast-in place decks, curbs, barriers, sidewalks, medians, abutment diaphragms, abutment roof slabs, approach slabs, sleeper slabs, pier diaphragms, intermediate diaphragms, deck joint blockouts, top of abutment backwalls (300 minimum below road top surface), the entire straddle bent or pier cap where any portion of the component is a Splash Zone Surface, precast partial depth deck panels, MSE precast wall panels, MSE wall coping, all concrete within a depth of 300 mm of Splash Zone Surfaces					

Type	Minimum Compressive Strength at 28 Days (MPa)	Nominal Maximum Size of Coarse Aggregate (mm)	Air Content (%)	Slump (mm)	Maximum W/C Ratio By Mass
• Standard [4]	45	28[1]	5.0-6.5%	50 ± 20	0.38
• With Silica Fume	45	28[1]	5.0-6.5%	50 ± 20[2]	0.38
• With Type F Fly Ash [3,4]	45	28[1]	5.0-6.5%	50 ± 20	0.38
Type C Concrete: Pile caps, substructure elements, monolithic concrete protection barriers other than concrete within a depth of 300 mm of Splash Zone Surfaces, sign structure foundations (except cement shall be type HS), MSE wall levelling pads, cast-in place retaining walls.	30	28	5.0-7%	50 ± 20	0.40
Type C1 Concrete: Concrete Slope protection, Concrete drain troughs	30	20	5.0 ± 1.0	30 ± 20	0.45
Type P1 Concrete: Pipe Pile Infill	25	28	5-7	70 ± 20	.40
Type P2 Concrete: Drilled caissons	30	28	5-7	70 ± 20	.40
Type G Concrete: Precast bridge girder concrete as per Section 300.4.4	As design requires (45 min)	As design requires	5.0-6.5%	As design requires	0.38
Type G1 Concrete: Keyways between Box Stringers	45	14	5.0 ± 1.0	20 ± 10	0.38

(1) The maximum proportion of aggregate passing the 5 mm screen shall be 35% of the total mass of aggregate.
(2) Silica fume application rates shall be 8% maximum by mass of Portland cement. Slump specifications based on prior to adding superplasticizer admixture to concrete. Slump specification of superplasticized concrete shall be 80 ± 20.
(3) Application rate shall not exceed 15% by mass of Portland cement. Type CI fly ash shall not be used.
(4) Superplasticizer shall not be used.
(5) The gradation of the 28 mm nominal size aggregate shall conform to Table T1 "Gradation Requirements for Coarse Aggregates" unless noted otherwise in this clause.
(6) For MSE wall panels, smaller aggregate may be required to suit panel design.
(7) For MSE wall panels, the range of slump may be determined by Project Co.
(8) For partial depth deck panels f'ci at release shall not be less than 30 MPa
(9) Slumps higher than 100 mm shall be obtained using superplasticizers. Slump ranges proposed by Project Co that are outside those specified require approval in writing from the Engineer of Record.

300.4.2.5.2 Type DC and Type DC with Steel Fibres

Mix designs for Type DC and Type DC with steel fibres concrete shall meet the following requirements:

- Mix shall include silica fume and fly ash as supplementary cementing materials in combination with compatible air entraining, water reducing and/or superplasticizing admixtures, as required.
- The gradation limits for the fine aggregate shall conform to CSA Standard A23.1, except that the amount of material finer than 160 μm shall not exceed 5%.
- Coarse aggregate shall conform to CSA Standard A23.1 and the maximum combination of flat and elongated particles (4:1 ratio), as determined by CSA Test Method A23.2-13A, shall not exceed 10% of the mass of coarse aggregate.
- Sum of silica fume and fly ash by mass of cementitious materials shall be 17% to 20%.
- Silica fume by mass of Portland cement shall be from 6% to 8%. In lieu of silica fume, Metakaolin may be used at a rate of 12% to 15% by mass of Portland cement.
- Fly ash by mass of Portland cement shall be maximum 15%.
- Rapid chloride ion penetration shall be determined in accordance with ASTM Specification C1202 on duplicate laboratory moist cured samples at 56 days. The average of all tests shall not exceed 1000 coulombs, with no single test greater than 1250 coulombs. For Type DC with steel fibres, rapid chloride ion penetration testing shall be done without the presence of the steel fibres.
- Alkali reactivity of aggregates shall be assessed in accordance with CSA A23.2-27A and preventative measures taken assuming a minimum service life > 75 years.
- Rapid freeze thaw salt scaling potential shall be determined in accordance with ASTM Specification. The surface mass loss after 30 cycles shall not be more than 0.4 kg/m2
- An air-void spacing factor shall be determined in accordance with ASTM Specification C457 modified point-count method at 100 times magnification. The average of all tests shall not exceed 230 μm with no single test greater than 260 μm.

- When Type DC with steel fibres is specified, it shall contain 60 kg of 50 mm long steel fibres, per cubic metre. Project Co shall review test results of the aluminum content in the steel fibres prior to placing concrete at the site. When alternative steel fibres are proposed, their equivalency and dosage rate shall be determined in accordance with ASTM Specification C1609. The toughness (TD600) shall be greater than or equal to that specified.
- The temperature of the centre of the in-situ concrete shall not fall below 10° Celsius or exceed 60° Celsius and the temperature difference between the centre and the surface shall not exceed 20° Celsius. In addition, the requirements of Table 21 of CSA Standard A23.1 shall apply.
- Project Co shall take steps to ensure that the proportions selected will produce concrete of the quality specified. Trial batch(es) shall be performed at least 35 days prior to placement of concrete at site. Each trial batch shall be a minimum of 4 m^3 or 50% of the rated mixer capacity (whichever is greater) and simulate the anticipated placing procedures at site. The trial batch shall assess the workability and slump retention characteristics of the concrete. Point of discharge sampling and testing shall be carried out by Project Co to verify the pertinent parameters of the proposed mix design. If placement is by pump, concrete shall be sampled and fully tested at both the truck chute discharge at the pump discharge locations. Batching, haul times and conveyance procedures used for the test batch shall emulate the procedures expected during the actual concrete placement. Trial batches shall be conducted specifically for the project.
- The initial slump of the trial batch shall be measured after an elapsed time from batching of not more than 15 minutes. Slump retention shall be assessed at 45 minutes after batching, and shall be at least 75% of initial slump. At an elapsed time of 70 minutes from the time of batching, the concrete shall be sampled and samples shall be cast to verify that requirements pertaining to compressive strengths at 7 and 28 days, rapid chloride ion penetration, rapid freeze thaw salt scaling potential and air void system parameters of hardened concrete will be met. The shrinkage of the trial batch concrete shall be measured in accordance with CSA Test Method A23.2-21C. Shrinkage test results shall be submitted to the Ministry within seven days of test completion. For multi-year projects, all trial batch testing shall be repeated annually in conjunction with required aggregate testing.

300.4.2.5.3 Coarse and Fine Aggregate Gradation Tables for Saskatchewan

Coarse Aggregate

All coarse aggregate materials shall conform to the following requirements:

- Sampling shall be according to CSA Test Method A23.2-1A.
- Gradation shall be determined in accordance with CSA Test Method A23.2-2A and 5A. (All gradations shall be based on a washed sieve analysis, see footnote 1 on Table T3.
- The maximum size of coarse aggregates for concrete to be used in slabs, curbs, and sidewalks shall be 28 mm. the maximum size for all other concrete work shall be 56 mm.

- Gradation of the coarse aggregate shall be within the limits shown in Table T1 for the particular size range or nominal maximum size of coarse aggregate specified.

Table T1 – Gradation Requirements for Coarse Aggregates

Nominal Maximum Size of Coarse Aggregate (1) mm	Product Size mm	Percent By Mass Passing (%) Canadian Metric Sieve Series s								
		56 mm	40 mm	28 mm	20 mm	14 mm	10 mm	5 mm	2.5 mm	1.25 mm
40	40-5 (2)	100	95-100	—	35-70	—	10-30	0-5	—	—
28	28-5 (2)	—	100	95-100	63-83	30-65	—	0-10	0-5	—
20	20-5	—	—	100	90-100	50-90	25-60	0-10	0-5	—
14	14-5	—	—	—	100	90-100	45-75	0-15	0-5	—
10	10-2.5	—	—	—	—	100	85-100	10-30	0-10	0-5

(1) Nominal maximum size of coarse aggregate - the standard sieve size opening immediately smaller than the smallest through which all of the aggregate shall pass.
(2) To prevent segregation, aggregates that make up the above gradings shall stockpiled and batched in two or more separate sizes as per CSA Standard A23.1
(3) The gradation of coarse aggregates used shall be such that the percentage passing any one sieve does not vary more than 5% from the initially approved coarse aggregates used in the mix design.
(4) The maximum Petrographic Number (PN) of coarse aggregate shall not exceed 125, and shall be determined in accordance with CSA Test Method A23.2-15A.
(5) The amount of deleterious substances in coarse aggregate shall not exceed the limits prescribed in Table T4.
(6) Other specified physical properties measuring aggregate quality referenced in Table T3 shall not exceed the limits prescribed in Table T4.
(7) The gradation of the 28 mm nominal size aggregate shall conform to Table T1 “Gradation Requirements for Coarse Aggregates” unless noted otherwise in this clause.

Fine Aggregate

Fine aggregate shall conform to the following requirements:

- Sampling shall be according to CSA Test Method A23.2-1A.
- Grading shall be within the limits given in Table T2 when tested in accordance with CSA Test Method A23.2-2A and 5A. (All gradations shall be based on a washed sieve analysis).
- Fineness modulus shall be between 2.3 and 3.1.
- Fineness modulus tolerance shall be ±0.2 (except that the above sentence shall apply) from the fineness modulus of the initially approved fine aggregate used in the design mix.

- A maximum 45% shall be retained between any 2 consecutive sieves.
- The amount of deleterious substances in fine aggregate shall not exceed the limits prescribed in Table T4.
- Other specified physical properties measuring aggregate quality referenced in Table T3 shall not exceed the limits prescribed in Table T4.

Table T2 – Gradation Requirements for Fine Aggregates

Sieve Designation	Percent By Mass Passing (%) Canadian Metric Sieve Series
10.0 mm	100
5.0 mm	95 - 100
2.5 mm	80 - 100
1.25 mm	50 - 90
630 µm	25 - 65
315 µm	5 - 35
160 µm	0 - 10

Table T3 – Required Aggregate Testing For Normal Density Coarse and Fine Aggregate (Per Individual Product and Aggregate Source)

CSA Standard A23.2 Test Method	Test Description	Test Data Validity[5]
A23.2-2A[1] A23.2-5A[1]	Sieve Analysis of Fine and Coarse Aggregate Amount of Material finer than 80 µm in Aggregate	Within 90 days[6] Within 90 days[6]
A23.2-3A	Clay Lumps in Natural Aggregate	Within 3 years
A23.2-4A	Low Density Granular Material in Aggregate	Within 3 years
A23.2-6A, 12A	Relative Density and Absorption of Fine and Coarse Aggregate	Within 1 year
A23.2-7A	Test for Organic Impurities in Fine Aggregates for Concrete	Within 2 years
A23.2-8A[3]	Measuring Mortar-Strength Properties of Fine Aggregate	Within 2 years
A23.2-9A[2]	Soundness of Aggregate by Use of Magnesium Sulphate	Within 4 years
A23.2-14A	Potential Expansivity of Aggregates (Procedure for Length Change Due to Alkali-Aggregate Reaction in Concrete Prisms)	Within 18 months

CSA Standard A23.2 Test Method	Test Description	Test Data Validity[5]
A23.2-13A	Flat and Elongated Particles in Coarse Aggregate - Procedure A (Length to Width Ratio 4:1)	Within 3 years [6]
A23.2-16A[7]	Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine	Within 4 years
A23.2-23A[2]	Test Method for the Resistance of Fine Aggregate to Degradation by Abrasion in the Micro-Deval Apparatus	Within 4 years
A23.2-29A[2]	Test Method for the Resistance of Coarse Aggregate to Degradation by Abrasion in the Micro-Deval Apparatus	Within 4 years
A23.2-15A[4]	Petrographic Analysis of Coarse & Fine Aggregate specific for use as concrete aggregate; and Determination of the Petrographic Number	See Note [4]
A23.2-24A[8]	Test Method for the Resistance of Unconfined Coarse Aggregate to Freezing and Thawing	See Note [8]

(1) Each aggregate product that may be used as a component of the proposed mix shall have a washed sieved analysis performed showing the cumulative percent passing for each of the following sieve sizes; 56, 40, 28, 20, 14, 10, 5, 2.5, 1.25, 0.630, 0.315, 0.160 and 0.080 mm. Sieve analysis reports are to include all relevant sampling information (date/sampled by/location/field sample size) and include the actual test specimen sample mass.
(2) Subject to approval by the Quality Manager and the Engineer of Record, Test Method A23.2-9A can be performed as an alternative to performing Test Method A23.2-23A and A23.2-29A. Refer to CSA Standard A23.1, Section 4.2, Table 12 for further information.
(3) Test Method A23.2-8A is required only if the aggregate fails to meet the requirements of Test Method A23.2-7A as described in CSA Standard A23.1 Section 4.2.3.3.3.2
(4) Petrographic Assessment of Aggregates: Project Co shall submit the results of the Petrographic Analysis, certified by a qualified professional registered with the Association of Professional Engineers and Geoscientists of Saskatchewan and indicating the aggregate's suitability for its intended use.
(5) The petrographic analysis shall not be used to forfeit the requirement of performing other necessary aggregate quality testing.
(6) Test data validity requirements are based on time periods prior to the expected initial date of concrete production. It is only applicable to aggregate sources proven to be materially consistent, based solely on historical test data. The Ministry, based on submitted test data and/or visual observations, may reduce the above listed time periods.
(7) Quality control during aggregate production shall include the following test methods at the specified test frequencies: Test Methods A23.2-2A & A23.2-5A (1 per 500 tonnes), and A23.2-13A (1 per 1000 tonnes).
(8) Subject to approval by the Quality Manager and the Engineer of Record, Test Method A23.2-16A can be waived if Test Method A23.2-29A test results meet the specified criteria.
(9) This test shall be required should any of Test Methods 4A, 9A, 16A or 29A fails to satisfy the allowable limits.

Table T4 – Limits for Deleterious Substances in and Physical Properties of Aggregates

CSA Standard A23.2 Test Method	Substance or Property	Maximum Percentage by Mass of Total Sample	
		Coarse Aggregate	**Fine Aggregate**
A23.2-3A	Clay Lumps	0.25	0.5
A23.2-4A	Low-Density Granular Materials	0.5	0.5
A23.2-5A	Material Finer than 80 µm	1.0	3.0
A23.2-9A	Magnesium Sulphate Soundness Loss	12	16
A23.2-16A,	Los Angeles Abrasion Loss for Concrete Subject to Wear	50 (35) (All deck concrete)	N/A
A23.2-23A-29A	Micro-Deval Abrasion Loss	17	20
A23.2-12A	Absorption Percentage	1.75	N/A
A23.2-7A	Organic Impurities in Fine Aggregate	N/A	Standard colour or lighter (1)
A23.2-13A	Flat and Elongated Particles in Coarse Aggregate - Procedure A (Length to Width Ratio 4:1)	20	N/A
A23.2-14A	Alkali-Reactivity Expansion in Concrete Prisms	0.040 (2)	0.040 (2)
A23.2-24A	Test Method for the Resistance of Unconfined Coarse Aggregate to Freezing and Thawing	6	N/A
A23.2-15A	Petrographic Examination of Aggregates	125	N/A

(1) Standard colour is defined as Organic Plate No. 3.
(2) Expansion measured at 1 year.

300.4.2.5.4 Aggregate Tests and Concrete Mix Design

Project Co shall prepare a concrete mix design for each proposed class of concrete.

For each mix design the following aggregate analysis shall be provided:

- Source(s) of proposed aggregates.
- Fine and coarse aggregate sieve (CSA Test Method A23.2-2A).
- Amount of material finer than 80 µm in aggregate (CSA Test Method A23.2-5A).
- Organic impurities in sands for concrete (CSA Test Method A23.2-7A).
- Results of deleterious substances and physical properties of aggregates included in Table T3.
- Assessment of potential for deleterious alkali-aggregate reactivity ("AAR") (CSA Test Method A23.2-27A).
- Petrographic examination of coarse aggregate for concrete (for Type DC and Type DC with steel fibres only) (CSA Test Method A23.2-15A).

The analysis of the aggregates shall be current and fully represent the material to be used in production. In accordance with CSA Standard A23.1 Clause 4.2.3, yearly testing is required for concrete aggregates. All sampling and testing for sieve analysis, material finer than 80 µm and organic impurities in sand shall have been done no more than 90 days prior to concrete production. Petrographic examination of coarse aggregate for concrete shall have been done no more than 180 days prior to concrete production. Additional analyses of more recent sampling shall be provided as required to confirm that the aggregates continue to meet requirements. A break in production of a particular class of concrete shall not constitute the need for additional testing provided Project Co has conclusive evidence that the material initially tested is still representative.

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.

Fine aggregate, tested in accordance with CSA Test Method A23.2-7A, "*Organic Impurities in Sands for Concrete*", shall produce a colour not darker than the standard colour (Organic Plate Number 3). Aggregate producing a colour darker than the standard colour will be rejected in the absence of a satisfactory record of performance of a similar class of concrete (minimum 30 tests over the last 12 months); provisions 4.2.3.3.3.2 (a) and (b) of CSA Standard A23.1 shall not apply.

The potential for deleterious alkali-aggregate reactivity shall be assessed in accordance with CSA Test Method A23.2-27A. This assessment shall include the risk level associated with structure size and environment, the level of prevention related to design life requirements and the determination of the appropriate preventative measures, including testing in accordance with

CSA Test Method A23.2-28A. Current (less than 18 months old) test data evaluating the potential alkali-silica reactivity of aggregates tested in accordance with CSA Test Method A23.2-14A or CSA Test Method A23.2-25A is required. In the absence of current test data and

outside of areas of known highly reactive aggregate, the aggregate shall be presumed to be moderately reactive. Contrary to Test Method A23.2-27A, the total alkali content (Na2O equivalent) contributed by the Portland cement to the concrete mix shall not exceed:

- 2.2 kg/m^3 for aggregates classed as moderately reactive.
- 1.8 kg/m^3 for aggregates classed as highly reactive. Aggregates classed as extremely reactive shall not be used.

Petrographic analysis on the proposed coarse aggregates shall be performed in accordance with CSA Test Method A23.2-15A by experienced personnel employed by a CSA certified laboratory. The (weighted) petrographic number shall not exceed 125, and the ironstone content shall not exceed 0.8%. The petrographic analysis report shall be stamped by either a Professional Engineer, a professional geologist, or a geological engineer registered in the Province of Saskatchewan.

The sampling and testing of aggregates, and the concrete mix design shall be completed by an independent CSA certified and qualified concrete testing laboratory. Concrete mix designs including sampling and testing of aggregates may be completed by the concrete supplier, with the condition that documentation is stamped by a Professional Engineer. For either situation, the mix design including sampling and testing shall be reviewed and stamped for compliance with the respective specifications, by an independent CSA certified and qualified concrete testing laboratory. For either case, the testing laboratory shall provide an engineering opinion that the concrete aggregate and mix designs are acceptable for the intended use and are expected to perform to specified standards.

Concrete mixes that will be placed by concrete pump shall be designed for pumping.

Notwithstanding the Ministry's review of, or failure to review, the concrete mix designs, it remains Project Co's responsibility to meet the Technical Requirements.

300.4.2.5.5 Mix Adjustments

For all classes of concrete other than Type DC and Type DC with steel fibres, if during the progress of the work the mix design is found to be unsatisfactory for any reason including poor workability, Project Co shall make the necessary adjustments, and shall provide details of all adjustments to the Ministry for review in accordance with Schedule 9 – Review Procedure. Notwithstanding the Ministry's review of, or failure to review, the concrete mix design adjustments, it remains Project Co's responsibility to meet the Technical Requirements.

300.4.2.5.6 Measurement of Materials

Coarse and fine aggregate materials shall be separated and measured separately by weighing. The apparatus provided for weighing the aggregates and cement shall be suitably designed and constructed for this purpose. Each size of aggregate and the cement shall be weighed separately. The accuracy of weighing devices shall be such that successive quantities can be measured to within 1% of the desired amount. When aggregates are measured by mass, batch masses shall be based on the required mass of saturated surface dry aggregate corrected for the moisture conditions of the aggregate at the time of batching.

The mix water shall be measured by volume or by weight. The water measuring devices shall be capable of control accurate to +/- 0.5% of the design quantity. Adjustments for free water contained in batched materials, such as free water in the aggregates, water contained in admixture solutions, shall be made to the quantity of water to be batched.

Air entraining agent or other admixtures shall be added to the mix in a water-diluted solution. For mix adjustments at the site, Project Co shall provide facilities to control the amount of superplasticizer and air entrainment so that the required tolerances can be met.

300.4.2.6 Mixing and Delivery of Concrete

Batching equipment shall comply with the requirements of CSA Standard A23.1.

Mobile continuous mixers or other such concrete supply equipment shall not be used.

All concrete shall be mixed thoroughly until it is uniform in appearance, with all ingredients uniformly distributed. In no case shall the mixing time per batch be less than one minute for mixers of one cubic metre capacity or less. Mixing time shall be increased by 15 seconds for each additional half cubic metre capacity or part thereof. The mixing period shall be measured from the time all materials are in the mixer drum. The “batch” is considered as the quantity of concrete inside the mixer.

Project Co shall in no case load the mixer above its rated capacity. Project Co shall maintain the mixer in good condition. Inner surfaces of the mixer shall be kept free of hardened concrete and mortar. Mixer blades which are bent or worn down so as to affect the mixing efficiency shall be renewed. Any mixer leaking mortar or causing waste of materials through faulty charging shall be taken out of service until repaired. Project Co shall, at all times, operate the mixer at the speed recommended by the manufacturer and shall, if requested, supply the manufacturer's certification of the mixing capacity of the machine in use.

The mixer shall be fitted with an accurate and dependable means for measuring the water added, which is not affected by variation in pressure in the water supply line. All joints, valves and other parts shall be maintained so that there is no leakage of water into the mixer drum. Mixers that do not have an accurately working and dependable water gauge shall not be used.

Water shall be released first and continue to flow while the solid materials are entering the mixer. The water discharge pipe shall be so arranged and be of such size that the flow into the mixer is completed within the first quarter of the mixing time, and the water is delivered well within the mixer where it will be quickly mixed with the entire batch.

Air entraining agents and admixtures shall be placed in the mixer after the initial water is in the mixer drum but before the remaining materials are added. Superplasticizer shall be added after initial mixing and as per the manufacturer's recommendation.

300.4.2.6.1 Truck Mixing

Truck mixers shall be of the revolving drum type, watertight, and so constructed that the concrete can be mixed to ensure uniform distribution of materials throughout the mass. All materials for the concrete shall be accurately measured and charged concurrently at the proportions which satisfy the approved mix design into the drum at the production plant. Increases in water-cement ratio will not be permitted.

Mixing drums shall be clean and empty before being charged.

The drum shall be rotated at the manufacturers' recommended mixing speed during charging and mixing.

Concrete shall be mixed to the uniformity requirements of CSA Standard A23.1, Section 5.2.3.5.

The maximum size of batch in truck mixers shall not exceed the maximum rated capacity of the mixer as stated by the manufacturer and stamped in metal on the mixer. Truck mixing shall commence immediately upon introduction of ingredients into the drum and be continued for not less than 70 revolutions, with the mixing rate being in accordance with the manufacturer's recommended rate, and shall be such as to thoroughly mix the concrete.

When adjustment to the mix by adding air entraining agent or superplasticizer at the site is made, the mixer shall rotate for a minimum of 70 additional revolutions to ensure homogeneity of the concrete before discharge. Discharge chutes shall be kept clean and free from hardened concrete and shall be wetted down prior to use.

300.4.2.6.2 Time of Hauling and Placement

The maximum time allowed for all classes of concrete other than Type DC and Type DC with steel fibres including delivery to the site of the work and discharge shall not exceed 90 minutes after batching. For Type DC and Type DC with steel fibres this requirement is reduced to 70 minutes. In hot weather, or under conditions contributing to quick setting of the concrete, a further reduction in these times shall be considered. Batching of all classes of concrete is considered to occur when any of the mix ingredients are introduced into the truck mixer drum, regardless of whether or not the drum is revolving.

Time of placement extensions will be considered on a case by case basis and may require the use of hydration stabilizing admixtures (HSA's) conforming to the requirements of ASTM Specification C494 Type B, retarding or Type D, water-reducing and retarding admixtures.

Guidelines for the use of HSA's shall be as follows:

- When HSA's are used, concrete shall be fully discharged and placed within 3 hours after water and cement have been combined.
- When HSA's are used, these time extensions are subject to preconstruction trials being conducted by the Construction Contractor to establish the appropriate HSA dosage to provide suitable extended slump life of concrete without increasing the water/cementitious ratio of the concrete above that which would be required if HSA's were not used.
- The use of HSA's shall in no instance modify the maximum concrete temperature required at time of placement.
- A one time only addition of HSA will be allowed, this will be during initial batching of the concrete or immediately at completion of batching as recommended by the admixture manufacturer.
- Addition of HSA at any other time will be cause for rejection of the concrete.

300.4.2.6.3 Delivery

The concrete supplier shall have sufficient plant capacity and satisfactory transporting equipment to ensure continuous delivery at the rate required. The rate of delivery of concrete during concreting operations shall be such that cold joints will not develop. The methods of delivering and handling the concrete shall facilitate placing with a minimum of rehandling, and without damage to the structure or the concrete. Delivery of mixed concrete in non-agitating equipment will not be permitted.

300.4.2.6.4 Discharge Temperature

The temperature of all classes of concrete not containing silica fume shall be between 13° Celsius and 25° Celsius at discharge. Temperature requirements for Type DC and Type DC with steel fibres shall be between 10° Celsius and 17° Celsius at discharge.

300.4.2.7 Inspection and Testing

The Ministry shall be afforded full access for any inspections that it may carry out relative to the concrete itself and/or the constituent materials. This includes at the worksite and any plant used for the manufacture of concrete wherever this may be situated. The access shall be adequate to permit proper sampling of concrete, making of test cylinders and testing slump and air content.

The proper storage of all site cast concrete cylinders in accordance with the relevant specifications, including cylinders cast by the Ministry, is the responsibility of Project Co and adequate cylinder storage space shall be provided prior to any concrete pour.

Project Co shall utilize CSA certified testers with extensive related experience to test at site, the air content, density slump and temperature of each batch. Additional tests shall be done if the results are borderline or widely variable. In case of an unacceptable result, one check test will be accepted. The certified testers shall cast the test cylinders as specified in Section 300.4.2.7.3 of Schedule 15-2 – Design and Construction. The certification of the testers shall be current and available for ad hoc auditing by the Ministry.

Current summaries of concrete testing results including bridge identification pour location, cylinder identification, slump, air, and individual and average compressive strengths at 7 days and 28 days shall be kept by concrete type for each bridge, and these summaries shall be forwarded to the Ministry at the end of every month.

300.4.2.7.1 Strength Tests

A strength test shall consist of the compression tests of four standard test specimens, sampled, made, cured, and tested in accordance with CSA Standards as modified herein. One cylinder shall be tested at seven days. The 28-day test result shall be the average of the strengths of the remaining three specimens, except that any specimens in a test showing distinct evidence of improper sampling, molding or testing, shall be discarded and the remaining strengths averaged. Additional cylinders may be cast, at the discretion of Project Co.

For Type DC and Type DC with steel fibres Project Co shall take a strength test to represent each approximate 20 m^3 portion of the concrete pour, to a minimum of one strength test for every two loads of concrete. For all other concrete, Project Co shall take a strength test to represent each bridge element or portion of the element (e.g. abutment seat, abutment backwall, pier footing, and pier cap. On larger pours a strength test shall be taken to represent each approximate 30 m^3 portion of the concrete pour, to a minimum of one strength test for every three loads of concrete. Such tests shall be taken from representative batches.

300.4.2.7.2 Sampling

Sampling of concrete shall be carried out in accordance with CSA Test Method A23.2-1C.

When a concrete pump is used to place concrete, sampling shall be at the end of the discharge hose.

300.4.2.7.3 Test Cylinders

Making and curing concrete test cylinders shall be carried out in accordance with CSA Test Method A23.2-3C, except that the time for cylinders to reach the testing laboratory shall be between 20 and 48 hours. The test cylinders shall be cast by Project Co in standard CSA

approved heavy duty steel or plastic moulds. Plastic moulds shall have a wall thickness of at least 6 mm. Project Co shall provide properly designed temperature-controlled storage boxes for test cylinders, as specified in section 8.3.2.1 of CSA Test Method A23.2-3C for a period of at least 24 hours and for protection, from adverse weather and mishandling until removed from the site. Project Co shall provide a max-min thermometer for each storage box and record site curing temperatures for all test cylinders. Storage in a portable building which shall be used by Project Co's personnel or the Ministry during the first 24-hour storage period is not permitted. Storage facilities shall be provided, installed, and reviewed by the Ministry before any concrete is placed.

Handling and transporting of the cylinders shall be in accordance with CSA Test Method 23.2-3C. No extra laboratory curing time shall be allowed for cylinders that are delivered late to the laboratory. For Type DC and Type DC with steel fibres, the ends of cylinders shall be ground flat prior to testing.

If the test cylinders exhibit frost etchings or were stored at temperatures below 10° Celsius or above 25° Celsius, or are otherwise mishandled resulting in unreliable strength test results, Project Co shall reject those portions of the work represented by the cylinders unless the strength of the concrete is confirmed by core testing in accordance with Section 300.4.2.18 of Schedule 15-2 – Design and Construction.

300.4.2.7.4 Slump

Slump tests shall be conducted in accordance with CSA Test Method A23.2-5C.

300.4.2.7.5 Air Content and Density

Air content and density tests shall be made in accordance with CSA Test Method A23.2- 4C and A23.2 – 6C respectively.

300.4.2.7.6 Testing Cylinders

Test cylinders shall be tested in compression in accordance with CSA Standard A23.2 by an independent CSA certified testing laboratory engaged by Project Co.

300.4.2.7.7 Failure to Meet Slump or Air Content Specifications

If any batch of concrete fails to meet slump or air content specifications, attempts at mitigation shall be limited to adjusting the quantities of superplasticizer and air entraining agent at site. When super plasticized concrete falls below the designated slump due to delay, it shall be re-tempered with super plasticizing admixtures only, not water, and shall only receive a maximum of one re-tempering. Project Co shall reject any batch in the event of confirmed unacceptability as determined by quality control tests, and shall immediately remove any concrete from this batch which may have already been placed in the structure.

300.4.2.8 Falsework and Formwork

300.4.2.8.1 General

All falsework and formwork drawings shall be prepared and sealed by a Professional Engineer, and inspected prior to placing concrete to confirm that it is in conformance with the design and drawings. The drawings shall be submitted a minimum of two weeks before the start of installation.

No load shall be placed on the formwork or falsework until the Professional Engineer responsible for the design has inspected and certified, in writing, that the work has been carried out in accordance with the formwork drawings and specifications and a copy of the formwork Engineer of Record's certification has been provided to the Quality Manager, and when requested, to the Ministry.

Formwork and falsework shall be designed, supplied, installed and removed in accordance with CSA Standard S269.3 and the requirements for concrete formwork and falsework given in the Saskatchewan Employment Act and *The Occupational Health and Safety Regulations*, 1996 unless otherwise noted.

All forms shall be of wood, metal or other acceptable materials, and shall be designed and built mortar-tight and of sufficient rigidity to prevent distortion due to the pressure of vibrated concrete and other loads incidental to the construction operation. The forms shall be substantial and unyielding, and shall be designed so that finished concrete will conform to the design dimensions and contours. The shape, strength, rigidity, water tightness and surface smoothness of re-used forms shall be maintained at all times. Any warped or bulged formwork shall be repaired or replaced before being used. For narrow walls and columns, where the bottom of the form is inaccessible, removable panels shall be provided in the bottom form panel to enable cleaning out of extraneous material immediately before placing the concrete. Forms which are unsatisfactory in any respect shall not be used.

All falsework shall be designed and constructed to provide the necessary rigidity and to support the loads without appreciable settlement or deformation. Falsework which cannot be founded on a satisfactory footing shall be supported on piling. All falsework and temporary formwork shall be completely removed from the permanent Works.

All formwork shall be removed from the completed structure.

300.4.2.8.2 Standard Details

Refer to Drawing SK-3 (Standard Concrete Joints) and Alberta Transportation standard drawings S-1412-99 (Standard Construction Joints) and Drawing SK-4 (Deck Water Proofing System With 80mm Two Course Hot-Mix ACP) for details of joints.

300.4.2.8.3 Deck Formwork

Prior to commencing deck formwork, Project Co shall profile all the girders and determine the deck concrete thickness and girder haunch dimensions required to achieve the specified grade line, and shall perform an independent check to confirm the girder survey and haunch calculations. In the event that actual girder camber values vary significantly from the estimated values indicated on the drawings, Project Co may raise or lower the grade line accordingly.
Project Co shall design and install support brackets to avoid damage to girder flanges and webs. Where brackets bear against girder webs, Project Co shall protect the contact surface with timber or neoprene softeners. No drilling of additional holes, or any other modifications including field welding, shall be made to the superstructure elements. Effects of concentrated loads on thin webs shall be checked, and where necessary, sufficient means shall be provided to distribute or carry such concentrated loads to the supporting flanges or stiffeners. Formwork for decks, curbs, sidewalks and parapets shall be fabricated so that the lines and grades shown on the drawing are achieved, with adjustments made where necessary to compensate for variances in girder dimensions, positioning, alignment and sweep.

300.4.2.8.4 Forms for Exposed Surfaces

Forms for exposed surfaces which require a Class 1 "Ordinary Surface Finish" shall be made of good quality plywood, or an equivalent, of uniform thickness, with or without a form liner. Forms for exposed surfaces requiring a Class 2 "Rubbed Finish" or Class 3 "Bonded Concrete Surface Finish" are designated “coated formply”, which shall be all new material consisting of Douglas Fir substrate with resin-impregnated paper overlay and factory treated chemically active release agent. All form material for exposed surfaces shall be full-sized sheets, as practical.

All forms for exposed surfaces shall be mortar-tight, filleted at all sharp corners, and given a bevel or draft in the case of all projections. All corners of exposed surfaces shall have formed chamfers.

The minimum acceptable forming for all exposed concrete where the pour height is 1.5 m or less shall have 18 mm approved plywood, supported at 300 mm maximum on centres. Where the pour height is greater than 1.5 m the minimum acceptable forming for all exposed concrete shall have 18 mm approved plywood supported at 200 mm maximum on centres. The support spacings specified here assume the use of new material. Closer spacings may be required in case of re-used material. Strong-backs or walers placed perpendicularly to the supports shall be employed to ensure straightness of the form.

Metal bolts or anchorages within the forms shall be so constructed as to permit their removal to a depth of at least 20 mm from the concrete surface. Break-back type form ties shall have all spacing washers removed and the tie shall be broken back a distance of at least 20 mm from the concrete surface. All fittings for metal ties shall be of such design that, upon their removal, the cavities which are left will be of the smallest possible size. Torch cutting of steel hangers and ties will not be permitted. Formwork hangers for exterior surfaces of decks, including underside surfaces, shall be an acceptable break-back type with surface cone, or removable threaded type.

All cavities created from ties or associated hardware removal shall be filled with an approved concrete patching material and the surface left sound, smooth, even and uniform in colour. When plastic sleeves with removable inner rods are used, the plastic sleeves shall be removed for a distance of 100 mm back from the face of the concrete, except for curbs, barriers and medians where the entire plastic sleeve shall be removed. The entire cavity shall be filled with an approved non-shrink grout.

300.4.2.8.5 Protection of Atmospheric Corrosion Resistant (Weathering) Structural Steel

Where members are fabricated of weathering steel, it is essential that the uniformity of rust formation is not adversely affected by Project Co's operation.

Project Co shall exercise utmost care and provide the necessary protection to prevent marking or staining of the girders. All joints between deck formwork and steel members (including interior girders, and diaphragms) shall be sealed to prevent leakage of cement paste or concrete. Caulking, duct tape, “Ethafoam”, or any other suitable means or material, shall be used to achieve the seal.

Should foreign material spill onto the girders despite the protection provided, Project Co shall clean off, wash, and sandblast and repair coatings at the contaminated areas.

Weathering patina shall be restored by repeatedly fogging the girder faces with clean water and allowing them to dry. Fogging should leave the girders wet but not "running wet", and should be repeated when the girders are completely dry.

300.4.2.8.6 Protection of Sub-Structure from Staining

Project Co shall take precautions to protect all concrete work from staining prior to the deck, curb or barriers being cast and deck joints installed. All staining shall be removed and the specified finish completed.

300.4.2.9 Handling and Placing Concrete

300.4.2.9.1 General

The method of concrete placement shall have a consistent minimal impact on the concrete properties. All the necessary equipment for any particular pour shall be on site and proven to be in working condition before the pour commences, with backup equipment on site. The equipment shall be well maintained, suitable in kind and adequate in capacity for the work.

In preparation for the placing of concrete, all sawdust, chips and other construction debris and extraneous matter shall be removed from the interior of forms. Struts, stays, and braces, serving temporarily to hold the forms in correct shape and alignment, pending the placing of concrete at their locations, shall be removed when the concrete placing has reached an elevation rendering

their service unnecessary. These temporary members shall be entirely removed from the forms and not buried in the concrete.

Concrete shall be placed so as to avoid segregation of the materials and the displacement of the reinforcement. When placing operations would involve free drop of concrete by more than 1 m, it shall be deposited through metal or other acceptable pipes.

Concrete for the structure shall be deposited in the forms in the order indicated on the Design Data, and each portion placed between construction joints shall be placed in one continuous operation. Concrete placing operations shall not work off, or transport concrete directly over concrete already placed, when this concrete is less than 48 hours old, no matter what system of runways, supports or protection is used on the surface of the concrete already placed if it is subjected thereby to live or dead loads.

300.4.2.9.2 Consolidation

Concrete, during and immediately after depositing, shall be thoroughly consolidated. The consolidation shall be done by mechanical vibration, and subject to the following conditions:

- The vibration shall be internal;
- Vibrators shall be capable of transmitting vibrations to the concrete at frequencies of not less than 4500 impulses per minute;
- The intensity of vibration shall be such as to visibly affect a mass of concrete of 25 mm slump over a radius of at least 0.5 m;
- Project Co shall provide a sufficient number of vibrators to properly compact each batch immediately after it is placed in the forms;
- Vibrator operators shall be suitably instructed in the use of vibrators, and the importance of adequate and thorough vibration of the concrete;
- Vibrators shall be manipulated so as to thoroughly work the concrete around the reinforcement and embedded fixtures, and into the corners and angles of the forms. Vibration shall be applied at the point of deposit and in the area of freshly deposited concrete. The vibrators shall be inserted vertically and withdrawn out of the concrete slowly. The vibration shall be of sufficient duration and intensity to thoroughly compact the concrete, but shall not be continued so as to cause segregation. Vibration shall not be continued at any point to the extent that localized areas of grout are formed. Application of vibrators shall be at points uniformly spaced and not farther apart than the radius over which the vibration is visibly effective;
- Vibration shall not be applied directly or through the reinforcement of sections or layers of concrete which have hardened to the degree that the concrete ceases to be plastic under vibration. It shall not be used to make concrete flow in the forms over distances so great as to cause segregation, and vibrators shall not be used to transport concrete in the forms; and

- Vibration shall be supplemented by such spading as is necessary to ensure smooth surfaces and dense concrete along form surfaces and in corners and locations impossible to reach with the vibrators.

Once vibrated, Project Co shall avoid disturbing concrete, and shall not step into it or add additional concrete after vibration.

300.4.2.9.3 Additional Requirements

When concrete placing is discontinued, for whatever reason, all accumulations of mortar splashed on the reinforcing steel and the form surfaces shall be removed. If the accumulations are not removed prior to the concrete becoming set, care shall be exercised not to injure or break the concrete-steel bond at and near the surface of the concrete, while cleaning the reinforcing steel.

Concrete shall be placed while fresh and before it has taken its initial set. Partially hardened concrete shall not be re-tempered with additional water. No concrete shall be used which does not reach its final position in the forms within the time stipulated in Section 300.4.2.6.2 of Schedule 15-2 – Design and Construction above.

After initial set of the concrete, the forms shall not be jarred and no strain shall be placed on the ends of reinforcing bars which project.

Concrete which would be adversely affected by the presence of freestanding water shall be protected to prevent its occurrence, and Project Co shall take whatever steps may be necessary to prevent free water build-up in the event of unexpected rainfall or similar occurrences for the first 24 hours.

Water used to keep equipment clean during the pour, or to clean equipment at the end of the pour, shall be discharged clear of the structure and any water channel.

Any damaged concrete such as honeycomb, cavities, cracking and other casting defects shall be repaired. Repair procedures shall be developed by Project Co and submitted for review in accordance with Schedule 9 – Review Procedure and Part 7 of Schedule 14 – Integrated Management System, by the Ministry prior to the commencement of the repair.

Honeycomb, Cavities, Casting Defects

Honeycomb, cavities and other deficiencies are defined as those areas that are greater than 30 mm in depth or 0.1 m2 in area.

As a minimum the repair procedure shall include removing and replacing the damaged concrete with the originally specified class of concrete. Repair extents shall be saw cut 25 mm deep in neat perpendicular lines and concrete removed to a depth of 25 mm below reinforcing steel.

Repair areas shall be roughened to remove all loose material and laitance. Exposed reinforcing steel shall be clean and repaired to its original condition. Repair areas shall be saturated with water for a period of 24 hours prior to concrete placement. Curing shall be in accordance with the requirements for the class of concrete.

Formwork misalignment for highly visible components, including barriers, pier shafts, and exterior faces of wingwalls shall in no case exceed 3 mm in any direction. Formwork misalignment for all other components shall in no case exceed 5 mm in any direction. Concrete sections with formwork misalignments exceeding the allowable tolerances shall be removed and recast.

Cracks

In addition to the requirements stated in Section 300.4.2.15.4 of Schedule 15-2 – Design and Construction, all cracks 0.2 mm or greater in width, for all classes of concrete, shall be repaired by epoxy injection in accordance with the manufacturer's recommendations.

300.4.2.9.4 Pumping

The operation of the pump shall produce a continuous flow of concrete without air pockets. The equipment shall be so arranged that the freshly placed concrete is not damaged by any form of vibration caused by the pump. When pumping is completed, the concrete remaining in the pipeline, if it is to be used, shall be ejected in such a manner that there will be no contamination of the concrete or separation of the ingredients.

300.4.2.10 Placing Pile Concrete

300.4.2.10.1 General

Project Co shall make every attempt to obtain a dry pile hole prior to placing pile concrete. The placement of pile concrete under water will only be permitted in the event that all attempts at obtaining a dry hole fail.

300.4.2.10.2 Concrete Placed in the Dry

Pile concrete shall be placed by means of a hopper equipped with a centre pipe drop tube. The pipe drop tube shall be a minimum of 200 mm in diameter and 2 m long. Concrete may be placed free fall, providing the fall is vertically down the centre of the casing or drilled hole and there are no transverse ties or spacers. Concrete in the upper 3 m of the piles shall be consolidated by the use of an approved concrete vibrator.

300.4.2.10.3 Concrete Placed Under Water

Placement of pile concrete under water shall be in accordance with Section 300.4.2.14 of Schedule 15-2 – Design and Construction. In addition, all drilled pile shafts cast under water shall be inspected by Crosshole Sonic Logging ("**CSL**") to check structural integrity.

In order to test for voids or other abnormalities in the concrete, all drilled pile shafts cast under water shall be equipped with steel access tubes to permit inspection by CSL. Project Co shall submit the proposed method for review in accordance with Schedule 9 – Review Procedure, 2 weeks before beginning drilled pile work. Project Co shall supply and install four 50 mm inside diameter tubes in each drilled pile with a diameter of 1.5 m or less and six tubes in each pile with a diameter greater than 1.5 m.

Tubes supplied shall be round and have a regular internal diameter that is free from defects, obstructions and joints, and shall be watertight, free from corrosion and have clean internal and external faces to ensure a good bond between the concrete and the tubes. Tubes may be extended with watertight mechanical couplings but all coupling locations shall be recorded. Tubes shall be installed in a manner that the CSL probes pass through the entire length of the tube without binding.

Project Co shall fit all tubes with watertight shoes on the bottom and removable caps on the top. Tubes shall be secured to the interior of the reinforcement cage at least every 1.2 m along the length of the pile. Tubes shall be installed uniformly and equidistantly around the circumference of the pile such that all tubes are parallel for their full length. Tubes shall extend to within 150 mm of the drilled shaft bottoms, and shall extend a minimum of 600 mm above the drilled shaft tops or where they are accessible. Tubes shall be capped to prevent debris from entering the access tubes.

Project Co shall ensure that CSL tubes are not damaged during the installation of the reinforcement cage. If testing equipment does not pass through the entire length of the CSL tube, a 50 mm diameter core hole shall be drilled. Special care shall be taken to avoid tube debonding between the concrete and the tubes. If tube debonding occurs, Project Co shall core drill a 50 mm diameter hole to the depth of debonding for each debonded tube.

Project Co shall make CSL measurements at depth intervals of 65 mm from the bottom of the tubes to the top of each pile. Upon completion of testing and acceptance of the pile concrete, the tubes shall be filled with an approved grout mix.

Qualifications

The testing agency hired by Project Co shall have a minimum of three years of experience in CSL testing and have a Professional Engineer supervising the testing and interpretation of results. Project Co shall provide written evidence of successful completion of CSL tests by the testing agency on drilled piles in the Province of Saskatchewan. Project Co's submission of such written evidence shall also include personnel qualifications and equipment description.

CSL Results

The condition of the concrete piles shall be evaluated based on the results of the CSL testing according to the criteria listed in the table below. Project Co shall not grout the CSL tubes or perform any further work on the CSL tested drilled piles until it has been demonstrated to the Engineer of Record's satisfaction that the drilled pile is acceptable.

Concrete Condition Rating Criteria

Rating	Velocity Reduction (1)	CSL Results
Good ("**G**")	≤ 10%	Good quality concrete
Questionable ("**Q**")	>10% & <20%	Minor contamination or intrusion: questionable quality concrete
Poor/Defect ("**P/D**")	≥ 20%	Defects exists, possible water/slurry contamination, soil intrusion and/or poor quality concrete
No Signal ("**NS**")	No Signal Received	Soil intrusion or other severe defect absorbed the signal

(1) From highest measured signal velocity in the comparable zone

CSL test results with ratings other than "G" shall be considered unacceptable and shall result in rejection of the pile. However, in the event that Project Co elects to carry out further investigation to prove the acceptability of the pile, boundaries of any defective/unconsolidated zones shall be delineated by means of cross-hole tomography, supplemented by additional testing as required by the designer. This additional testing may include 3D tomographic imaging, single-hole sonic testing, sonic echo or impact response tests, or concrete coring. Project Co shall then submit to the Ministry pursuant to Schedule 9 – the Review Procedure a full report signed and stamped by the Engineer of Record that demonstrates the functionality of the pile, including test summaries, results and analyses.

Pile edge defects are considered critical and any defects that expose the rebar are not acceptable under any circumstance and shall result in rejection of the pile.

The depth, location, diameter and number of core holes when concrete coring is required shall be proposed by Project Co in a written submittal pursuant to Schedule 9 – Review Procedure. If the Ministry is concerned about concrete strength or requires the use of a borehole camera for inspection, large diameter cores may be required. A minimum of two cores would be required to intercept the suspected defect zones.

Correction of Unacceptable Drilled Pile

When a drilled pile is unacceptable, Project Co shall submit a remedial action plan with supporting calculations for review in accordance with Schedule 9 – Review Procedure, by the Ministry. The remedial action shall be designed by Project Co and stamped by a Professional Engineer.

300.4.2.11 Placing Type DC Concrete and Type DC Concrete with Steel Fibres

300.4.2.11.1 General

Project Co shall not place Type DC concrete or Type DC concrete with steel fibres without using established cold weather concreting procedures when the air temperature is below 5° Celsius, or expected to fall below 5° Celsius during the curing period, or when the ambient temperature is above 25° Celsius, or in the event of rain or excessive wind or dust, or when there are other conditions detrimental to the concrete.

Deck, abutment roof slab, approach slab and deck overlay concrete shall be placed between the hours of 6:00 pm and 10:00 am of the following day, except in occasional exceptional circumstances when the sky will be overcast for the duration of the pour, the ambient temperature is below 15° Celsius, and it can be demonstrated that no detrimental conditions will occur despite placing concrete outside the specified hours. Deck, abutment roof slab, approach slab and deck overlay concrete shall not be placed when the evaporation rate exceeds 0.5 $kg/m^2/hr$. The evaporation rate shall be determined using Figure D.1, of CSA Standard A23.1 – Annex D. The rate of evaporation shall be recorded as concrete placing operations progress and Project Co shall make all necessary adjustments to ensure the evaporation rate does not exceed the specified limit. Proper lighting shall be provided for night pours. The temperature of the concrete during discharge shall be in accordance with Section 300.4.2.6.4 of Schedule 15-2 – Design and Construction. The temperature of the mix shall be controlled by the inclusion of ice to the mix which shall not alter the design water cementing materials ratio. Immediately prior to placing concrete, the substrates shall be thoroughly wet with clean water.

All deck concrete and deck overlay concrete shall be consolidated in accordance with Section 300.4.2.9.2 of Schedule 15-2 – Design and Construction even when vibratory drum type finishing machines are used.

300.4.2.11.2 Placing/Finishing Machines

For all deck concrete and deck overlay concrete, screeding shall be by concrete placing/finishing machines as follows or equivalents:

- Bidwell Model RF200, 364, 2450, 3600 and 4800
- Gomaco Model C450 and C750

Project Co shall provide two work bridges, separate from the placing/finishing machine, of adequate length to completely span the width of the pour, and shall provide details of these to the Ministry for review in accordance with Schedule 9 – Review Procedure. The work bridges will facilitate the operations of concrete finishing and placing of curing blankets. The work bridges shall be supported essentially parallel to the concrete surface, between 250 mm and 600 mm above the concrete surface, and shall be at least 800 mm wide to permit diverse uses concurrently, and be rigid enough that dynamic deflections are insignificant.

300.4.2.11.3 Screed Guide Rails

Steel screed guide rails shall be installed to suit the profile of the required surface and to ensure a smooth and continuous surface from end to end of the bridge, as well as run off length at both ends of a pour to allow finishing of the full length of any pour by the screed machine. Guide rails shall be located outside of the finished surface of the pour, and shall extend beyond the ends of the bridge to accommodate finishing of the entire surface with the deck finishing machine.

300.4.2.11.4 Dry-Run

The finishing machine shall be set-up to match the skew angle of the bridge, when the skew angle exceeds 15°. For skewed bridge structures on vertical curves, this requirement may be altered to suit actual site conditions.

The finishing machine and guide rails shall be adjusted so that the height of the screed will finish the concrete to the design grade line and crown. To confirm the adjustment of the machine and guiderails, the screed shall be dry-run prior to the pour and clearance measurements taken at each of the girder tenth points. Project Co shall perform an independent check to confirm the resulting design surface profile, deck thickness and rebar cover. Re-setting of the machine and/or screed rails shall be done as necessary, to obtain an acceptable dry-run. Adjustments to the machine or screed rails shall not be done after an acceptable dry-run has been completed. The dry run shall be done again if the finishing machine is lifted off the screed rails for repositioning.

Where screed rails are supported on cantilevered formwork that could deflect under the weight of the fresh concrete and the deck finishing machine, Project Co shall pre-load a section of the cantilevered formwork on each side of the bridge to determine deflections that will occur during concrete placement. The formwork, machine and/or screed rails shall be adjusted to compensate for the expected formwork deflection.

300.4.2.11.5 Screeding Concrete

Concrete shall be placed as close as practical ahead of the finishing machine, and at no time more than 6 m in front of the trailing end of the finishing machine's roller. The screed shall be moved slowly and at a uniform rate. In general the direction of the pouring shall be from the low end of the bridge to the high end. A roll of concrete shall be maintained along the entire front of the screed at all times to ensure the filling and consolidation of the surface concrete. Project Co shall also ensure that the required concrete thickness is being placed by randomly probing the

concrete behind the finishing machine.

Screeding shall be completed in no more than two passes. The screed shall not be allowed to run except when screeding is actually in progress. The screeded surface shall not be walked on or otherwise damaged.

300.4.2.11.6 Bull Floating/Surface Texturing

The concrete surface produced behind the finishing machine shall be manually bull floated with a magnesium bull float to ensure that the surface is free from open texturing, plucked aggregate and local projections or depressions. Bull floating and surface texturing shall follow as close as practically possible behind the screed. It is imperative that competent workers be employed to carryout bull floating and surface texturing.

Evaporation reducer or water shall not be finished into the concrete at any time during finishing operations.

The surface shall be checked for tolerance by Project Co with a 3 m long straight edge immediately after final bull floating and before texturing or application of evaporation reducer.

300.4.2.11.7 Surface Defects and Tolerances

The finished surface of the concrete shall conform to the design grade line profiles as indicated in the Design Data.

The surface shall be free from open texturing, plucked aggregate and local projections.

Except across the crown, the surface shall be such that when checked with a 3 m long straight edge placed anywhere in any direction on the surface, there shall not be any gap greater than 3 mm between the bottom of the straight edge and the surface of the deck.

Areas that do not meet the required surface accuracy shall be clearly marked out and Project Co shall:

- Grind down any areas higher than 3 mm but not higher than 10 mm above the correct surface.
- Correct any areas lower than 3 mm but not lower than 10 mm below the correct surface, by grinding down the adjacent high areas.
- When the deviation exceeds 10 mm from the correct surface, the deck slab shall be replaced for a length, width and depth which will allow the formation of a new slab, of the required quality, in no way inferior to the adjacent undisturbed slab. The perimeter of the joint created by the repair area shall be waterproofed in accordance with the joint details on Drawing SK-4 (Deck Water Proofing System With 80mm Two Course Hot-Mix ACP).

Grinding shall be carried out by a machine, of a type and capacity suitable for the total area of grinding involved, until the surface meets the specified requirements.

300.4.2.11.8 Deck Joint Assembly Installation

The finished surface of the concrete shall conform to the design grade line profiles as indicated in the Design Data. Project Co shall check the deck joint assembly grade, elevation, gap, and crown prior to concrete placement, and shall not place concrete if the deck joint assembly position is incorrect.

Project Co shall confirm the deck joint assembly grade, elevation, gap, and crown immediately after the concrete curing period. Measurements shall be done by instrument. If the deck joint assembly position is incorrect, Project Co shall promptly remove and replace the deck joint and concrete.

300.4.2.12 Construction Joints

300.4.2.12.1 General

Construction joints shall be made only where indicated in the Design Data or shown in the pouring schedule.

If not detailed in the Design Data, or in the case of emergency, construction joints shall be installed according to the standard drawings. Shear keys or inclined reinforcement shall be used where necessary to transmit shear, or to bond the two sections together. Construction joints shall be located to allow a minimum of 50 mm minimum concrete cover on reinforcing steel running parallel to the joint.

300.4.2.12.2 Bonding

Before depositing new concrete on or against concrete that has hardened, the forms shall be re-tightened and the surface of the hardened concrete shall be thoroughly cleaned and in a saturated surface dry condition. The placing of concrete shall be carried out continuously from joint to joint. The face edges of all joints that are exposed to view shall be carefully finished true to line and elevation.

300.4.2.13 Concreting In Cold Weather

Project Co shall accept full responsibility for the protection of concrete during adverse weather conditions. In addition to the requirements stated below, all concrete shall be cured in accordance with Section 300.4.2.15 of Schedule 15-2 – Design and Construction.

Cold weather concreting procedures shall be used when the ambient temperature is, or is forecast to be, below 5° Celsius during placement, and/or is forecast to fall below 5° Celsius during the first seven days after placing. The following requirements for cold weather concreting shall be put in place:

- All aggregate and mixing water shall be heated to a temperature of at least 20° Celsius but not more than 65° Celsius. The aggregates may be heated by either dry heat or steam; in the latter case the quantity of mixing water shall be reduced as necessary to maintain the mix design water cement ratio. The temperature of the concrete at the time of placing shall be in accordance with Section 300.4.2.6.4 of Schedule 15-2 – Design and Construction.
- Project Co shall enclose the structure in such a way that the concrete and air temperature within the enclosure can be kept above 10° Celsius for a period of seven days after placing the concrete.
- Enclosures shall be constructed with a minimum 300 mm clearance between the enclosure and the concrete. However, for casting of Type DC concrete an enclosure shall be constructed large enough to comfortably accommodate the men and equipment necessary to place finish and cure the Type DC concrete. In addition, the underside of the deck shall be suitably protected. For casting of Type DC concrete an enclosure is mandatory and no alternatives are acceptable.
- The relative humidity within the enclosure shall be maintained at not less than 95%.
- Heaters shall be kept well clear of the formwork housing. The system of heating, and positioning of steam outlets, heaters, and fans, shall be designed to give a uniform distribution of heat, and the use of salamanders, coke stoves, oil or gas burners and similar spot heaters that have an open flame and intense heat is prohibited. Heaters shall have air intakes outside the enclosures to prevent the accumulation of carbon dioxide within the enclosure.
- Before any concrete is placed, all ice, snow or frost shall be completely removed from the forms and reinforcing steel and the temperature of contact surfaces raised to a minimum of 5° Celsius, with such minimum established and maintained for at least one hour prior to placement.
- Heat shall be applied uniformly and at a rate which will not induce excessive thermal stresses in the section being heated.
- Ambient air temperatures shall not exceed concrete temperatures by more than 13°Celsius and shall be raised at a maximum rate of 2° Celsius/hr.
- Projecting reinforcing steel shall be insulated when temperatures are between 0° Celsius and -10° Celsius for a minimum of 300 mm away from the fresh concrete and for a minimum of 600 mm when temperatures are below -10° Celsius.

Fully insulated formwork may be used as an alternative to provision of further heat during the curing period. Project Co shall design and insulate such formwork to enable the initial heat of the mix, and the heat generated during the hydration of the cement, to maintain the specified curing conditions, throughout the curing period. In the event that the insulated formwork fails to maintain the specified curing conditions, Project Co is responsible for immediately implementing

supplementary measures to restore the specified curing conditions.

The adequacy of protection shall be monitored and recorded a minimum of every 4 hours for the first 72 hours, and every 8 hours for the remainder of the curing period, including measurement

of internal and surface concrete temperature and relative humidity. The protective measures shall be modified as necessary to maintain the specified curing conditions.

Protection and heating, where used, shall be withdrawn in such a manner so as not to induce thermal shock stresses in the concrete. The temperature of the concrete shall be gradually reduced at a rate not exceeding 10° Celsius per day to that of the surrounding air. To achieve this, in an enclosure, the heat shall be slowly reduced. The temperature differential between the core of the element and the surface of the element shall not exceed 20° Celsius. In addition the temperature differential between the surface of the element and the ambient air shall not exceed 15° Celsius. Ambient air temperature is defined as the temperature at mid-height and 300 mm from the surface of the element. Project Co shall measure the temperature of internal concrete, surface of the concrete and ambient air temperatures a minimum of every 4 hours, and shall make adjustments as necessary to keep the rate of cooling within the specified parameters.

300.4.2.14 Depositing Concrete Under Water

Concrete shall not be deposited in water unless this is unavoidable, in which case anti-washout admixtures incorporating viscosity modifiers (whelan gum, etc.) may be used.

Concrete to be deposited in water shall be of the specified type, with mix design modified to yield 170 mm +/- 30 mm slump, and with an excess of 15% of the cement quantity added beyond its normal designed amount. The mix shall contain an approved “anti-washout” admixture to enhance the performance of the mix. The concrete temperature shall be between 10° Celsius and 25° Celsius. The modified concrete mix design shall be reviewed and stamped by a Professional Engineer.

To prevent segregation, concrete shall be carefully placed in a compact mass, in its final position, by means of a concrete pump. When specifically reviewed by the Engineer of Record, a properly designed and operated tremie may be used. The concrete shall not be disturbed after being deposited. Still water shall be maintained at the point of deposit and the forms underwater shall be watertight.

The discharge end of the concrete pump line shall be lowered to the bottom of the form or hole. Pumping shall then proceed with the end of the discharge line being continually buried no less than 500 mm below the surface of fresh concrete at all times, to maintain a seal until the form or hole is completely filled with fresh uncontaminated concrete.

Concrete shall not be placed in water which is below 4° Celsius.

The surface of the concrete shall be kept as nearly horizontal as is practicable at all times. The

discharge end of the tremie shall be kept buried at least 500 mm in previously placed concrete.

Dewatering will not be permitted while concrete is being placed. Dewatering may proceed when the concrete seal is sufficiently hard and strong. All laitance or other unsatisfactory material shall be removed from the exposed surface by scraping, chipping or other means which will not injure the surface of the concrete.

300.4.2.15 Curing Concrete

300.4.2.15.1 General

Freshly deposited concrete shall be protected from freezing, abnormally high temperatures or temperature differentials, and premature drying, excessive moisture, and moisture loss through the curing period. This includes protection from freezing during the full duration of moist cure and for 12 hours after the removal of moist cure. In addition the temperature of the centre of in-situ concrete shall not fall below 10° Celsius or exceed 60° Celsius, and the temperature difference between the centre and the surface, as well as the temperature differential between top and bottom surfaces, shall be controlled to be within 20° Celsius. In addition, the requirements of Table 21 of CSA Standard A23.1 shall apply.

All concrete surfaces other than concrete slope protection shall be moist cured. Project Co shall cover the concrete surface(s) with a single layer of clean, light coloured curing blanket as soon as the surface will not be marred by so doing. The light coloured curing blanket shall be kept continuously wet for a minimum of 5 days unless otherwise specified. Where the formwork is left in place for 5 days or more, no additional curing will be required. Curing compound shall not be used on any concrete surfaces other than for concrete slope protection.

300.4.2.15.2 Curing Requirements for Concrete Slope Protection

Concrete slope protection shall receive two coats of a "Type 1-D" curing compound meeting the requirements of ASTM Specification C309 (or ASTM Specification C1315). The first coat is to be applied immediately after the concrete has been satisfactorily finished, and the second coat is to be applied within three hours after the application of the first coat. Each application shall be at the rate specified by the manufacturer. In cases where premature drying is severe or is anticipated to be severe, then moist curing, as specified in Section 300.4.2.15.1 of Schedule 15-2 – Design and Construction, shall be done prior to application of curing compound.

300.4.2.15.3 Curing Requirements for Type DC Concrete and Type DC Concrete with Steel Fibres

Project Co shall prepare a procedure for the wet cure of Type DC concrete and Type DC concrete with steel fibres. Details shall include information with regards to the type and

description of equipment and materials being used, and the work methods/techniques employed to satisfactorily carry out the work. The wet cure procedure shall be demonstrated to the Ministry for adequacy and suitability prior to scheduling placement of these types of concrete.

During the cure period for Type DC concrete and Type DC concrete with steel fibres, Project Co shall provide whatever means and take whatever actions are necessary to ensure that the concrete temperature and the temperature differences within the concrete remain within the limits specified in Section 300.4.2.15.1 of Schedule 15-2 – Design and Construction.

During the cure period Project Co shall provide protection to ensure that the difference between the concrete temperature and the ambient air temperature at the site remains within 5° Celsius. Project Co shall supply and install two thermocouples, one in the centre and one at the surface of the concrete, for every 100 m^2 of deck, at locations determined by the Engineer of Record. Project Co shall monitor and record the temperatures every four hours for the first 72 hours after concrete placement and every 8 hours thereafter for the remainder of the specified cure period and shall provide whatever means, and take whatever actions are necessary to ensure that the concrete temperature and the temperature differences within the concrete remain within the limits specified in Section 300.4.2.15.1 of Schedule 15-2 – Design and Construction. Project Co shall make these temperature readings available to the Ministry on a daily basis if requested.

For concrete decks, an evaporation reducer, such as “Confilm” manufactured by BASF or an approved equivalent, having a monomolecular film-forming compound intended for application to fresh concrete for temporary protection against moisture loss, shall be applied through a misting nozzle at the manufacturer’s recommended concentration and application rate immediately after final bull floating and/or surface texturing, prior to installation of the wet cure system. Evaporation reducer or water shall not be finished into the concrete at any time during finishing operation.

Two layers of light coloured curing blanket shall be placed on the fresh concrete surface as soon as the surface will not be marred as a result of this placement. A fine spray of clean water shall be immediately applied to the filter fabric until the filter fabric is saturated. Edges of the curing blanket shall overlap a minimum of 150 mm and shall be held in place without marring the surface of the concrete. The curing blanket shall be maintained in a continuously wet condition throughout the curing period, by means of soaker hoses or other means. Wet curing with filter fabric and water shall be maintained for a minimum period of 7 days at an average ambient temperature of 10° Celsius.

For those locations where formwork is removed prior to the completion of this specified curing period, the resulting exposed concrete surfaces shall be wet cured for the remaining days. Wet curing shall commence immediately after formwork removal.

In the event that any portion of the Type DC or Type DC with steel fibres becomes surface dry during the curing period, the concrete may be considered unacceptable.

300.4.2.15.4 Type DC Concrete and Type DC Concrete with Steel Fibres – Crack Identification and Repair

After the curing period Project Co shall inspect the dry concrete surface(s) and identify and plot all cracks, recording the crack widths in millimetres and the crack lengths in metres.

Project Co shall repair cracks with widths equal or greater than 0.2 mm using the following procedure:

- Clean and dry cracks with oil-free compressed air.
- Seal partial depth cracks with a gravity flow concrete crack filler in accordance with the manufacturer's recommendations. The crack filler shall maximize the penetration by taking into consideration the ambient temperature, substrate temperature, viscosity and pot life of the material. The crack filler shall be chosen from the Alberta Transportation Product List/Crack Treatment/Concrete Crack Filler/Proven or Potential Products and have a viscosity less than 105 centipoises (cP).
- When cracks extend the full depth of the deck slab, barriers or curbs or extend partial depth of decks that are cast to grade, epoxy injection will be required. The epoxy resin shall meet the requirements of ASTM Specification C881 Type IV, Grade 1, Class B or C and have a viscosity less than 500 cP. The injection procedure shall be submitted by Project Co for review in accordance with Schedule 9 – Review Procedure by the Ministry.

Project Co shall repair all cracks, regardless of their width if the total crack frequency is greater than 0.150 m/m^2, using the following procedure:

- Shotblast the deck surface to ICRI CSP No 3. Clean and dry cracks with oil-free compressed air. Apply a gravity applied reactive methacrylate resin or approved equivalent at the manufacture's recommended application rate to the entire deck surface. The resin shall have a maximum viscosity of 15 cP, a tensile strength greater than 25 MPa and elongation greater than or equal to 5.5%.
- For decks that are to be waterproofed, once the resin is applied and fully cured the deck shall be shotblasted again to remove surface resin and blown clean with oil-free compressed air prior to receiving its waterproofing system.

300.4.2.16 Concrete Surface Finish

300.4.2.16.1 General

Prior to concrete surface finishing, all surfaces shall conform to the requirements of Section 300.4.2.11.7 of Schedule 15-2 – Design and Construction.

On unexposed concrete surfaces all cavities, honeycomb, and other deficiencies shall be thoroughly chipped out, cleaned, and after having been kept saturated with water for a period of

not less than 30 minutes, shall be filled with a non-shrink grout approved by the Engineer of Record. All patches shall be cured as specified in Section 300.4.2.15 of Schedule 15-2 – Design and Construction.

On exposed concrete surfaces to 600 mm below grade or, in the case of river piers, 600 mm below lowest water level, surface finishes shall be applied as follows:

Class 1 - Ordinary Surface Finish

- All exposed concrete surfaces unless other finishes are specified; and
- Top surfaces of abutment seats and pier caps.

Class 2 - Rubbed Surface Finish

- Solid shaft river piers; and
- Inside vertical surfaces of curb, barrier, median and sidewalk.

Class 3 - Bonded Concrete Surface Finish

- Abutment seats except top surface;
- Pier caps except top surface;
- Exterior faces of curtain walls/wingwalls, cast-in-place walls and MSE wall copings;
- Grade separation piers except top surfaces;
- exterior concrete girder faces (when specified) (see Sketch SK-1 in Appendix B);
- Exposed end surfaces of cast-in-place concrete diaphragms;
- Underside of the deck overhang to top flange of girder; and
- Exterior surfaces of deck slab, curb, barrier and sidewalk.

Class 4 - Floated Surface Finish

- Top surfaces of concrete deck and roof slabs which are to receive waterproofing membranes and wearing surfaces;
- Top surface of curbs and barriers; and
- Top surfaces of abutment seats and pier caps.

Class 5 - Floated Surface Finish, Broomed Texture

- Top surfaces of sidewalks, and medians;
- Approach slab concrete which will be covered by a wearing surface only (without waterproofing membrane); and
- Concrete slope protection.

Class 6 - Floated Surface Finish, Surface Textured

- Top surfaces of deck, deck overlay, roof and approach slabs which will not be covered with either waterproofing membrane or wearing surface.

Only approved wood or magnesium floats shall be used for finishing concrete. Finishing agents are not permitted during concrete finishing.

Class 2 and 3 finished concrete surfaces shall be such that when checked with a 3 m long straight edge placed anywhere in any direction on the surface, there shall not be any gap greater than 2 mm between the bottom of the straight edge and the concrete surface unless otherwise specified.

Class 1, 4, 5 and 6 finished concrete surfaces shall meet the requirements of Section 300.4.2.11.7 of Schedule 15-2 – Design and Construction and be such that when checked with a 3 m long straight edge placed anywhere in any direction on the surface, there shall not be any gap greater than 3 mm between the bottom of the straight edge and the concrete surface unless otherwise specified.

300.4.2.16.2 Class 1. Ordinary Surface Finish

Unformed Surfaces

Immediately following placing and compacting, the concrete shall be screeded to conform to the required surface elevations, and then trowelled to ensure that the surface is free from open texturing, plucked aggregate, and local projections or depressions.

Formed Surfaces

Immediately following the removal of forms, all fins and irregular projections shall be removed from all surfaces. On all surfaces the cavities produced by form ties, and all other holes, honeycomb areas, broken corners or edges and other defects, shall be thoroughly chipped out, cleaned, and shall be filled with a non shrink grout or patching product, in each case approved by the Engineer of Record. The repair material shall be appropriate for the intended application, and shall be placed in accordance with the manufacturer's recommendations. All repairs shall be wet cured for a minimum of 72 hours. Curing compounds are not permitted.

300.4.2.16.3 Class 2. Rubbed Surface Finish

Immediately following the removal of forms, all fins and irregular projections shall be removed from all surfaces. All lines that are not true shall be corrected by chipping, grinding or patching as necessary. Parging to correct irregularities will not be permitted. On all surfaces, the cavities produced by form ties, air bubbles and all other holes, honeycomb areas, broken corners or edges and other defects, shall be thoroughly exposed by wire brushing with a stiff bristled, powered, wire brush. The cleaned surface shall be filled with a non shrink grout or patching product, in

each case approved by the Engineer of Record. The repair material shall be appropriate for the intended application, and shall be placed in accordance with the manufacturer's recommendations. The small surface voids formed by air bubbles shall be filled with a pre-bagged with a sack rub material, placed in accordance with the manufacturer's recommendations. All repairs and sack rubbed surfaces shall be wet cured for a minimum of 72 hours. Curing compounds are not permitted. When the patching and filling have adequately hardened, a carborundum stone shall be used to finish the surface to a smooth, uniform and closed texture. Any voids opened during the stone rubbing process shall be refilled.

It is essential that the prepared concrete surface, including all patching and filling be uniform in colour and texture. All portions of bridge elements, including those cast in more than one pour, shall be of the same colour and texture. Any staining caused by cement, water, weather, or other conditions shall be prevented, removed, or covered. After the surface preparation has been completed Project Co shall apply sealer as specified in Section 300.4.2.17 of Schedule 15-2 – Design and Construction.

300.4.2.16.4 Class 3. Bonded Concrete Surface Finish

Surface preparation shall be done as is specified for Section 300.4.2.16.3 of Schedule 15-2 – Design and Construction above, except that uniformity in colour is not required. After the surface preparation has been completed, the concrete surfaces shall be pressure washed to remove all dust, dirt, laitance and all other bond breaking materials. The concrete surface shall be dried for a minimum of 24 hours. Project Co shall then apply a pigmented concrete sealer, which meets the requirements for a Type 3 sealer in Alberta Transportation's "*Specifications for Concrete Sealers*" (B388).

The pigmented concrete sealer shall be applied in accordance with the manufacturer's specifications and as a minimum two applications are required. When spray application is used the surface shall be back rolled. Project Co shall ensure that no colour variation is visible, and shall match the colour of any previously painted adjoining surfaces. Acceptance of the pigmented sealer used will not relieve Project Co of full responsibility for its acceptable appearance.

300.4.2.16.5 Class 4. Floated Surface Finish

Unless otherwise noted in the Design Data, concrete which is to receive a waterproofing membrane and a final wearing surface, shall be floated with a magnesium bull float and trowelled as necessary to provide a smooth surface.

300.4.2.16.6 Class 5. Floated Surface Finish, Broomed Texture

The concrete surface shall be floated and trowelled as necessary to produce a smooth surface. The surface shall not vary more than 3 mm under a 3 m long straightedge.

After the concrete has set sufficiently, the surface shall be given a transversely broomed finish using a coarse broom to produce regular corrugations to a maximum depth of 2 mm. An edging tool shall be used at all edges and expansion joints. Where indicated in the Design Data, sidewalk surfaces shall be laid out in blocks using an approved grooving tool.

300.4.2.16.7 Class 6. Floated Finish, Surface Textured

After the concrete has been bull floated, it shall be given a suitable texture with a "flat wire" texture broom having a single row of tines. The desired texture is transverse grooving which may vary from 1.5 mm width at 10 mm centres to 5 mm width at 20 mm centres, and the groove depth shall be 3 mm to 5 mm. This operation shall be done at such time and in such manner that the desired texture will be achieved while minimizing the displacement of the larger aggregate particles or steel fibres. The textured surface shall be uniform and consistent.

Following the surface texturing, a strip of the concrete along the inside curb line, shall be trowelled smooth and the surface left closed.

300.4.2.16.8 Concrete Finishing Under Bearings

All concrete areas on which bearing plates or pads are to be placed are to be at the required elevation, and are to be finished or ground to a smooth and even surface in preparation for bearing plates or pads. The finished surface shall not vary more than 1 mm over an area whose dimensions exceed the dimensions of the bearing plates by 60 mm. Air voids created by forming grout-pad depressions shall be filled with an approved patching material, well in advance of girder erection. In cold weather conditions this work shall be completed while the concrete is still warm and adequate protection shall be provided.

300.4.2.17 Type 1c Sealer

An approved Type 1c sealer shall be applied to all concrete surfaces which are susceptible to deterioration by water and de-icing salts. This shall include all concrete surfaces to 600 mm below grade, or in the case of river piers 600 mm below lowest water level, or as specified and shall include all surfaces which are to receive a Class 2, Class 4, Class 5 and Class 6 Finish. This does not apply to surfaces covered with waterproofing membrane and ACP wearing surface, drain troughs and concrete slope protection. Sealer will not be required on the underside of bridge decks and on concrete diaphragms in the interior bay areas; however, the faces of the end diaphragms nearest the abutment backwalls, inside faces of backwalls, top surface of abutment seats, excluding bearing recess pockets, and the deck and curb overhangs shall be sealed.

Type 1c sealers shall meet the current Alberta Transportation's "*Specifications for Concrete Sealers*" (B388).

The sealer shall be applied in accordance with the manufacturer's recommendations; however, the application rate shall be increased by 30% from that indicated on the approval list. Before applying the sealer the concrete shall be cured for at least 28 days. The concrete surface shall be

dry, and air blasted to remove all dust prior to applying sealer. In order to ensure uniform and sufficient coverage rates Project Co shall apply measured volumes of sealing compound to appropriately dimensioned areas of concrete surface, using a minimum of two coats.

300.4.2.18 Concrete Strength Requirements

Concrete with Strength Test Results shown below shall be removed:

- Type DC concrete less than 40 MPa
- Type C concrete less than 25 MPa
- Type C1 concrete less than 25 MPa
- Type P1 concrete less than 20 MPa
- Type P2 concrete less than 25 MPa

Concrete shall meet the requirements for that type of concrete as stated in Section 300.4.2.5 of Schedule 15-2 – Design and Construction.

300.4.2.18.1 Coring for Compressive Strength Testing

When coring is used to confirm or contest low concrete strength test results, arrangements shall be made by Project Co, to employ a CSA Category 1 or higher level certified testing laboratory, all at the expense of Project Co. The cores shall be taken and tested within seven days of the testing of the 28-day cylinders representing the concrete in question. Where practical, three 100 mm diameter cores shall be taken for each non-compliant strength test previously taken, and there shall be no doubt that the cores taken and the cylinders under consideration, represent the same batch of concrete. Cores may not be taken unless the Ministry is present. Cores shall be tested by an independent CSA certified Category 1 or higher level testing laboratory and in accordance with the requirements of CSA Standard A23.2-14C. CSA Standard A23.1, Clause 4.4.6.6.2 (Cores drilled from a structure) shall not apply. The average strength of each set of three cores shall be equal to or greater than the 28-day specified strength. The average strength of the cores as reported by the independent testing service shall constitute a test.

In cases where the concrete strength, as indicated by the cores, is higher than the strength based on the concrete cylinder results, the core results shall be used as the basis for acceptance of the concrete. If the core strengths are lower than the strength from the concrete cylinder tests, the cylinder tests shall govern.

The average strength of each set of three cores shall be equal to or greater than the 28 day specified strength. CSA Standard A23.1 Clause 4.4.6.6.2 “Cores Drilled from a Structure” does not apply.

300.4.3 Structural Steel

300.4.3.1 General

This specification is for the supply, fabrication, delivery and erection of structural steel. Structural steel shall include steel girders, trusses, diaphragms, bracing, splice plates, deck drains, structural bearings, anchor bolts, dowels, deck joint assemblies, buffer angles, connector angles, anchor bolt sleeves, curb and median cover and trough plates, pier nose plates, pier bracing, bridge rails and miscellaneous components.

300.4.3.2 Submissions

The following information shall be submitted to the Ministry by a date that is reasonable having regard to the design and construction process and in any event within the times noted below. In the event that the Ministry requests any of the following information, the requested information shall be provided within seven days, notwithstanding the times noted below.

- Proposed fabrication sequences (at least five days prior to fabrication). The Ministry shall be advised a minimum of two days prior to a component being ready for inspection at an inspection station;
- Web and flange plate arrangements for welded plate girders (at least five days prior to fabrication);
- Welding procedures for all welds (at least five days prior to fabrication);
- Shop drawings (two copies) (at least five days prior to fabrication);
- Mill certificates for all material;
- Repair procedures for excessive girder camber, if required;
- Repair procedures for unsatisfactory weldments and accidental arc strikes, if required;
- Repair procedures for flame straightening of members, if required;
- Product data sheets for coatings required between galvanized steel and concrete;
- Repair procedures for galvanizing, if required;
- All results from Section 300.4.3.3.8 of Schedule 15-2 – Design and Construction;
- Erection procedures, including drawings for falsework, berms and traffic accommodation (two copies) (at least 14 days prior to erection);
- Procedures for straightening bent material during erection, if required; and
- Methods of forming and pouring grout (at least 14 days prior to placing grout).

300.4.3.3 Supply and Fabrication

300.4.3.3.1 Standards

Fabrication of structural steel shall conform to the Bridge Design Code including latest supplements.

All welding, cutting and preparation shall be in accordance with the CSA Standard W59.

300.4.3.3.2 Qualification

Project Co shall be responsible for the work of all subcontractors.

The fabrication shall occur in a recognized steel fabrication shop and be fully certified by the Canadian Welding Bureau (the "**CWB**") as per CSA Standard W47.1 in the following Divisions:

- Fabrication of steel girders, girder components and welded steel trusses – Division 1.
- All other bridge components – Division 2.

The fabrication shop shall have CISC Steel Bridges Certification.

Only welders, welding operators and tackers approved by the CWB in the particular category shall be permitted to perform weldments. Their qualifications shall be current and available for auditing by the Ministry.

Prior to fabrication, Project Co shall submit to the Quality Manager the names of the welding engineer, the engineer experienced in steel bridge fabrication, and the welding supervisors who are to be employed on the Work.

300.4.3.3.3 Engineering Data

Welding Procedures

Welding procedures, including welding procedure datasheets shall be prepared for each type of weld used in the structure. The procedures shall bear the acceptance of the CWB and shall also be submitted to the Ministry prior to commencement of fabrication.

Shop Drawings

Shop drawings showing all details shall be prepared by Project Co. The shop drawings shall be legible and of adequate quality to be reproduced and microfilmed.

In addition to specific details, the shop drawings shall include the following:

- Drawings showing details of connections not shown in the Design Data signature and stamp of a Professional Engineer;
- All dimensions shall be correct at 0° Celsius unless otherwise noted;
- Weld procedure identification shall be shown on the shop drawings in the tail of the weld symbols;
- All material splice locations shall be shown on the drawings;
- Bearings shall be centered at 0° Celsius;

- Shop assembly drawings shall indicate camber and splice joint offsets; and
- The Ministry's bridge file number and project name shall be shown on all the shop drawings.

Proposed Fabrication Sequence

Prior to commencement of fabrication, Project Co shall prepare an outline of the fabrication sequence and details of equipment which will be used for the fabrication. The fabrication scheme shall include the order of make-up and assembly of all the component parts, as well as shop assembly, inspection stations, and surface preparation. If any equipment causes repeated defective work it shall be substituted with a suitable alternative.

Mill Certificates

Mill test certificates showing chemical analysis and physical tests of all steel shall be submitted to the Ministry prior to commencement of fabrication. If material cannot be identified by mill test certificates, coupons shall be taken and tested and these test certificates shall be made available.

Where mill test certificates originate from a mill outside Canada or the United States of America, Project Co shall have the information on the mill test certificate verified by independent testing by a Canadian laboratory. 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 certificate. The mill test certificates shall be stamped with the name of the Canadian laboratory and appropriate wording stating that the material specification number, testing date, and the signature of an authorized officer of the Canadian laboratory.

300.4.3.3.4 Materials

Structural Steel

Structural steel shall conform to the standard noted in the Design Data.

Plates provided from coils shall not be used.

All steel for bridgerail shall conform to the standard noted in the Design Data. The silicon content for various bridgerail and handrail components shall be as follows:

- Structural tubing less than 0.04%.
- Structural sections, handrail bars, base plate less than 0.04% or between 0.15% to 0.25%.

Bolts

All bolts, nuts and washers shall conform to ASTM Specification A325/A325M or shall meet property Class 8.8 of the Industrial Fasteners Institute for metric high strength structural bolts, nuts and washers. Certified mill test reports for the fastener material shall be obtained and available for submission to the Ministry.

Stud Shear Connectors

All stud shear connectors shall conform to the chemical requirements of ASTM Specification A108, Grades 1015, 1018 or 1020. In addition they shall meet the mechanical properties specified in CSA Standard W59, Table H.1 for Type B studs. Certified mill test reports for the stud material shall be obtained.

Bearings

Bearings shall conform to Sections 200.6.13 and 300.4.15 of Schedule 15-2 – Design and Construction.

300.4.3.3.5 Welding

Filler Metals and Welding Processes

Low hydrogen filler, fluxes and low hydrogen welding practices shall be used throughout. The deposited weld metal shall provide strength, durability, impact toughness and corrosion resistance equivalent to base metal. The low hydrogen covering and flux shall be protected and stored as specified by CSA Standard W59. 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, and will not be permitted.

- **Submerged Arc Welding ("SAW")** - SAW process is allowed for all flat and horizontal position welds. All flange and web butt joints shall be made by an approved semi or fully automatic submerged arc process. All web to flange fillet welds and all longitudinal stiffener to web fillet welds shall be made by an approved fully automatic submerged arc process.
- **Shielded Metal Arc Welding ("SMAW")** - SMAW is allowed for girder vertical stiffener to flange fillet welds and for miscellaneous components such as deck drains, bridge bearings, deck joint assemblies, pier nose plates and buffer angles.
- **Metal-Cored Arc Welding ("MCAW")** - MCAW process utilizing low hydrogen consumables with a diffusible hydrogen content designation of H4 is allowed for intermediate stiffeners that are less than 1500 mm long, horizontal gusset plates, bridgerails, and miscellaneous components such as deck drains, bridge bearings and deck joint assemblies. Field application of metal-cored arc welding (MCAW) is not allowed.

Cleaning Prior to Welding

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

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 length shall not exceed 15 times the weld size, and shall be subject to the same quality requirements as the final welds. Tack welds shall be sufficiently ground out prior to final weld in order to obtain a uniform weld bead. Cracked tack welds shall be completely removed prior to welding over.

Run-off Tabs

Run-off tabs shall be used at the ends of all welds that terminate at the edge of a member. The tabs shall be a minimum of 100mm long unless greater length is required for satisfactory work. 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.

Preheat

Preheat requirements shall be performed and maintained as per CSA Standard W59, except that all welds on girder flanges shall be preheated to a minimum temperature of 100° Celsius unless a higher temperature is required by CSA Standard W59 for the flange thickness. The preheat temperature of the web to flange joint shall be measured 75 mm from the point of welding on the side of the flange opposite to the side where the weld is being applied.

Welding at Stiffener Ends

To prevent notching effects, stiffeners and attachments fillet welded to structural members shall have the fillet welds terminate 5 mm short of edges.

Methods of Weldment Repair

Repair procedures for unsatisfactory weldments shall be prepared by an experienced welding engineer registered as a Professional Engineer prior to repair work commencing.

Arc Strikes

Arc strikes will not be permitted. In the event of accidental arc strikes a repair procedure shall be prepared by an experienced welding engineer registered as a Professional Engineer. The repair procedure shall include the complete grinding out of the crater produced by the arc strike.

Grinding of Welds

Flange butt welds shall be ground flush or to a specified slope on both sides. Web butt welds which are sufficiently smooth with a neat appearance and uniform profile, as determined by Project Co's independent welding inspector but subject to the Ministry's review in accordance with Schedule 9 – Review Procedure , will not require grinding. Fillet welds not conforming to acceptable profile shall be ground to the proper profile without substantial removal of the base metal. Grinding shall be smooth and parallel to the line of stress. Caution shall be exercised to prevent over grinding.

Plug and Slot Welds

Plug welds or slot welds shall not be permitted.

Field Welding

Where field welding of structural members is carried out, the following requirements shall be met:

- All welding, cutting and preparation shall be in accordance CSA Standard W59.
- Only welders approved by the Canadian Welding Bureau in the particular category shall be permitted to perform weldments.
- Welding procedures approved by the Canadian Welding Bureau shall be prepared and submitted for review in accordance with Schedule 9 – Review Procedure by the Ministry prior to use on the structure.
- Low hydrogen filler, fluxes and welding practices shall be used in accordance with Section 300.4.3.3.5 of Schedule 15-2 – Design and Construction.
- When the air temperature is below 10° Celsius, all material to be welded shall be preheated to 100° Celsius for a distance of 80 mm beyond the weld and shall be sheltered from the wind.
- When the air temperature is below 0° Celsius, welding shall not be permitted unless suitable hoarding and heating is provided. The air temperature inside the enclosure shall be a minimum of 10° Celsius. If the steel temperature is less than 10° Celsius, preheat as in the bullet above.
- All field welds of structural members shall be visually inspected by an independent welding inspector certified to Level 3 of CSA Standard W178.2.

Where field welding of non-structural members is carried out, the following requirements shall be met:

- Journeyman welders with Class B tickets shall be permitted to perform weldments.
- Welding procedures prepared and stamped by a Professional Engineer shall be prepared.
- Low hydrogen filler, fluxes and welding practice shall be used in accordance with Section 300.4.3.3.5 of Schedule 15-2 – Design and Construction.

- When the air temperature is below 5° Celsius, all material to be welded shall be preheated to 100° Celsius for a distance of 80 mm beyond the weld and shall be sheltered from the wind.
- When the air temperature is below 0° Celsius, welding shall not be permitted unless suitable hoarding and heating, is provided.

Structural field welds are welds that are required to maintain the integrity of the structure.

Welding to Girder Flanges and Webs

With the exception of longitudinal web to flange welds, all stiffener, gusset plate, or any other detail material welds to girder flanges shall be a minimum of 300 mm from the flange butt welds.

With the exception of longitudinal web to flange welds and longitudinal stiffener to web welds, all stiffeners, gusset plate, or any other detail material welds to girder webs shall be a minimum of 300 mm from the web butt welds.

300.4.3.3.6 Fabrication

The Quality Manager will convene a prefabrication meeting with the fabricator and Ministry to review, in accordance with Schedule 9 – Review Procedure, issues including but not limited to, procedures on quality control, quality assurance, welding procedures, procedures for non-destructive testing, mill certificates and heat numbers, splices, coatings, updated schedule for fabrication, and to confirm the Technical Requirements.

Fabrication shall be performed in a fully enclosed area which is adequately heated. The shop temperature shall be at least 10° Celsius.

Heat Number Transfer

As the plate is subdivided for webs and flanges, all heat numbers shall be transferred to each individual section. The numbers shall remain legible until such time as the material location in the final assembly has been recorded. Mill identification numbers stamped into the material shall be removed by grinding at an appropriate time. Steel, which is unidentified, shall not be used in the Work.

Marking Systems

Steel stamps shall not be used. The only exception is the match marking of splice plates which may be steel stamped using low stress stamps. The stamps and specific locations of such stamps shall be shown on the shop drawings.

Cutting of Plate

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

Flange Stripping

All flange material shall be cut so that the direction of the applied stress will be parallel to the direction of the plate rolling.

Flame or Plasma Arc Cut Edges

The flame or plasma arc cut edges of girder flanges shall have a maximum Brinell hardness as stated by hardness test requirements in Section 300.4.3.3.8 of Schedule 15-2 – Design and Construction. The surface roughness of the cut edge shall not be greater than 500 μin. (12.5 μm) and be such that to allow Brinell hardness testing without spot grinding. Project Co shall report all blow backs or signs of lamination observed during the cutting of the material. Project Co will perform Brinell hardness tests on the as-is flame or plasma arc cut edge. If the hardness exceeds the requirements, the edges shall be repaired so that they meet the requirements.

The surface of flame or plasma arc cut apertures shall be finished by grinding and shall be free of nicks and gouges.

Vertical Alignment

The structure shall be fabricated to conform to the requirements of the deflection and vertical curve, as noted in the Design Data. For rolled shapes, advantage shall be taken of mill camber that may be inherent in the material.

Shop Assembly

- **Plate Girders** - Shop assembly of girders shall be by the progressive assembly method according to AASHTO, except that only two, instead of three, sections need to be assembled. The detailed method of assembly, including points of support, dimensional checks, method of trimming to length, drilling and marking of splices, shall be to the proposed fabrication sequence procedure prepared as per Section 300.4.3.3.3 of Schedule 15-2 – Design and Construction. Each individual girder 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. Correction for variation in flange thickness shall be considered. When the camber of the girder fails to meet the required tolerance, Project Co shall develop a method of repair prior to commencement of repair. The camber of each individual girder section shall be known for the next two girder sections in the girder line prior to shop assembly of any particular girder section. This is to allow the use of a best fit line to reduce the effect of any camber differences

should it be deemed necessary. Camber for plate girders shall be measured on the top of the top flange. The camber of plate girders shall be measured in the "no load" condition.

- **Box Girders** - The progressive shop assembly for box girders shall be similar to the plate girder requirements above, items described in this section are specific to box girders.
- **Camber** - The camber of box girders shall be measured on the top of the top flange, and each top flange of a box shall individually meet the required camber. Girder sections assembled for splicing shall be supported within 2 m of the end of each section. Girder sections shall be supported in such a manner as to provide the correct angular relationship at the splice between girder sections while the splices are being reamed or drilled. Shop drawings shall clearly indicate the expected dead load deflection of each section and the elevations of the sections while supported for the drilling or reaming of each splice.
- **Drilling** - 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.

Splice Plates

After shop assembly, splice plates and girders shall be clearly match marked to assure proper orientation and location of splice material for erection. All holes shall align with holes in the attached member. Splice plates shall then be removed, de-burred, solvent cleaned to remove all oil and sandblasted to remove all mill scale. These plates shall then be securely ship-bolted to the girders. The match marking system shall be shown on the shop drawings.

Bolt Holes

Clause 11.4.8 in AASHTO LRFD Bridge Construction Specifications shall apply except that all bolt holes in load carrying segments of main members and any material welded to main members shall be drilled full size or sub-punched 5 mm smaller and reamed to full size. Punching of full size holes for secondary members such as bracings which are not welded to main member is allowed for material less than 16 mm thick. All holes in girder splices shall be circular and perpendicular to the member and shall be deburred to ensure a proper faying surface.

Dimensional Tolerances

Normal tolerance for structural steel fabrication and fitting between hole groups will be ± 3 mm unless specified otherwise. The dimensional tolerances for structural members shall be within the CSA Standard W59 limits, except as otherwise noted below:

- **Girder Camber** - Camber of beams and girders shall be uniform, true and accurate to the centreline of the top flange. Permissible variation in camber shall be within ± (0.2 L_t + 3) mm; where L_t is the test length in metres. This applies to fabricated pieces only, prior to shop assembly. During shop assembly, splice points shall be located on the theoretical camber line or at a specified amount from the line. Where field splices are eliminated by combining girder segments into longer girder lengths, the cambers of the girders at the eliminated splice points shall be within ± 3 mm.

- **Box Girders** - Tolerances for box girder camber, sweep and depth shall be measured relative to two imaginary surfaces: a vertical plane passing through the centre line of the girder; and a surface located at the theoretical underside of the top flanges following the theoretical camber of the girder.
- **Splices** - Fill plates shall not be permitted at main girder field splices unless specified. The tolerance for girder depth or box girder geometry shall be as specified by CSA Standard W59, except that the difference between similar dimensions of the adjoining sections being spliced shall not exceed ± 2 mm.
- **Fitted Stiffeners** - The bearing ends of stiffeners finished to bear shall be flush and square with the web and shall have at least 75% of this area in contact with the flanges, whereas snug fit stiffeners may have a gap of up to 1 mm between stiffener and flange.
- **Bearing to Bearing Dimension** - Bearing to bearing distance is a set dimension and therefore has no tolerance.
- **Combined Warpage and Tilt** - Combined warpage and tilt of flange at any cross section of welded I-shape beams or girders shall be determined by measuring the offset at the toe of the flange from a line normal to the plane of web through the intersection of the centerline of the web with the outside surface of the flange plate. This offset shall not exceed 1/200 of the total width of the flange or 3 mm whichever is greater at bolted splice location. Bolted splices of main stress carrying members shall have parallel planes and the surfaces shall be in full contact without any gap.
- **Deck Joint Assemblies** - Deck joint assemblies shall be assembled for inspection in a relaxed condition with erection angles removed. Approval of the assembly by the Engineer of Record is required prior to application of the erection angles. Tolerances for straightness shall be considered over the length of the assembly between the crown and gutter line both before and after galvanizing. Deviation from straightness in a vertical plane shall not exceed ± 3 mm. Horizontal sweep or variations in gap setting shall not be greater than 3 mm.

Corner Chamfer

Corners of all flanges shall be ground to a 2 mm chamfer. Corners of stiffeners, structural sections and plates shall be ground to a 1 mm chamfer.

Milling Tolerances

Tolerance for milled to bear stiffeners shall be 0.05 mm with at least 75% of the area in bearing.

Web Panning

The maximum variation from flatness for webs shall be 0.01d where d is the least dimension of the panel formed by the girder flanges and/or stiffeners. Should the panning in one panel be convex and the panning in the adjacent panel be concave then the sum of the panning in the two adjacent sections shall not exceed that allowed for one panel. Localized deformation in the web shall not exceed 3 mm in 1 m.

Flame Straightening

Flame straightening shall not be performed on any material or member without the development of a repair procedure by a Professional Engineer. The repair procedure shall address locations, temperatures and cooling rates.

Stress Relieving

When stress relieving is specified, it shall be performed in accordance with CSA Standard W59. Copies of the furnace charts shall be supplied to the Ministry.

Handling and Storage

All lifting and handling shall be done using devices that do not mark, damage, or distort the assemblies or members in any way. Girders shall be stored upright, on timber blocking, supported on sufficient skids and safely shored to maintain the proper section without buckling, twisting or in any way damaging or misaligning the material.

300.4.3.3.7 Surface Preparation and Coating

Blast Cleaning, Painting

For weathering steel bridges, all structural steel shall be painted for the larger of the following distances from deck joint locations:

- 3 000 mm.
- 1.5 times the superstructure depth (including girder, haunch and slab thickness).

For overpasses, the entire exterior face of the exterior girder shall be painted.

Areas where oil or grease are present shall be cleaned in accordance with the requirements of Steel Structures Painting Council surface preparation Specification No.1 (SSPC-SP1) Solvent Cleaning. The type of solvent used shall first be approved by the Engineer of Record.

Areas covered by wet concrete may be cleaned by washing with water.

Unpainted steel surfaces stained by dry concrete, and steel surfaces to be painted that have previously been blast cleaned to SSPC-SP6, shall be cleaned in accordance with the requirements of Steel Structures Painting Council Surface Preparation No.7 (SSPC-SP7) Brush-off Blast Cleaning.

All steel surfaces which may have been subjected to salt spray during transport shall be pressure washed using a minimum pressure of 20 MPa prior to any abrasive blast cleaning.

Clean water, or compressed air from which oil and water have been removed, shall be used to remove dust and blasting abrasive from the cleaned bare steel or painted surfaces. Where necessary, the surface shall also be wiped with dry cloths.

The abrasive used for blast cleaning shall be clean and dry, with a grading and hardness suitable to produce an acceptable anchor pattern.

Blast cleaned surfaces shall be painted as soon as possible following completion of the cleaning operations. If unusual circumstances occur which prevent all repaired surfaces from being primed the same day, or if significant rusting forms, a light sandblast will be required over all unprimed surfaces prior to recommencement of priming.

Paint shall not be applied when air temperature or the steel temperature are below 10° Celsius, nor when the steel has absorbed sufficient heat (above 50° Celsius) to cause the paint to blister or produce a porous paint film, nor when it is possible the air temperature may drop below 2° Celsius before the paint is dry. No painting shall be done when relative humidity meets or exceeds 85% or when the substrate temperature is within 3° Celsius of the dew point.

Paint shall not be applied to damp surfaces, nor when the air is misty, windy or otherwise unsatisfactory for the work.

All steelwork, which is to be painted, shall be given three shop coats of paint – primer, stripe coat and midcoat.

Paint shall be chosen from the Ministry’s Approved Product List for 3 coat systems.

Surfaces surrounding bolt holes at connection locations shall receive the prime coat only and shall be masked off so that no stripe coat, midcoat or topcoat paint will be under the bolt heads, washers or nuts.

These masked off areas shall have the stripe coat, midcoat and topcoat paint applied in the field after installation of the bolts.

All faying surfaces of steelwork shall be cleaned by sand blasting in the shop. Faying surfaces of steelwork to be painted shall be painted only with 1 coat of inorganic zinc primer. Primer coatings shall meet the Class B coating requirements as specified in the Bridge Design Code. The class of coating shall be determined based on testing in accordance with the “Specification for Structural Joints Using ASTM A325 or A490 Bolts” issued by the Research Council on Structural Connections. Primers shall be supplied with a Class B certificate and be applied and cured at the conditions specified on the certificate. Over thickness will not be accepted.

Paint shall be applied in a covered area in accordance with the manufacturer's specifications.
Paint shall not be exposed to the air until it is required for immediate use. Any paint which has become oxidized, thickened, ropy, lumpy or dirty shall be discarded.

Paint shall be applied by brush, roller or spray, or a combination of these methods. On all surfaces which are inaccessible for brushes or rollers, and where spraying is not being employed, the paint shall be applied with sheepskin daubers specially constructed for the purpose. "Dry overspray" shall be removed prior to application of the next coat of paint.

Spray equipment shall be of ample capacity for the work and shall at all times be kept clean and in good working order. Spray guns shall be suited to the kind of paint being used, and shall be operated with orifices, nozzles and pressure suited to the kind of paint and its consistency. Air lines shall be equipped with water traps to positively remove condensed moisture.

Brushes shall be in good condition, with uniform hair length and free of loose hairs. Brushes shall generally be moved in a series of part circles to thoroughly fill all irregularities after which the coating shall be smoothed by a series of parallel strokes. All areas showing excessive brush marks will be rejected.

All coats of paint shall be allowed to dry thoroughly prior to application of subsequent coats. In general, at least 24 hours of favourable drying weather will be required before a mid-coat may be applied over the primer, or before the finish coat may be applied over the primer or mid-coat.

Painted surfaces will be considered to lack uniformity, continuity and soundness if any of the following defects are apparent to the Engineer of Record:

- Runs, sags, holidays or shadowing caused by inefficient application methods.
- Evidence of poor coverage at bolts or rivets, plate edges, lap joints, crevices, pockets, corners and re-entrant angles.
- Surfaces which have been bashed, scraped, spotted by rain or otherwise damaged.
- "Orange peel" texture.
- Surfaces damaged by overspray.

All edges, corners, crevices, bolts, nuts, protrusions and welds (unless ground flush) shall be stripe painted by brush for a width of 50 mm with the midcoat paint before the midcoat coat is applied. Stripe coating paint shall be applied as per SSPC-PA1 and may be applied by spray, but shall be brushed in. Stripe painting shall be cured before the midcoat coat is applied.

Blast cleaning shall be conducted and scheduled to avoid contamination of wet painted surfaces. Surfaces shall be cleaned to SSPC SP6 – Commercial Blast Clean.

Project Co shall measure the wet film thickness at sufficient locations to substantiate that proper technique is being used to apply the paint, and to confirm that paint thickness will meet these specifications without resulting in runs or sags.

Thinners shall not be used unless prior approval of the Engineer of Record has been obtained. When approved, only thinners meeting the requirements of the paint manufacturer and added in accordance with the manufacturer's directions shall be used.

The midcoat shall be applied to all surfaces including tops and sides of the top flanges, except faying surfaces and surfaces surrounding bolt holes. The midcoat shall not be applied until the primer and stripe coat are accepted by the Quality Manager to be sufficiently cured.

Any surfaces inaccessible after erection, except faying surfaces and tops and sides of top flanges, shall be given in addition to the 3 shop coats, 1 coat of the topcoat paint appropriate for the paint system being used.

Topcoat

The topcoat may be applied in the shop or in the field.

The topcoat shall be chosen from the Ministry's Approved Product List for 3 coat systems.

If the topcoat is to be applied in the shop, then the quality control program shall specifically address the integrity of the topcoat through to project completion.

If the topcoat has not been applied in the shop, then the steelwork shall be given 1 topcoat coat of paint applied in accordance with the manufacturer's specifications.

For weathering steel, unless noted otherwise, the topcoat colour shall match the expected colour of the oxidized surfaces.

Marking and Shipping

Each member shall be marked by a method agreed to by the Quality Manager and the Ministry with an erection mark, corresponding to the mark shown on the erection diagram. Each member with a mass of over 1 tonne shall also be marked with the mass.

Members shall be loaded on trucks or cars in such a manner that they can be transported to and unloaded at their destination without being damaged.

After steelwork has been delivered to site it shall be inspected by the Quality Manager. Project Co shall clean the steelwork after it has arrived at site of any dirt, road salts, slush or other contaminants accumulated during transport and shall carry out any other surface preparation work necessary to meet the specified surface preparation requirements.

Field Painting, Touch-Up and Final Cleaning

For each application of field paint, all bolts, nuts and washers, and all edges of plates and rolled shapes shall be pre-painted. This pre-paint shall be allowed to dry completely if general painting of the entire surface, including the pre-painted areas, cannot be done before the pre-paint begins to dry.

After the completion of all deck and overhead concrete Work, steelwork shall be thoroughly cleaned of all rust, dirt, dust, oil and other foreign materials. Concrete splash and staining on painted surfaces shall be cleaned in accordance with the requirements of Steel Structures Painting Council Surface Preparation No. 2 (SSPC-SP2), Hand Tool Cleaning and Surface Preparation Specification No. 3 (SSPC-SP3), Power Tool Cleaning.

Non-visible salts shall meet the SSPC-SP12 / NACE No. 5 NV-2 levels. Bare, rusty or damaged areas shall be cleaned to SSPC-SP11, Power Tool Cleaning to Bare Metal.

The shop coats of paint shall be touched up as necessary as directed by the Quality Manager. Feather edges into the existing coating and build the coating. Build the coating using coatings from the Ministry's Approved Product List for three coat systems. The coating system shall be from the same manufacturer as the shop coating system on the steel.

After installation, ASTM Specification A325/A325M Type 3 bolts, nuts and washers in the areas to be painted shall be cleaned to SSPC-SP1, Solvent Cleaning. These bolts, nuts and washers shall then receive the prime coat, stripe coat, midcoat and topcoat paint. The masked off surfaces surrounding the bolt holes at connection locations shall be cleaned and shall receive the stripe coat, midcoat and topcoat paint.

At the completion of the Project Agreement, all steelwork, painted or unpainted, shall be cleaned of concrete spatter, mud, oil and other foreign materials.

Defects shall be repaired by Project Co to the satisfaction of the Engineer of Record. Where necessary, repairs may include paint removal, recleaning the steel and repainting. All repair work shall be the responsibility of Project Co.

In the case of unpainted weathering steel, the outer faces of the girders and stringers, which includes the exposed edge of the top flange, the underside of the top flange, the girder web, and the top, bottom and edges of the bottom flange shall present a uniform surface free of mill scale and, if necessary, shall be power washed and/or sandblasted per SSPC-SP6 prior to installation. Cleaning shall also include all shop marks located on the exterior faces of the girders, and in all areas of interior girders that are readily visible to the public, as determined by the Quality Manager and Ministry.

Galvanizing

All steelwork to be galvanized shall be galvanized after complete fabrication.

Galvanizing shall be by the hot-dip method, after fabrication, in accordance ASTM Specification A123/A123M, *Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products* and ASTM Specification A153/A153M, *Standard Specifications for Zinc Coating (Hot-Dip) on Iron and Steel Hardware* with additions and exceptions as described in this specification.

The fabricator shall provide a smooth finish on all edges and surfaces, and remove all weld spatter and all welding flux residue from the steel components prior to galvanizing.

Repair of galvanizing shall only be done if bare areas are infrequent, small, and suitable for repair. A detailed repair procedure shall be prepared by a Professional Engineer prior to its use. It should be noted that repairs may require complete removal of the galvanized coating and regalvanizing. Repair shall be in compliance with ASTM Specification A780, Method A3 Metallizing. The thickness of the metallizing shall be 180 μm, and the repair shall be tested for adhesion. The finished appearance shall be similar to the adjacent galvanizing.

Additional Galvanizing Requirements for Bridgerail, Handrail and Light Standards

The bottom surface of each base plate shall be protected by a medium grey colour barrier coating to prevent contact between the zinc and the concrete. The galvanized surface shall be roughened prior to application of barrier coating. The surface preparation of the galvanized surface and the dry film thickness of the coating shall be in accordance with the coating manufacturer's recommendations. Project Co shall test the adhesion of fully cured coating as per ASTM Specification D3359. The method selected for testing (Method A or B) shall depend on the dry film thickness of the coating. The coating manufacturer's product data sheets shall be obtained prior to the application of the coating. The adhesion test result shall meet a minimum of "4B" classification, i.e. a maximum allowable flaking of 5%.

The fabricator shall provide a smooth finish on all edges and surfaces, and remove all weld spatter and all welding flux residue from the steel components prior to galvanizing. The galvanized finish shall meet the aesthetic requirements of the application and shall have a continuous outer free zinc layer without any significant zinc-iron alloy showing through the outside surface. Lumps, globules or heavy deposits of zinc will not be permitted. Handrails shall be free of any sharp protrusions or edges.

Double dip galvanizing is not advised but will be accepted if a surface finish similar in appearance, colour and quality to that of single dip galvanizing is produced. The lapped area of the double dip shall be straight, the coating smooth, adherent and free of uncoated areas, blisters, flux deposits, dross inclusions, acid and black spots.

300.4.3.3.8 Testing and Inspection

Access

Project Co shall provide full access for the inspection of material and workmanship by the Ministry. Free access shall be allowed to the Ministry to all parts of the Works. When required by the Ministry, Project Co shall provide needed manpower for assistance in inspection duties.

Testing by the Ministry

The Ministry may perform visual, radiographic, ultrasonic, magnetic particle and any other inspection that may be required at its own expense.

Testing by Project Co

Any test records made by the fabricating shop in the course of normal quality control shall be open to the Ministry for inspection.

All welds shall be visually inspected by an independent welding inspector certified to Level 3 of CSA Standard W178.2.

Inspection Station

To ensure that each stage of inspection is performed in an orderly manner, during the fabrication of major structures, inspection stations shall be set up at specific points. Sub-assemblies of the work will then be checked by Project Co, and all deficiencies shall be corrected, prior to the work being sent to the next stage of fabrication.

Typical check points for a plate girder are:

- Flange plates prepared.
- Web plates prepared.
- Web to flange welds completed prior to fitting any stiffeners.
- Completion of all welding prior to splicing.
- Splice set-up prior to drilling.
- Surface preparation and coating.
- Clearance to ship.

Non-destructive Methods of Examination

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

- Radiography as per CSA Standard W59
- Ultrasonic as per CSA Standard W59
- Magnetic particle as per ASTM Specification E709 and CSA Standard W59
- Dye-Penetrant as per ASTM Specification E165
- Hardness tests as per ASTM Specification E103

The non-destructive examination shall be done by a company certified to CSA Standard W178.1. Radiographic testing and magnetic particle testing technicians shall be certified to Level II of CGSB.

Radiographic Inspection Schedule

Unless otherwise noted, radiographic inspection of welded plate girders shall be performed by Project Co in accordance with the following schedule:

- 100% of all tension flange and stress reversal butt welds, all stiffener butt welds and all diaphragm butt welds, and any groove welded attachments to flange plates.
- A minimum of 25% of all other flange butt welds randomly selected for each structure. Additional testing may be required to ensure the quality of welds.
- All web butt welds in tension and stress reversal zones plus additional 300 mm of web butt weld in compression zone at the end of the web.

Radiographic Testing of Structural Steel Material

Unless otherwise noted, radiographic inspection of miscellaneous material shall be performed by Project Co in accordance with the following schedule:

- 100% of all tension members.
- 50% of all other members.

In lieu of radiography, phased array ultrasonic non-destructive testing may be done subject to the following conditions:

- Inspectors shall be CGSB Level II or Level III.
- Amplitude linearity checks performed as per AWS D1.5.
- Calibration setting tested on calibration block.
- Provision of a Scan Plan.
- Scanning speed controlled to reduce data drop to less than 5%.
- Scanning performed using linear scanning technique with encoder.
- Use a fixed guide to maintain distance of probe to weld.
- Data displayed in A-Scan, D-Scan and S-Scan format.
- Data is stored. Including raw data, weld identification, weld thickness and length.

Magnetic Particle Inspection Schedule

Unless otherwise noted, magnetic particle inspection of welded plate girders shall be performed by Project Co for each girder section in accordance with the following schedule:

- 50% of the web to flange welds or any fillet welds placed on flange plates.
- 10% of the web to stiffener welds.
- 100% of the stiffeners to flange welds.
- 100% of the bearing sole plate to flange welds.
- 20% of the diaphragm connector plate welds.

Dye Penetrant Inspection

Dye penetrant inspection shall be performed by Project Co at the ends of the weld metal of all flange butt welds after the removal of run-off tabs. Defects discovered by this inspection shall be repaired by Project Co, and the suspect area re-inspected.

Hardness Tests

Hardness tests shall be performed by Project Co on the flame or plasma arc cut edges of the girder flange prior to assembly. Unless otherwise noted, the hardness of the flame or plasma arc cut edges shall not exceed a maximum Brinell as noted below:

- For carbon steels with a yield strength less than and including 300 MPa, the maximum Brinell shall be 200 BHN.
- For carbon steels with a yield strength greater than 300 MPa, the maximum Brinell shall be 220 BHN.

Testing Stud Shear Connectors

Stud shear connectors shall meet all requirements as outlined by CSA Standard W59. Project Co shall perform bend testing in accordance with CSA Standard W59. When bend testing, the studs shall be bent towards the centre of the girder.

Testing of Deck Joint Strip Seal

The installation of strip seals in deck joints shall be tested by Project Co for leakage. The failed areas shall be corrected and retested. The defective or torn seal shall be replaced at Project Co's expense.

Defects, Repairs and Acceptance

The Quality Manager and Ministry shall be notified of any defects found in the Work. In general, no repair shall be made until agreed to by the Engineer of Record who shall consult with the Ministry. In the case of minor corrections, as described by the Bridge Design Code clause 10.23.5.4, approval to proceed may be given either verbally by the Engineer of Record, or in advance provided that written repair procedures are submitted for acceptance by the Engineer of Record and Ministry prior to the work commencing. In such cases as repair of cracks, or repairs as described by the Bridge Design Code clause 10.23.5.5, or a revised design to compensate for deficiencies, the means of correction shall be prepared and sealed by a professional engineer registered with APEGS. It shall be submitted in writing, with adequate sketches, to the Engineer of Record for review, with copy to the Ministry.

Each main member shall be certified as acceptable by the Quality Manager before it is shipped from the shop. This certification shall not relieve Project Co of responsibility for subsequent damage or for defects which become apparent before the Work is finally accepted.

300.4.3.4 Transportation and Erection

Project Co shall erect the structural steel, remove any temporary construction, and do all work required to complete the erection in accordance with the Design Data and the Technical Requirements. No drilling of additional holes or any other modifications including field welding shall be made to steel elements other than deck joints. Lifting devices shall not be welded to girders. Project Co 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. Without restricting generality, erection includes:

- Placing of anchor bolts and bearings;
- Erection of temporary supporting structures;
- Erection of structural steel;
- Placing of expansion assemblies;
- Grouting of anchor bolts;
- Placing and sealing of grout pads; and
- Touch-up painting as required.

300.4.3.4.1 Transporting, Handling and Storing Materials

Material to be stored shall be placed on timber blocking. It shall be kept clean and stored in a properly drained area. Girders and beams shall be placed upright and shored. Long members, such as deck joint assemblies, buffer angles, columns and chords, shall be supported on timber blocking to prevent damage from deflection.

Girders and beams shall be transported in the vertical position. However these elements may be transported in other positions provided:

- A Professional Engineer (structural discipline) performs the analysis and provides a written statement that the proposed method will not damage the elements and a copy of the same shall be provided to the Ministry forthwith.
- Upon arrival at the site and prior to erection, the elements shall be checked by Project Co to ensure all tolerances are met. Project Co shall provide an adequate flat storage area for the inspection.
- Any structural steel member damaged during transportation, handling, storage or erection shall be immediately reported to the Ministry, and an engineering assessment prepared by a Professional Engineer experienced in evaluation and inspection of damaged steel members. Project Co shall also provide three days' notice for access, and facilitate any activities required for an independent assessment by the Ministry if requested.

300.4.3.4.2 Bridge Girders

Temporary Supporting Structures and Berms

The temporary supporting structures and berms shall be designed, constructed and maintained to safely support all loads. Berms shall be constructed in a manner and of such materials that they will not be eroded by stream flow nor introduce silt into the water. Project Co shall prepare drawings for temporary supporting structures, berms, and for traffic control and accommodation where applicable. All drawings shall bear the seal of a Professional Engineer.

Temporary supporting structures and/or berms will not be permitted to remain in any stream channel during spring break-up or run-off periods, unless all necessary approvals have been obtained from pertinent agencies.

Repair to any damage to other property, such as earth fills and stream banks, resulting from the existence of berms, shall be the responsibility of Project Co.

Erection Procedure

Project Co shall prepare, and provide to the Ministry forthwith, a detailed erection procedure in advance of the scheduled start of erection. The erection procedure shall include all drawings and documents necessary to describe the following:

- Traffic accommodation strategy, as applicable.
- Access to work, earth berms and work bridges.
- Type and capacity of equipment. Cranes shall be used for handling and erecting structural steel girders.
- Sequence of operation including position of cranes and trucks with members.
- Position of cranes relative to substructure elements such as abutment backwalls, with details of load distribution of wheels and outriggers.
- Lifting devices and lifting points. No drilling of additional holes or any other modifications, including field welding, shall be made to steel elements other than deck joints. Lifting devices shall not be welded to the girders.
- Details of temporary works, supporting structures drawings, including proposed methods to be used to ensure the required splice elevations and structure shape prior to bolt torquing method of providing temporary supports for stability, top of girder elevations at each bearing and each slice location where appropriate.
- Bolt tightening sequence.
- Grout pad construction (refer to Section 300.4.3.4.2 of Schedule 15-2 – Design and Construction).
- Details of release of temporary supporting structures.
- Provide an “As-Built” detailed survey of the substructure showing the following:
    - Location and elevation of all bearing grout pad recesses;
    - Shim height at each bearing location;

- Top of girder elevations at each bearing (and each splice location where appropriate); and
- Longitudinal measurements between centrelines of bearings of all substructure units.

The erection procedure shall be stamped by a Professional Engineer who shall assume full responsibility to ensure that the erection procedure is being followed, and complies with the Saskatchewan Employment Act and The Occupational Health and Safety Regulations, 1996.

Before erection begins Project Co shall do a complete superstructure layout by means of chalk lines and markings applied to all substructure units, showing bearing and girder positions in accordance with the layout plan.

Fall Protection for Girder Erection and Deck Forming

In order to provide a safe working area for girder erection and deck formwork, Project Co shall provide 100% fall protection and a safe work procedure.

Bearings and Anchorage

Masonry bearing plates shall not be placed upon bridge seat bearing areas which are improperly finished, deformed or irregular. Bearing plates shall be set level in their exact position.

Project Co shall remove anchor bolt void forming materials, and accurately set the anchor bolts, except where the bolts were cast into the concrete. Any residues on the concrete surfaces, such as oils, grease or other contaminants, shall be removed by sandblasting. All methods and materials for setting anchor bolts and constructing bearing pads shall be subject to the Ministry's prior review in accordance with Schedule 9 – Review Procedure. The location of the anchor bolts, in relation to the slotted holes in the expansion shoes, shall correspond with the temperature at the time of erection. The nuts on the anchor bolts, at the expansion ends of spans, shall be adjusted to permit free movement of the spans.

When steel bearings are employed in conjunction with grout pockets in the substructure, the bearings shall be set accurately on galvanized steel shims, and grouted as detailed in the Design Data, after the erection has been completed. The shims shall be located so that a minimum of 75 mm grout coverage is provided. When grout pockets are not detailed, the bearing plates shall be set on the properly finished bearing areas in exact position and shall have a full and even bearing on the concrete.

When required, field welding adjacent to elastomeric pads shall be performed with care to avoid damage to the elastomer. The temperature of the steel adjacent to the elastomer shall be kept below 120° Celsius. The distance between the weld and the elastomer shall be at least 40 mm.

Straightening Bent Material

Straightening of plates, angles or other shapes will not be permitted without a detailed procedure prepared by a Professional Engineer, and provided to the Engineer of Record for acceptance and the Ministry for review in accordance with Schedule 9 – Review Procedure, prior to any straightening being undertaken.

Following the straightening of a bend or buckle, the surface of the metal shall be carefully inspected for evidence of fractures, which may include non-destructive testing.

Assembly

The parts shall be accurately assembled as shown on the shop drawings and all match-marks shall be followed. The material shall be carefully handled to avoid damage. Hammering, which will injure or distort the members, shall not be permitted. Bearing surfaces and surfaces to be in permanent contact shall be clean before the members are assembled.

Splices and field connections shall have one half of the holes filled with bolts and cylindrical erection pins (half bolts and half pins evenly distributed throughout the splice or connection) before bolting. Splices and connections carrying traffic during erection shall have three-fourths of the holes filled.

Fitting-up bolts shall be of the same nominal diameter as the bolts, and cylindrical erection pins shall be sized to accurately fit the holes.

Should adjustments in elevation of the girder splices become necessary to allow free rotation of the joint, only enough pins or bolts shall be removed.

High Tensile Strength Bolted Connections

- **General** - Bolted parts shall fit solidly together when assembled. Contact surfaces, including those adjacent to the washers, shall be descaled or carry the normal tight mill scale. Contact surfaces shall be free of dirt, paint, oil, loose scale, burrs, pits and other defects that would prevent solid seating of the parts. Unless otherwise noted, bolts in exterior girders shall be installed with the heads on the outside face of the girder web and bolts in all girders shall be installed with the heads on the bottom faces of lower flanges. Nuts for bolts that will be partially embedded in concrete shall be located on the side of the member that will be encased in concrete. 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. For sloped surfaces, bevelled washers shall be used. The bevelled washers shall be designed to produce a bearing surface normal to the bolt axis. Bolts shall be of new quality and stored in weatherproof containers to prevent loss of lubrication or accumulation of dirt. All girders shall be erected with elevations and alignments checked prior to any bolt tightening.

- **Bolt Tension** - Tightening of all high strength bolts shall be by the turn-of-nut method. Before final tightening there shall be a sufficient number of 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, Project Co 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 4 bolt diameters or less
    - 1/2 turn where bolt length is over 4 bolt diameters and not exceeding 8 bolt diameters
    - 2/3 turn where bolt length exceeds 8 bolt diameters
    - tolerance 1/6 turn (60o) over, nothing under
    - length of bolt measured from underside of head
- **Reuse of Fasteners** - High strength bolts shall be tensioned only once and shall not be reused. Retightening previously tightened bolts, which may have been loosened by tightening adjacent bolts shall not be considered as reuse.
- **Ministry Inspection** - Project Co shall provide safe and adequate access meeting the requirements of the Saskatchewan Employment Act and The Occupational Health and Safety Regulations, 1996, to all working areas, including all necessary scaffolding to enable the Ministry to carry out its inspection. Project Co shall provide a competent workman to assist the Ministry in the inspection of bolt tightening work.

Misfits

The correction of minor misfits involving reaming, cold cutting and chipping for secondary members may be allowed by the Ministry. If such field corrections are proposed by Project Co they shall immediately be reported, and a repair procedure submitted, to the Engineer of Record and to the Ministry. If the repair procedure is accepted, it shall be done in the presence of both Engineer of Record and the Ministry.

Girder Adjustment

It is essential that the girders are erected with utmost attention being given to girder positioning, alignment, and elevation. Adjustment to girder position, bearing location and bearing elevation shall be done in order to achieve as closely as possible the lines and grades shown in the Design Data.

Project Co shall ensure that the structural steel is maintained in correct alignment until the adjoining or encasing concrete components have been completed.

Grout Pockets and Grout Pads

Project Co shall fill the grout pockets and construct the grout pads using Sika 212 flowable grout or equivalent. Filling of grout pockets and construction of grout pads shall be done by workers competent in this work.

Grout shall be packaged in waterproof containers with the production date and shelf life of the material shown. It shall be mixed, placed, and cured in strict accordance with the manufacturer's recommendations.

The method of forming and pouring the grout shall be submitted for review in accordance with Schedule 9 – Review Procedure. Dry-pack methods of constructing grout pads will not be accepted.

Sealer shall be supplied and applied to the exposed grout pad surfaces in accordance with Section 300.4.2.17 of Schedule 15-2 – Design and Construction.

Grouting in Cold Weather

When the daily minimum air temperature, or the temperature of the girders, bearings or substructure concrete, in the immediate area of the grouting, falls below 5° Celsius, the following provisions for cold weather grouting shall be affected:

- 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 10° Celsius.
- Temperature of the grout during placing shall be between 10° Celsius and 25° Celsius.
- The grout pads (or girders where appropriate) shall be enclosed and kept at 10° Celsius to 25° Celsius for at least 5 days. The system of heating shall be designed to prevent excessive drying-out of the grout.

Removal of Falsework, Berms, and Clean-Up

Upon completion of the erection Project Co shall remove all earth material or falsework placed in the stream channel or elsewhere during construction. Project Co shall remove all piling, excavated or surplus materials, rubbish and temporary buildings, replace or renew any damaged fences, and restore in an acceptable manner all property damaged during the execution of its work.

Project Co shall leave the bridge site, roadway and adjacent property in a neat restored and presentable condition. When required, Project Co shall provide written evidence to the Ministry that affected property owners or regulatory agencies have been satisfied.

All steel shall be left clean and free of oil, grease, mud, dust, road spray or other foreign matter.

300.4.4 Precast Concrete Units

300.4.4.1 General

This specification is for the supply, manufacture, delivery and erection of prestressed and precast concrete bridge units and miscellaneous precast components.

300.4.4.2 Submissions

The following information shall be submitted to the Ministry by a date that is reasonable having regard to the design and construction process and in any event within the times noted below. Units fabricated without meeting the time limits noted below will be rejected. In the event that the Ministry requests any of the following information related to ongoing production, the requested information shall be provided within seven days.

- Fabrication schedules and location of manufacture (at least 14 days prior to fabrication)
- Shop drawings (two copies) (at least five days prior to fabrication);
- Stressing calculations including jack calibration data (two copies) (at least five days prior to fabrication);
- Load/elongation curve for prestressing strand (at least five days prior to fabrication);
- Concrete and grout mix designs, including test data showing conformance of cement, silica fume, aggregate and admixtures to required standards (at least five days prior to fabrication);
- Details of concrete curing systems (at least 14 days prior to fabrication);
- Details of standard concrete repair procedures (at least five days prior to fabrication);
- Time-temperature graphs showing concrete curing rates;
- Mill certificates for miscellaneous steel;
- Certified mill test reports for all bearing material;
- Repair procedures for galvanizing, if required;
- Repair procedures, if required, for repair of casting defects or other damage to precast concrete units;
- Concrete cylinder strength results;
- Concrete core strength results, if required;
- Erection procedures, including drawings for falsework, berms and traffic accommodation (two copies) (at least 14 days prior to erection and grading); and
- Methods of forming and pouring grout.

300.4.4.3 Reference Drawings

Drawing SK-1 (Finishes and Sealing for Exterior Concrete Girders) is attached in Appendix B.

300.4.4.4 Supply and Fabrication

300.4.4.4.1 Standards

The manufacture of prestressed and precast concrete bridge units shall be in accordance with CSA Standard A23.4.

Where imperial/metric conversions are necessary, The CSA Standard Z234.1 shall be used as the basis of conversion.

300.4.4.4.2 Qualification

Precast concrete elements shall be manufactured in plants certified to the CSA Standard A23.4 requirements in the appropriate category by a certification organization accredited by the Canadian Precast Prestressed Concrete Institute (CPCI) in the subject area of building products and structures.

Certification shall be in effect prior to the beginning of Work, and maintained throughout the period of fabrication.

300.4.4.5 Engineering Data

300.4.4.5.1 Shop Drawings

Shop drawings showing all necessary fabrication details of the precast units, such as reinforcing steel, blockouts, stressing system, anchorage devices, void support system and screed rail shall be prepared. The shop drawings shall be legible and of adequate quality to be reproduced and microfilmed.

The Ministry's bridge file number and project name shall be shown on shop drawings.

300.4.4.5.2 Stressing Calculations

Stressing calculations showing elongations and gauge pressures as well as the strand release sequence data shall be prepared. Jack calibrations, performed within the previous six months, shall be obtained.

300.4.4.5.3 Stressing Steel Certificate

A copy of the load/elongation curve for each lot of stressing steel shall be obtained.

300.4.4.5.4 Concrete and Grout Mix Design

A concrete mix design and grouting mortar mix design shall be prepared by Project Co and submitted for review in accordance with Schedule 9 – Review Procedure by the Ministry. The

mix design shall indicate the design strength, proportions of the constituent materials, type and brand of cement, type and brand of silica fume, origin of aggregates and brand names of all admixtures. The sampling and testing of aggregates, and the concrete mix design, shall be completed by an independent CSA certified and qualified concrete testing laboratory, which shall have the appropriate permit to practice in the Province of Saskatchewan. Concrete mix designs, including sampling and testing of aggregates, may be completed by the concrete supplier, provided that the documentation is stamped for compliance by a Professional Engineer. The mix design, including sampling and testing, shall be reviewed and stamped for compliance with the respective specifications by an independent CSA certified and qualified concrete testing laboratory, which has the appropriate permit to practice in the Province of Saskatchewan. The testing laboratory shall provide an engineering opinion that the concrete aggregate and mix designs are acceptable for their intended use and are expected to perform to specified standards.

The concrete mix design information shall include one microscopic air-void analysis performed by an independent testing laboratory in order to determine the spacing factor of the hardened concrete. The test sample shall be made from a trial concrete batch, vibrated into a cylinder mould so as to represent the level of vibration of the production concrete in the forms. If adjustments to the mix design are necessary, the air-void analysis shall be repeated.

Only the reviewed mix design shall be used to cast units. Changes in cement type, and/or decreasing cement content shall be construed as a change in mix design and will not be allowed.

6% to 8% condensed silica fume by weight of cement shall be used in all precast girders and stay in place deck panels. An acceptable compatible superplasticizing admixture shall be used together with the silica fume. Metakaolin may be used in lieu of silica fume at a rate of 12% to 16%.

300.4.4.5.5 Other Data

Test data to prove conformance to the standards for other materials including cement, silica fume, aggregate and admixtures shall be obtained.

300.4.4.5.6 Construction Data Sheets

During manufacture, the construction data sheets shall be kept up to date and available for the Ministry's review in accordance with Schedule 9 – Review Procedure.

300.4.4.6 Materials

300.4.4.6.1 Cement

Portland cement conforming to the requirements of CSA Standard A3001 shall be used.

300.4.4.6.2 Water

Water to be used for mixing concrete or mortar shall conform to the requirements of CSA Standard A23.1 and shall be free from injurious amount of alkali, organic materials or deleterious substances. Project Co shall not use water from shallow, stagnant or marshy sources.

300.4.4.6.3 Silica Fume

Condensed silica fume shall conform to CSA Standard A3001, for a Type SF supplementary cementing material, with a SiO_2 content of at least 85%, a maximum loss on ignition of 10%, and SO_3 content shall not exceed 1%.

300.4.4.6.4 Aggregates

Normal Weight Aggregates

Fine and coarse normal weight aggregates shall conform to the requirements of CSA Standard A23.1, with maximum aggregate size of 14 mm.

Lightweight Aggregates

Fine and coarse lightweight aggregates shall conform to the requirements of the ASTM Specification C330, with maximum aggregate size of 14 mm.

300.4.4.6.5 Air Entraining Agent

Air entraining agent shall conform to the requirements of the ASTM Specification C260.

300.4.4.6.6 Chemical Admixtures

Chemical admixtures shall conform to the requirements of ASTM Specification C494. All chemical admixtures shall be suitable for use in precast concrete, be supplied by the same manufacturer as the air entrainment agent, and be compatible with each other. The addition of calcium chloride, accelerators, retarders or set controlling admixtures and air reducing agents will not be permitted.

Acceptable admixtures are air-entraining agents, superplasticizers and water-reducing agents.

300.4.4.6.7 Concrete

Concrete shall consist of Portland cement, condensed silica fume or Metakaolin, aggregates, water and acceptable admixtures. The type of concrete to be used will be specified in the Design Data.

The density, entrained air and air void spacing requirements for the various types of concrete are specified in Table 300.4.4.6.7 below.

Table 300.4.4.6.7 Concrete Performance Requirements

Type of Concrete	Aggregates	Concrete Unit Weight, Plastic State kg/m^3	Minimum Total Air Content %	Maximum Air Void Spacing Factor (hardened concrete) mm
Standard Weight	Fine and Coarse Standard Weight	--	5	0.23
Lightweight	Fine and Coarse Lightweight	1680 ± 5%	6	0.23
Semi-Lightweight	Fine Standard Weight & Coarse Lightweight	1920 ± 5%	6	0.23

300.4.4.6.8 Reinforcing Steel

Reinforcing steel, including cover requirements, shall conform to Sections 200.7.6, 200.7.7 and 300.4.10 of Schedule 15-2 – Design and Construction.

300.4.4.6.9 Stressing Strand

Prestressing strand shall conform to the requirements of CSA Standard G279 or ASTM A416/A416M for low relaxation strand (f_{pu} = 1860 MPa).

Shop drawings and stressing calculations shall clearly show the type of strand to be used, and changes will not be allowed during production.

300.4.4.6.10 Lifting Hooks

Lifting hooks made of prestressing strand shall conform to the requirements of CSA Standard G279 or ASTM A416/A416M, and shall be fabricated in a manner that distributes the load evenly to all strands.

300.4.4.6.11 Miscellaneous Steel

Miscellaneous steel shall conform to the requirements of the CSA Standard G40.21 grade 300W. Project Co shall obtain mill certificates to prove conformance to the standard. Fabrication shall conform to Section 300.4.3 of Schedule 15-2 – Design and Construction.

300.4.4.6.12 Bridgerail and Anchor Bolts

The assemblies shall be hot-dip galvanized after fabrication. All nuts and washers shall be shop assembled on the anchor bolts.

300.4.4.6.13 Voids and Ducts

All void and duct material shall remain dimensionally stable during the casting and curing of the units. Voids shorter than 400 mm shall not be permitted.

300.4.4.6.14 Galvanizing

Galvanizing shall be by the hot-dip method, after fabrication, in accordance with the current edition of ASTM Specification A123/A123M, *Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products* and ASTM Specification A153/A153M, *Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware*, with additions and exceptions as described in this specification. Project Co shall provide a smooth finish on all edges and surfaces, and remove all weld spatter and all welding flux residue from the steel components prior to galvanizing.

Repair of galvanizing shall only be done if bare areas are infrequent, small and suitable for repair. A detailed repair procedure shall be prepared by a Professional Engineer, and submitted to the Ministry pursuant to Schedule 9, Review Procedure, prior to its use. It should be noted that repairs may require complete removal of the galvanized coating and regalvanizing. Repair shall be in compliance with ASTM Specification A780, Method A3 Metallizing. The thickness of the metallizing shall be 180 μm, and the repair tested for adhesion. The finished appearance shall be similar to the adjacent galvanizing.

300.4.4.7 Fabrication

300.4.4.7.1 Forms

Precast concrete units are to be manufactured in steel forms.

For all beam members, the forms shall be designed such that they can be removed without damaging the beam. For all “I” or “T” beam members, the side forms shall be removed horizontally away from the beam by a method that prevents any contact of the form with the top flange after release of the form. The top flange shall not be subjected to a vertical force at any time.

Holes or voids shall not be cast into the top flange of "I" or "T" girders to accommodate deck formwork.

MSE wall panels shall be manufactured in smooth steel forms, mortar tight, and set on a rigid foundation.

300.4.4.7.2 Reinforcing Steel

Fabrication, handling, storage, placement and fastening of all steel reinforcement shall conform to Section 300.4.10 of Schedule 15-2 – Design and Construction.

300.4.4.7.3 Stressing Strand

Stressing strand shall be free from corrosion, dirt, grease, rust, oil or other foreign material that may impede the bond between the steel and the concrete. Stressing strand shall be protected at all times from manufacture through to encasing concrete or grouting. Stressing strand that has sustained physical damage at any time shall be rejected. Stressing strand splices shall not be placed within a precast concrete unit.

Stressing strands shall not be stressed for more than 36 hours prior to being encased in concrete. The stress in the stressing strands shall be measured both by the jacking gauges and by the elongation of the strands. The maximum allowable discrepancy between jack pressure and elongation shall be within 5%. Alternatively, the factors contributing to the difference shall be identified and corrected before proceeding. Changes in strand temperature and slippage at strand anchorages shall be measured between stressing and concrete encasement. Any changes in strand stress due to these effects shall be accounted for in the design.

Stressing strand with any broken wire shall be removed and replaced. All stressing strands shall be checked for wire breaks before placement of concrete.

The prestressed unit ends shall have 15 mm deep strand termination recesses formed around the strands. All strands shall be cut flush with the bottom of the recesses, and the recesses shall then be filled flush with the ends of the girders with a moisture insensitive epoxy paste adhesive meeting the requirements of ASTM Specification C881, Type IV, Grade 3, Class B or C. The paste shall be grey in colour. An approved Type 1c sealer shall be applied over the patched recessed areas prior to steam curing. Sealer shall not be applied to the patched recessed areas when girder ends are designed to be encased in field cast concrete.

Project Co shall be responsible for recording and reporting the elongation to the Ministry, or tension of each strand during the stressing operation, if requested by the Ministry.

300.4.4.7.4 Void and Duct Placement

Voids and ducts shall be placed as shown in the Design Data and shall be tied and securely held in the required positions to prevent movement. Continuous ducts shall align precisely. The ends of the voids shall be sealed. Voids found to be distorted, damaged or of insufficient strength will be rejected. 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. Holes or voids to accommodate formwork are not permitted.

300.4.4.7.5 Concrete Measuring, Mixing and Placing

The procedures outlined in ACI Standard 304 *Guide for Measuring, Mixing, Transporting and Placing Concrete* shall be followed. The time from initial mixing of the concrete until placing the concrete in the forms shall not exceed one hour. The elapsed time between the successive placement of concrete onto previously placed concrete shall not exceed 45 minutes.

300.4.4.7.6 Concrete Temperature

The concrete temperature shall be between 10° Celsius and 30° Celsius at the time of placing it in the forms.

300.4.4.7.7 Finished Riding Surface

Where the top surface of the girder is designed to be the riding surface, the use of a continuous screed rail, independent of the top of the grout keys, shall be employed. The top surface shall follow a smooth profile, which incorporates the required camber adjustments.

300.4.4.7.8 Camber Hubs

Three camber hubs shall be placed in each girder, located along the centreline of the girder at the midpoint and 150 mm from each end. The camber hubs shall consist of 10 mm galvanized bars, of sufficient length to project vertically 10 mm above the riding surface.

Project Co shall store the members in such a manner as to provide access for measuring camber. Project Co shall record the girder camber at the midpoint of each girder within 24 hours of girder destressing.

300.4.4.7.9 Concrete Finish

The exterior concrete girder faces shall have a Class 2 Rubbed Surface Finish. Except the top, all the remaining surfaces shall have a Class 1 Form Surface Finish.

Class 1 - Form Surface Finish

This finish is essentially that obtained when concrete has been cast and adequately compacted in a properly oiled steel form. All fins, honeycomb, irregularities, cavities over 10 mm diameter or other similar defects shall be thoroughly chipped out. These areas shall be saturated with water for a period of not less than 30 minutes, carefully pointed and trued with mortar of a colour which will match the existing concrete. Mortar used for pointing shall be less than one hour old.

The patches shall be properly cured by placing the repaired unit in the curing enclosure for a period of four days immediately after patching.

The finished surfaces shall be true and uniform. All surfaces which cannot be repaired satisfactorily shall be finished as specified for Class 2.

Class 2 - Rubbed Surface Finish

Class 2 finish shall be essentially the same as Class 1 except that all holes, cavities and defects shall be repaired so that the finished surface presents a smooth, true, dense, uniformly coloured, and non-stained appearance. The concrete surfaces shall be thoroughly wire brushed to expose any hole or cavity prior to repairs. All residue of form oil shall be removed from the surface.

Class 3 - Bonded Concrete Surface Finish

Surface preparation shall be done as is specified for (b) Class 2 (Rubbed Surface Finish) above, except that uniformity in colour is not required. After the surface preparation has been completed, the concrete surfaces shall be pressure washed to remove all dust, dirt, laitance and all other bond breaking materials. The concrete surface shall be dried for a minimum of 24 hours. Project Co shall then apply a pigmented concrete sealer, which meets the requirements for a Type 3 sealer in Alberta Transportation's "Specifications for Concrete Sealers" (B388).

The pigmented concrete sealer shall be applied in accordance with the manufacturer's specifications. A minimum of two applications, totalling the approved application rate of the pigmented sealer, are required. The colour(s) of the proposed coating scheme shall be as specified in the design. When spray application is used the surface shall be back rolled. Project Co shall ensure that no colour variation is visible, and shall match the colour of any previously painted adjoining surfaces

Class 4 - Floated Surface Finish

After the concrete has been consolidated and the surface carefully screeded to the cross section and profile shown in the Design Data, it shall be floated and trowelled as necessary to provide a closed, uniformly textured surface without brooming.

Class 5 - Floated Surface Finish, Broomed Texture

After the concrete has been consolidated, the surface shall be carefully screeded to the cross section and profile shown in the Design Data. When the concrete has hardened sufficiently, the surface shall be finished with a broom of an accepted type. The broom strokes shall be perpendicular to the edge of the unit, and extended from edge to edge, with adjacent strokes slightly overlapped producing corrugations of 2 to 3 mm in depth. Brooming shall be done when the concrete has set sufficiently to produce clear, crisp brooming marks which do not sag or slump, without tearing the surface or disturbing coarse aggregate particles. After final brooming the surface finish shall be free of porous spots, irregularities, depressions, pockets and rough spots and shall not vary more than 5 mm when measured using a 3 m straight edge.

Accepted finishing and edging tools shall be used on all edges and expansion joints after brooming.

300.4.4.7.10 Curing

The curing of concrete units shall be in accordance with CSA Standard A23.4 unless otherwise specified. The ambient curing temperature shall be increased at a rate not exceeding 20° Celsius per hour until a maximum temperature of not more than 60° Celsius is attained. After curing, the temperature of the units shall be reduced at a rate not exceeding 10° Celsius per hour until the temperature of the concrete has fallen to within 10° Celsius of ambient temperature outside the enclosure.

Care shall be exercised to protect prestressed and non-prestressed concrete units from thermal shock at all times until fully cured.

Prestressed Concrete

- **Curing in the Form** - The initial application of heat shall commence only after the last of the freshly placed concrete has attained its initial set, which is normally two to four hours after casting. Heat shall not be applied directly to the concrete, but by a method that will produce a consistent ambient temperature throughout the entire form and enclosure. The increase in temperature and the holding temperature shall be monitored and permanently recorded on a chart at a minimum of 3 quarter points along the form.
- **Curing After Removal From the Form** - Upon removal from the forms the units shall be cleaned, patched and finished within a period not exceeding 12 hours. The units shall be placed in a manner that will facilitate any clean up or repair work, and that will allow full inspection of all surfaces. Within 24 hours of removal from the form, the units shall be placed within a suitable enclosure, for curing. The curing enclosure shall provide a minimum of 150 mm of free air space between the concrete surfaces and the coverings. Flexible coverings shall be secured to prevent any moisture loss. The difference in ambient air temperature adjacent to the concrete at different locations within the enclosure shall not exceed 10° Celsius at any time. The curing process shall be continued for a period of 4 days with one of the following methods:

    - **Steam Curing** - Steam jets shall not directly impinge on the concrete surfaces. The steam shall be in a saturated condition maintaining an atmosphere of 95% to 100% relative humidity and a uniform ambient temperature between 40° Celsius and 60° Celsius. For days with periods of 4 or more hours within a 24-hour period, where measured temperature or humidity levels do not meet the required limits, these days will not count as a full day of steam cure. An additional day of steam cure beyond the specified four days will be required for each non-compliant day.

- **Curing with Continuous Misting & Heat** - Sufficient number of atomizing misting nozzles shall be strategically located to produce a fine mist with 100% relative humidity in the enclosure. The water shall be preheated to a temperature which will produce a misting temperature compatible with the ambient temperature. The enclosure shall be heated with radiant heaters to a temperature of between 40° Celsius and 60° Celsius. Dry heat shall never touch the concrete surface at any time. A control system shall be installed to shut off the heat when the humidity level drops below 90% in the enclosure. Should the temperature in the concrete rise above 40° Celsius without the misting, the unit will be rejected.

Two continuously recording thermometers and two continuously recording hygrometers shall be provided for each curing enclosure to monitor the concrete and curing rates. All time-temperature and time-humidity recordings shall be clearly shown on the graph.

Non-Prestressed Concrete

Curing of all non-prestressed concrete shall be in accordance with one of the following methods.

- **Elevated Temperature Curing** - Upon removal from the forms the units shall be cleaned, patched, finished and elevated temperature cured for four days as above.
- **Moist Curing** - The units may be moist cured in lieu of elevated temperature curing as noted below:
  - Upon removal from the forms the units shall be cleaned, patched, finished, and ready for inspection within a period not exceeding 12 hours. Patching shall be performed with an approved product and at an ambient temperature of between 15° Celsius to 30° Celsius. After completion of patching and finishing, within 24 hours of removal from the form, the units shall be placed under two layers of light coloured filter fabric (Nilex C-14 or equivalent) at an ambient temperature of not less than 15° Celsius. The filter fabric shall be kept in a continuously wet condition throughout the curing period by means of a soaker hose or other means as reviewed in accordance with Schedule 9 – Review Procedure. Curing with filter fabric and water shall be maintained for a minimum period of seven days.
  - For curing of MSE panels, covering with filter fabric is not required provided that the moist curing system maintains a continuously wet condition at all panel surfaces.

300.4.4.7.11 Release of Stressing Strand

The stressing strand shall not be released until the specified concrete release strength is attained, and the release shall be in accordance with the accepted sequence.

Evidence of casting defects shall be repaired prior to release of the strands.

300.4.4.7.12 Repairing Damaged Concrete

Serious damage, honeycombing and other casting defects shall be immediately reported to the Engineer of Record and to the Ministry.

Repairs to defects such as cracks, honeycombs or spalls shall be carried out in accordance with this section. Units with unacceptable cracks, honeycombs or spalls shall be rejected.

All repair procedures shall be developed by a Professional Engineer, agreed to by the Engineer of Record and reviewed in accordance with Schedule 9 – Review Procedure by the Ministry prior to the commencement of the repair. All repairs shall be completed prior to curing of the unit at an ambient temperature of 15° Celsius to 30° Celsius, and units shall be protected from dehydrating prior to curing.

In this section, the "bearing area" of a girder is defined as the portion of the girder bottom flange up to the underside, but not including the radiused transition between the bottom flange and the web, directly above the bearing. The bearing area extends from the end of the unit to 75 mm beyond the edge of the shoe plate. The anchorage area of a girder is defined as the full-height portion of the girder that is within two times the girder depth from the end of the girder but is not in the bearing area.

Cracks

The following cracks are unacceptable and shall result in rejection of the unit:

- Cracks in the bearing area of a girder.

The following cracks are unacceptable and shall result in repair or rejection of the unit:

- Cracks in the anchorage area of a girder exceeding 0.2 mm in width.
- Cracks outside of the girder bearing and anchorage areas exceeding 0.2 mm in width or longer than 300 mm.

All repairable cracks 0.2 mm or greater in width shall be repaired by epoxy injection in accordance with the manufacturer's instructions. Coring shall be carried out to confirm the penetration of the epoxy into the crack, if so requested by the Ministry.

Project Co shall immediately notify the Engineer of Record and the Ministry if a crack that has the potential to be a shear crack exceeds 0.15 mm in width and is longer than 0.25 times the girder depth. The crack length shall be measured along the horizontal axis, and a crack shall be considered to be a shear crack if it is inclined at an angle between 30° and 60° from the horizontal.

Honeycombs and Spalls

The following conditions of honeycomb or spall are unacceptable and shall result in rejection of the unit unless accepted and signed off by the Engineer of Record.

- Any honeycomb or spall in the bearing or anchorage areas of a girder.
- Major honeycombs and spalls in areas outside the bearing or anchorage areas of a girder.
- Honeycombs and spalls in precast units shall be considered major if more than 30 mm deep or more than 0.1 m^2 in area.

When approved by the Engineer of Record and reviewed in accordance with Schedule 9 – Review Procedure by the Ministry, repairs for honeycombs and spalls may be made using a cementitious material. Repairs of minor honeycombs and spalls may be made after destressing of the girder. However major honeycombs and spalls shall be repaired before destressing the girder.

300.4.4.7.13 Sealers

Project Co shall supply and install an approved Type 1c sealer to the girder surfaces as shown on Drawing SK-1 (Standard Details for Sealer Surface Treatments) in Appendix B. Type 1c sealers shall be in accordance with Section 300.4.2.17 of Schedule 15-2 – Design and Construction and pigmented sealer shall be in accordance with Section 300.4.2.16.4 of Schedule 15-2 – Design and Construction. The sealer shall be applied on clean dry surfaces free of form oil, and in accordance with the manufacturer's recommendations.

Project Co shall ensure that the sealer is not applied in the grout pockets, lifting hook pockets or areas of the girders that will have field concrete cast against them.

The Ministry reserves the right to sample and test the sealer supplied by Project Co.

300.4.4.7.14 Sandblasting

The concrete surfaces in shear key, block out, diaphragm and girder end void locations shall be sandblast roughened. The blasting shall be sufficient to remove all laitance and uniformly expose the aggregate particles. All loose materials and sandblast grit to be removed prior to shipping to site.

300.4.4.7.15 Dimensional Tolerances of Cast Units

The maximum dimensional deviation in mm, of cast units from that as detailed in the Design Data shall not exceed the following:

- Length ..... ± 20 mm x length (m) ÷ 50
- Width ..... ± 3 mm

- Depth.....± 5 mm
- Camber- .....± 20 mm x length (m) ÷ 50
- Sweep (NU Girders)* .....1 mm/m
- Sweep (Other Girders)* ..... deviation from true, 20 mm x length (m) ÷ 50
- Projection of Stirrups
  - Top of Girder .....± 12 mm
  - Bearing Areas- .....out of flatness of bearing areas, 3 mm
  - Bulkheads ..... warpage or tilt of ends, 5 mm
- Rail Anchor Bolts
  - ....out of line, 5 mm
  - .... in spacing, 5 mm
  - ....- ..... in projection, 5 mm
- Dowel Holes.....out of plumb, 5 mm
- Void Location..... surface to void dimension, ± 15 mm after casting

* Measured in the plant immediately prior to shipping to site.

300.4.4.7.16 Handling and Storage

Precast units shall be handled by means of accepted lifting devices at designated locations. Units shall be maintained in an upright position, supported near the ends and on stable foundations.

300.4.4.7.17 Identification of Units

Fabricator's name, year of manufacture, unit serial number and design loading shall be cast into the bottom of the units in 50 mm letters about 1.0 m from the unit end.

300.4.4.7.18 Fabrication of Prestressed/Precast Units in Cold Weather

Project Co shall accept full responsibility for the protection of prestressed/precast concrete units when fabricating in adverse weather conditions.

When the ambient temperature is, or is expected to be, below 5° Celsius during fabrication the following provisions for cold weather casting shall be put in place:

- Project Co shall construct an enclosure and shall maintain the ambient temperature within the enclosure between 15° Celsius and 30° Celsius. The enclosure shall be sufficiently sized that it will accommodate steel forms, workers and the casting equipment. The enclosure temperature shall be constantly monitored.
- The heating system shall be designed to provide uniform distribution of heat and the combustion by-products shall be kept out of the enclosure.

- Before casting concrete, adequate preheat shall be provided to raise the temperature of the formwork, reinforcing steel, stressing strand, miscellaneous iron, etc. to at least 10° Celsius.
- The fabricated units shall be kept in the enclosure until they are patched, repaired and transferred to the curing enclosure.

300.4.4.8 Testing and Inspection

300.4.4.8.1 Access

Project Co shall provide the Ministry with suitable and safe access to the Works for the purposes of testing and inspection of the precast concrete units. Project Co shall provide the following:

- Cylinder storage box with temperature control and a max./min. thermometer, as per CSA Standard A23.2-3C.
- A calibrated weigh scale.

300.4.4.8.2 Inspection

Project Co shall be responsible for all quality control and relevant testing. Inspection of the units by the Ministry will not relieve Project Co of its responsibility for quality control.

300.4.4.8.3 Test Methods

Sampling, making, curing and testing concrete specimens shall be in accordance with the requirements of the following CSA standards:

- Sampling - A23.2-1C
- Concrete Test Cylinders - A23.2-3C
- Testing Concrete Cylinders - A23.2 - 9C
- Air Content - A23.2-4C
- Density of Concrete - A23.2-6C
- Air Void Determination – A23.2-17C

300.4.4.8.4 Testing by Project Co

Project Co shall engage an independent CSA certified testing laboratory to conduct all the required concrete testing and ensure that the concrete supply meets all requirements of the Technical Requirements. The CSA certified testing laboratory shall be independent of both Project Co and Project Co's subcontractors. Project Co shall maintain the required air entrainment by testing and making adjustments to the mix prior to and during the placing of concrete in the forms.

Project Co's testing agency shall make and test concrete cylinders to determine the 28-day compressive strength. Samples for testing shall be taken from the fresh concrete being placed in the forms at the rate of one set of cylinders for every three bridge units cast continuously. A set shall consist of a minimum of three cylinders. A strength test will be the average of the 28-day strengths of the three cylinders (one set). Continuous casting shall mean no break in the casting longer than one hour.

300.4.4.8.5 Release Strength Test Cylinders

Project Co shall arrange to make and test concrete cylinders to prove that the required release strength as stated in the Design Data has been attained prior to release of the stressing strand. When one or more units are cast continuously, at least two cylinders shall be taken from the concrete of the last unit poured to represent the release strength for all units. These cylinders shall be cured with the bridge unit. Only testing of the first cylinder will be necessary if the required release strength is obtained. In the event all cylinders are tested without the required strength being obtained, the Engineer of Record and the Ministry shall be contacted.

300.4.4.8.6 Right of Rejection

Concrete shall meet the strength requirements stated in the Design Data

In the event that the concrete tested is more than 4 MPa below the specified 28-day compressive strength, the bridge units fabricated from the concrete represented by the test specimens shall be rejected. In the event that the unit has been delivered and/or erected in the field, it shall be removed and returned to Project Co plant for replacement.

300.4.4.8.7 Coring

If any concrete tested fails to meet the specified strength, Project Co may request permission to core. When coring is used to confirm or contest low concrete strength test results, , Project Co shall make arrangements, to employ a CSA certified, Category 1 or higher level qualified testing laboratory, at Project Co's expense.

Project Co's Engineer of Record shall specify the location of the coring to ensure that the cores represent the same concrete as the cylinders. The average of three adjacent cores taken from one bridge unit shall constitute a test. The cores shall be taken and tested in accordance with CSA Standard A23.2- 14C within seven days of the date of testing the 28-day cylinders, but contrary to CSA Standard A23.1, the compressive strength of the concrete will only be considered adequate if the average of each set of three cores is greater or equal to the 28 day compressive strength. The core test will represent all bridge units represented by the strength test. Alternatively, Project Co may choose to take a core test from each of the other units in question, in which case each of these core tests will then represent a bridge unit.

The acceptability of the as-delivered concrete shall be determined using the concrete cylinders, with the modification set out in the next two sentences. In cases where the concrete strength, as

indicated by the cores, is higher than the strength based on the concrete cylinder results, the core results shall be used as the basis for acceptance of the concrete. If the core strengths are lower than the strength from the concrete cylinder tests, the cylinder tests shall govern.

300.4.4.9 Transportation and Erection

300.4.4.9.1 General

Project Co shall erect the units, remove any temporary construction, and do all work required to complete the erection in accordance with the Design Data and the Technical Requirements. No drilling, coring, nailing, retrofitting of any fastening or anchoring systems, or any other modifications shall be made to the concrete elements. Project Co shall not erect precast concrete girders until the substructure concrete has been cured a minimum of three days and achieved 80% of the 28-day specified concrete strength requirements.

Without restricting generality, erection includes:

- Removing anchor bolt grout can lids;
- Placing and grouting anchor bolts and bearings;
- Erecting the girders;
- Placing and grouting of connector bolts and diaphragms;
- Post tensioning;
- Placing and sealing grout bearing pads; and
- Cutting-off lifting hooks and grouting lifting holes on exterior girders and all lifting hook pockets.

300.4.4.9.2 Handling And Storing Materials

Precast concrete units to be stored shall be placed upright and shored on timber blocking and kept clean and properly drained.

300.4.4.9.3 Temporary Supporting Structures And Berms

The temporary supporting structures and berms shall be properly designed and substantially constructed and maintained for the forces which may come upon them. Berms shall be constructed in a manner and of such materials that they will not be eroded by stream flow nor introduce silt into the water. Project Co shall prepare drawings for temporary supporting structures and berms, and for traffic control and accommodation where applicable. All drawings shall bear the seal of a Professional Engineer.

Temporary supporting structures and/or berms will not be permitted to remain in any stream channel during spring break-up or run-off periods, unless all necessary approvals have been obtained by Project Co from pertinent agencies.

Incidental damage to other property, such as fills and stream banks, resulting from the existence of berms, shall be the responsibility of Project Co.

300.4.4.9.4 Erection Procedure

Project Co shall prepare a detailed erection procedure for review in accordance with Schedule 9 – Review Procedure in advance of the scheduled start of erection. The erection procedure shall include all drawings and documents necessary to describe the following:

- Access to work, earth berms and work bridges.
- Type and capacity of equipment. Cranes shall be used for handling and erecting precast concrete units.
- Sequence of operation, including position of cranes, trucks with girders, and traffic accommodation.
- Detailed crane position on the ground, particularly adjacent to substructure elements, such as abutment backwalls, and MSE walls, with details of load distribution on wheels and outriggers.
- Details of crane position on the structure, showing wheel loads and axle spacing of equipment moving on structure.
- Loads and their position from crane wheels and outriggers during all positions of lifting when crane is on structure.
- Details of temporary works, supporting structure drawings, including proposed methods to be used to ensure the required splice elevations and structure shape prior to placing concrete, and/or post-tensioning and method of providing temporary supports for stability.
- Details of lifting of units, showing vertical forces at lifting hooks.
- Provisions for control and adjustment of errors for width and positioning of curbs or exterior units.
- Complete details of blocking for bearings where necessary to constrain movements due to horizontal forces and/or gravity effects.
- Details of post-tensioning procedures, including strand specifications, jack dimensions, pressures, forces and elongations, and grouting.
- Grout pad construction (refer to Section 300.4.3.4.2 of Schedule 15-2 – Design and Construction).
- Details of release of temporary supporting structures.
- Provide an “as-built” detailed survey of the substructure showing the following:
    - ....Location and elevation of all bearing grout pad recesses;
    - ....Shim height at each bearing location; and
    - ....Top of girder elevations at each bearing (and each splice location where appropriate).

The erection procedure shall bear the seal of a Professional Engineer, who shall assume full responsibility to ensure that its design is being followed. Safety and compliance with the

Saskatchewan Employment Act and *The Occupational Health and Safety Regulations*, 1996 thereunder, shall be integral parts of the design.

Before erection begins Project Co shall do a complete superstructure layout by means of chalk lines and markings applied to all substructure units, showing bearing and girder positions in accordance with the approved layout plan.

300.4.4.9.5 Girder Adjustments

It is essential that the girders be erected with utmost attention being given to girder positioning, alignment, and elevation. Project Co shall adjust girder position, bearing location and bearing elevation in order to achieve as closely as possible the lines and grades shown in the Design Data. Project Co shall minimize any differential camber (girder to girder), and the sweep of the girders, by jacking, loading of girders, winching, or whatever means are necessary, and shall provide the necessary temporary attachments to hold the girders in position. Project Co shall inspect for and map crack locations if force is required to bring girders into alignment.

The maximum dimensional deviation in mm, of erected precast concrete units from that as detailed in the Design Data shall not exceed the following:

- Sweep (NU Girders) .....1 mm/m
- Sweep (Other Units) ..... deviation from true, 20 mm x length (m) ÷ 50

300.4.4.9.6 Grout Pockets And Grout Pads

Project Co shall construct grout pads using Sika 212 flowable grout or equivalent. Filling of grout pockets and construction of grout pads shall be done by workers competent in this work.

Grout shall be packaged in waterproof containers with the production date and shelf life of the material shown. It shall be mixed, placed, and cured in strict accordance with the manufacturer's recommendations.

Dry pack methods of constructing grout pads will not be accepted.

Sealer shall be applied to the exposed grout pad surfaces in accordance with Section 300.4.2.17 of Schedule 15-2 – Design and Construction.

300.4.4.9.7 Grouting In Cold Weather

When the daily minimum air temperature, or the temperature of the girders, bearings or substructure concrete, in the immediate area of the grouting, falls below 5° Celsius, the following provisions for cold weather grouting shall be affected:

- 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 10° Celsius.

- Temperature of the grout during placing shall be between 10° Celsius and 25° Celsius.
- The grout pads (or girders where appropriate) shall be enclosed and kept at 10° Celsius to 25° Celsius for at least 5 days. The system of heating shall be designed to prevent excessive drying-out of the grout.

300.4.4.9.8 Bearings and Anchorage

Project Co shall remove anchor bolt void forming materials prior to grouting. Any residues on the concrete surface, such as oils, grease or other contaminants that can reduce bonding characteristics, shall be removed by sandblasting.

Anchor bolts shall be set accurately and grouted with a non-shrink cement grout. The location of the anchor bolts, in relation to the slotted holes in the expansion shoes, shall correspond with the temperature at the time of erection. The nuts on the anchor bolts, at the expansion ends of spans, shall be adjusted to permit free movement of the spans.

When steel bearings are employed in conjunction with grout pockets in the substructure, the bearings shall be set accurately on galvanized steel shims, and grouted as detailed in the Design Data, after the erection has been completed. The shims shall be located so that minimum 75 mm grout coverage is provided. When grout pockets are not detailed, the bearing plates shall be set on the properly finished bearing areas in exact position and shall have a full and even bearing on the concrete.

Where the design requires that the girders bear on elastomeric pads placed directly on pier or abutment seat concrete, Project Co shall ensure a properly finished bearing area so that the girders have full and even bearing. In the event full bearing is not achieved the neoprene pads shall be fabricated to the required dimensions so that each girder has full and even bearing.

Where required, field welding adjacent to the elastomeric pads shall be performed with care to avoid damage to the elastomer. The temperature of the steel adjacent to the elastomer shall be kept below 120° Celsius. The distance between the weld and the elastomer shall be at least 40 mm.

300.4.4.9.9 Assembly

The parts shall be accurately assembled as shown in the Design Data. The material shall be carefully handled so that no parts will be distorted, broken or otherwise damaged. Bearing surfaces, and surfaces to be in permanent contact, shall be cleaned before the members are assembled. Diaphragms shall be erected as indicated in the Design Data.

300.4.4.9.10 Lifting Hooks and Lifting Holes

After the girders are properly erected and positioned, all lifting holes on exterior girders shall be filled with an accepted grout; all lifting hooks shall be cut off 50 mm below surface, and all lifting hook pockets shall be filled with grout.

300.4.4.9.11 Removal of Falsework and Site Clean-Up

Upon completion of the erection Project Co shall remove all earth material or temporary supporting structures placed in the stream channel or elsewhere during construction. Project Co shall remove all piling, excavated or surplus materials, rubbish and temporary buildings, replace or renew any damaged fences, and restore in an acceptable manner all property damaged during the execution of its work.

Project Co shall leave the bridge site, roadway and adjacent property in a neat, restored, and presentable condition, and when required, Project Co shall provide the Ministry with written evidence that affected property owners or regulatory agencies have been satisfied.

300.4.5 Post Tensioning

300.4.5.1 General

This work consists of post tensioning and grouting of cable ducts for cast-in-place and precast concrete.

300.4.5.2 Submissions

The following information shall be submitted to the Ministry:

- Post-tensioning drawings illustrating the stressing system and, where appropriate, design details and sequence of stressing (two copies);
- Stressing calculations taking into account all applicable losses (two copies);
- Load/elongation curves for the prestressing strand;
- Mill certificates for the prestressing strand; and
- Details of permanent anchoring devices.

300.4.5.3 Standards

Applicable requirements of the current edition of the following standards shall be followed:

- CSA Standard A23.1/23.2 – Concrete Materials and Method of Concrete Construction.
- CSA Standard A23.4 – Precast Concrete Materials and Construction.
- Section 300.4.2 (Cast-in-Place Concrete).
- Guide Specification Acceptance Standards for Post Tensioning Systems – PT1.
- Specifications for Grouting of Post Tensioned Structures – PT1.
- AASHTO LRFD Bridge Construction Specifications.

Qualifications

Project Co, or its subcontractor, shall have extensive experience in this work and shall utilize only fully trained, competent and experienced operators. Project Co shall ensure that the site supervisor responsible for the tensioning and grouting operations is at the site whenever these operations are being carried out.

300.4.5.4 Materials

300.4.5.4.1 Prestressing Strand

Stressing strand shall conform to the requirements of Section 300.4.4.6.9 of Schedule 15-2 – Design and Construction.

Corrosion inhibitor is required when the stressing and grouting operations are not completed within 20 calendar days of the installation of the stressing steel. The corrosion inhibitor, when required, shall be water-soluble and shall have no deleterious effect on the steel, grout or concrete; or bond strength of steel to concrete.

300.4.5.4.2 Anchorages and Distribution

All stressing steel shall be secured at the ends by means of permanent anchoring devices. These devices shall comply with the Bridge Design Code Clause 8.4.4.1.

Steel distribution plates or assemblies may be omitted when the anchoring devices are sufficiently large and used in conjunction with an embedded steel grillage that effectively distributes the compressive stresses to the concrete.

300.4.5.4.3 Ducts

Ducts shall be corrugated, semi-rigid galvanized metal tubes and be capable of withstanding concrete pressures without excessive deformation or permitting the entrance of cement paste during the placement of concrete. The ducts shall have sufficient rigidity to maintain the required profile between points of supports. The interval between supports shall not exceed 1.0 m.

Project Co shall provide mortar tight inlets and outlets in all ducts with a nominal diameter of 20 mm in the following locations:

- The anchorage area;
- All high points of the duct, when the vertical distance between the highest and lowest point is more than 500 mm;
- Place an inlet at or near the lowest point; and
- Place a free draining outlet at all low points of duct.

Project Co shall provide inlets and outlets with valves, caps or other devices capable of withstanding the grouting pressure. The ducts and vents shall be securely fastened in place to prevent movement. Project Co shall provide details of inlets and outlets on the shop drawings.

300.4.5.4.4 Concrete

Concrete shall be supplied in accordance with Section 300.4.2 of Schedule 15-2 – Design and Construction, however the maximum size of coarse aggregate shall be 10 mm and the 28-day compressive strength shall be a minimum of 50 MPa.

300.4.5.4.5 Grout

Grout shall be Class C as described in AASHTO LRFD Bridge Construction Specification Table 10.9.3-1, and the properties as described in Table 10.9.3-2. In addition to the requirements noted in these tables, a test for wet density shall also be performed in accordance with the "Standard Test Method for Density" ASTM Specification C138. Prebagged grouts shall be packaged in plastic lined bags or coated containers, stamped with the date of manufacture, lot number and mixing instructions. Copies of the quality control data for each lot number and shipment sent to the job site shall be provided to the Ministry for review in accordance with Schedule 9 – Review Procedure prior to grouting. Materials with a total time from manufacture to usage in excess of six months shall be retested and certified by the supplier before use, or shall be removed from the job site and replaced.

The average compressive strength of 3 cubes at 28 days shall be a minimum of 50 MPa as per CSA Test Method A23.2-1B. The results for bleed test and fluidity test shall meet the requirements noted in Table 10.9.3-2 of the AASHTO LRFD Bridge Construction Specifications.

Project Co is responsible to perform all grout testing in the field and shall notify the Ministry a minimum of 24 hours prior to grouting and grout testing in the field. The frequency of grout testing shall be as follows:

- **Strength Test** - Precast concrete girders, one strength test per girder line. Cast-in-place girders, one strength test for every four longitudinal ducts.
- **Bleed Test** - At the beginning of each day's grouting operation, perform a wick induced bleed test in accordance with ASTM Specification C940 and with modifications noted in Table 10.9.3-2 of the AASHTO LRFD Bridge Construction Specifications.
- **Fluidity Test** - At the inlet and outlet, perform fluidity test in accordance with the standard ASTM Specification C939 flow cone test or the modified ASTM Specification C939 flow cone test.
- **Wet Density Test** - Perform wet density test in accordance with American Petroleum Institute Mud Balance Test API Practice 13B-1 "*Standard Procedures for Field Testing Water-Based Drilling Fluids*".

300.4.5.5 Equipment

300.4.5.5.1 Stressing

- Hydraulic jacks and pumps of sufficient capacity shall be used for tensioning of strands.
- The force induced in the prestressing strand shall be measured using calibrated jacking gauges, load cells or a calibrated dynamometer.
- The pressure gauge shall have an accurate reading dial at least 150 mm in diameter.
- The forces to be measured shall be within 25 and 75% of the total graduated capacity of the gauge, unless calibration data clearly establishes consistent accuracy over a wider range.
- The measuring devices shall be calibrated at least once every six months. The jack and the gauge shall be calibrated as a unit. A certified calibration chart shall be kept with each gauge.

300.4.5.5.2 Grouting

- A high speed shear mixer shall be used that is capable of continuous mechanical mixing and producing grout that is free of lumps and undispersed cement. The water supply to the mixer shall be measured by an accurate gauge.
- The holding tank shall be capable of keeping the mixed grout in continuous motion until it is used. The outlet to the pump shall have a screen with 3 mm maximum clear opening.
- A positive displacement type pump shall be used which is capable of producing an outlet pressure of at least 1 MPa. A pressure gauge having a full-scale reading of no greater than 2 MPa shall be placed at some point in the grout line between the pump outlet and the duct inlet. A spare fully functional pump shall also be on site.
- Standby flushing equipment with water supply shall be available at the site prior to commencing grouting.
- The grouting equipment shall be of sufficient capacity to ensure that grouting of the longest duct can be completed within 30 minutes after mixing.
- Grout hoses and their rated pressure capacity shall be compatible with the pump output and the maximum grout pressure. All connections from the grout pump to the duct shall be airtight so that air cannot be drawn into the duct.

300.4.5.5.3 Checking Post Tensioning Ducts

Prior to placing post-tensioning steel, Project Co shall verify that all ducts are unobstructed.

300.4.5.5.4 Welding

Welding of stressing tendons shall not be permitted. Stressing tendons shall not be used as an electrical “ground”. Where the ends of strands are welded together to form a tendon so that the tendon may be pulled through the ducts, the length of the strands used as an electrical “ground” or 1.0 m, whichever is greater, shall be cut off from the welded end prior to stressing.

300.4.5.5.5 Tensioning

Post tensioning shall be carried out as per the Design Data and stressing calculations. The stressing and release of tendons shall be done in the sequence specified in the Design Data. All strands in each tendon shall be stressed simultaneously with a multi-strand jack. The force in the tendons shall be measured by means of pressure gauge and shall be verified by means of tendon elongation. All tendons shall be tensioned to a preliminary force as necessary to eliminate any slack in the tensioning system before elongation readings are started. This preliminary force shall be between 15% and 25% of the final jacking force.

Stressing tails of post-tensioned tendons shall not be cut off until the record of gauge pressures and tendon elongations has been reviewed by a Professional Engineer. A record of the following post-tensioning operations shall be kept for each tendon installed:

- Project Name and File Number;
- Subcontractor;
- Tendon location and size;
- Date tendon installed;
- Tendon pack/heat number;
- Modulus of elasticity (E);
- Date stressed;
- Jack and gauge identifier;
- Required jacking force and gauge pressures;
- Elongation (anticipated and actual);
- Anchor set (anticipated and actual);
- Stressing sequence;
- Witnesses to stressing operation;
- Grout information (Brand Name);
- Time for grouting each tendon; and
- Date grouted.

300.4.5.5.6 Concreting

The anchorage recesses shall be concreted after tensioning but before grouting the tendons.

The concrete surface of the anchorage recesses shall be abrasive blasted. The recesses shall be thoroughly wetted and covered with a thin cement scrub coat immediately before placing fresh concrete.

300.4.5.5.7 Grouting

All ducts or openings shall be clean and free of all deleterious matter that would impair bonding of the grout to the ducts and stressing steel. All ducts shall be thoroughly flushed out with water

and blown out with compressed oil free air. All inlets and outlets shall be checked for their capacity to accept injection of grout by blowing compressed oil free air through the system.

Before stressing and grouting internal or external tendons, install all grout caps, inlets and outlets and test each tendon with compressed air to determine whether duct connections need repair. Pressurise the tendon to 345 kPa (50 psi) and lock-off the outside air source. Record pressure for 1 minute. A pressure loss of 170 kPa (25 psi) is acceptable for tendons up to 45 m long, and a pressure loss of 100 kPa (15 psi) is acceptable for tendons longer than this. If the pressure loss exceeds the acceptable, repair leaking connections using methods approved by the Ministry, and retest.

A thoroughly mixed grout, meeting all the requirements described in Section 300.4.5.4.5 of Schedule 15-2 – Design and Construction shall be passed through a screen with 3 mm maximum clear openings before entering the pump. All grout vents shall be opened prior to commencement of grouting. The duct shall be completely filled by injecting grout from the lowest end of the tendon in an uphill direction. Grout shall be pumped continuously through the duct until no visible signs of water or air are ejected at the outlet. A fully operational grout pump shall be on site for all pumping procedures. A continuous, one way flow of grout shall be maintained at a rate of 5 to 15 lineal metres of duct per minute. The grouting of a tendon shall be completed within 30 minutes of mixing of the grout.

Normal pumping pressure shall be between 0.1 MPa and 0.4 MPa measured at the inlet. The pumping pressure at the injection vent shall not exceed 1 MPa. If the actual pressure exceeds the maximum allowed, the injection vent shall be closed and the grout shall be injected at the next vent that has been or is ready to be closed as long as one-way flow is maintained. Grout shall not be injected into a succeeding vent from which grout has not yet flowed. For each tendon, immediately after uncontaminated uniform grout discharge begins, a fluidity test shall be performed on each tendon from the discharge outlet. The measured grout efflux time shall not be faster than the efflux time measured at the inlet or the minimum efflux time established. If the grout efflux time is not acceptable, additional grout shall be discharged from the discharge outlet. Grout efflux time shall be tested. This cycle shall be continued until acceptable grout fluidity is achieved. In addition to fluidity test, check the grout density using the wet density method. The density at the final outlet shall not be less than the grout density at the inlet. To ensure the tendon remains filled with grout, the ejection and injection vents shall be closed in sequence, respectively under pressure when the tendon duct is completely filled with grout. Valves and caps are not to be removed until the grout has set.

Grouting shall not be done when the air temperature is below 5° Celsius or above 25° Celsius, nor when there are other conditions that would be detrimental to the grouting operations.

Project Co shall provide 50 mm deep grout tube termination recesses formed around the tubes projecting from top of the deck. After grouting, all tubes shall be cut flush with the bottom of the recesses, and the recesses shall then be grouted flush with the top of the deck.

300.4.6 Construction of CSP and SPCSP Structures

300.4.6.1 General

Refer to Ministry Hydraulics Manual, Section 700.

300.4.7 Mechanically Stabilized Earth Walls

300.4.7.1 General

This specification is for the design, supply, fabrication and construction of mechanically stabilized earth ("**MSE**") retaining walls with precast concrete facing panels. MSE retaining walls shall include, but not be limited to, excavation for the wall, concrete levelling pads, precast concrete panels, compacted granular backfill, soil reinforcement, perforated drain pipe complete with filter fabric sock, surface drains, cast-in-place concrete wall coping, traffic barrier, pedestrian railing, permanent safety railing, hardware and all associated materials.

MSE retaining walls shall be designed and constructed in accordance with the drawings and the provisions contained herein.

300.4.7.2 Recognized Products List

Project Co shall use one of the following proprietary wall systems and shall indicate the proposed wall system in the Design Data:

Source	Product
The Reinforced Earth Company	Reinforced Earth MSE Precast Panel Retaining Walls
Armtec	Durisol Anchored Retaining Wall System
Tensar International Corporation	ARES Modular Panel Wall System
Hilfiker	Eureka Reinforced Soil
Hilfiker	RSE Smooth Face
VSL	VSoL Retained Earth Wall System
AIL	Vist-a-Wall MSE Structural Wall Systems

300.4.7.3 Materials

300.4.7.3.1 Concrete

Concrete for MSE wall precast concrete panels, MSE wall levelling pad concrete and MSE wall coping concrete shall be as specified in Section 200.7.6.8 of Schedule 15-2 – Design and Construction.

300.4.7.3.2 Concrete Reinforcing

Reinforcing steel shall be as specified in Section 200.7.6.10 and Section 300.4.10 of Schedule 15-2 – Design and Construction.

300.4.7.3.3 Soil Reinforcing Materials

Steel soil reinforcing shall be galvanized in accordance with ASTM Specification A123/A123M. All damage to galvanizing shall be repaired in accordance with ASTM Specification A780.

Geosynthetic reinforcements when permitted 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. Product specific durability studies shall be carried out to determine the product-specific long term strength reduction factor (RF). These studies shall be used to estimate the short term and long term effects of the environment factors on the strength and deformational characteristics of the geosynthetic reinforcement throughout the specified design life.

Geosynthetic reinforcing materials shall satisfy the requirements of the following tests:

- GG 1-87 "*Standard Test Method for Geogrid Rib Tensile Strength*"
- GG 2-87 "*Standard Test Method for Geogrid Rib Junction Strength*"
- GG 3-90 "*Standard Test Method for Tensile Creep Testing of Geogrids*"
- GG4-05 "*Standard Practice for Determination of the Long Term Creep Design Strengths of Geogrids*"

Geosynthetic reinforcing materials shall contain stabilizers or inhibitors to prevent degradation of properties due to ultraviolet light exposure.

The nominal long-term reinforcement 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 re-tested at least every 3 years.

300.4.7.3.4 Safety Rail Materials

Safety rail shall be fabricated in accordance with Section 300.4.3 of Schedule 15-2 – Design and Construction and shall meet the requirements of *Saskatchewan Employment Act* and *The Occupational Health and Safety Regulations*, 1996.

300.4.7.3.5 MSE Wall Materials

MSE wall backfill shall be crushed aggregate material meeting the requirements of the following table, and shall be free of organic matter and other deleterious substances:

MSE Retaining Wall Backfill Material Requirements

Metric Sieve Size (CGSB 8-GP-2M)	**Percent By Weight Passing Canadian Metric Sieve Series**		
Sieve Designation	**Type 31(1)**	**Type 33(1)**	**Type 35(1)**
31.5 mm	100.0		
18 mm	75.0-90.0	100.0	100.0
12.5 mm	65.0-83.0	75.0-100.0	81.0-100.0
5.0 mm	40.0-69.0	50.0-75.0	50.0-85.0
2.0 mm	26.0-47.0	32.0-52.0	32.0-65.0
900 µm	17.0-32.0	20.0-35.0	20.0-43.0
400 µm	12.0-22.0	15.0-25.0	15.0-30.0
160 µm	7.0-14.0	8.0-15.0	8.0-18.0
71 µm	6.0-11.0	6.0-11.0	7.0-12.0
Plasticity Index	0-7.0	0-6.0	0-5.0
Fractured Face %	60.0 Minimum		

(1) The backfill designation type shall be chosen by Project Co for wall design based on expected performance of reinforcement.

In addition, all MSE wall backfill material placed within 2.0 m of the face panels shall be free draining, and have no more than 5% passing the 71 µmsieve size.

The physical properties of the MSE wall backfill material selected by Project Co shall be used by the MSE wall supplier in the design of the MSE walls.

Soil filters between soil zones shall be designed based on the properties of the adjacent materials.

The MSE wall backfill material for steel soil reinforcing shall also meet the following electrochemical parameters with the understanding that the test methods are current at the time of construction:

Requirements for Steel Reinforcing

Select Backfill Requirements		Test Method (ASTM)	Test Method (AASHTO)
Resistivity	≥ 3000 ohm-cm	G57	T 288-91 I
pH	5 - 10	G51	T 289-91 I
Chlorides	≤ 100 ppm	G512	T 291-91 I
Sulphates	≤ 200 ppm	G516	T 290-91 I
Organic Content	≤ 0.1%	D2974	N/A

Requirements for Geosynthetic Materials

Select Backfill Requirements		Test Method (ASTM)	Test Method (AASHTO)
pH	5-10	G51	T 289-91 I
Organic Content	≤ 1.0%	D2974	N/A
Design Temperature at the Wall Site	≤ 30°C	N/A	N/A

300.4.7.3.6 Geotextiles

Non-woven geotextile filter fabric shall be in accordance with the following table of minimum average roll value properties:

Non-Woven Geotextile Requirements

Specifications and Physical Properties	
Grab Strength	650 N
Elongation (Failure)	50%
Puncture Strength	275 N
Burst Strength	2.1 MPa
Trapezoidal Tear	250 N
Minimum Fabric Lap to be 300 mm	

The impervious geomembrane shall be PVC, HDPE or LLDPE geomembrane with a minimum thickness of 0.75 mm, and in accordance with the following minimum properties:

Impervious Geomembrane

Specifications and Physical Properties	
Tear Strength - ASTM Specification D1004	45 N
Puncture Strength – ASTM Specification D48330	140N

Specific designs may warrant the use of roughened surface geo-membranes. The membrane shall be installed in accordance with the manufacturer's recommendations. All seams in the membrane shall be welded or bonded to prevent leakage.

300.4.7.4 Construction

300.4.7.4.1 Panel Production

The fabrication of precast concrete panels shall conform to the requirements of Section 300.4.4 of Schedule 15-2 – Design and Construction. Chamfered edges shall be created around the periphery of all precast facing panels. In addition to the tolerances specified in CSA Standard A23.4, the variation in panel face trueness for any line across a panel face from a straight edge shall be no more than 2 mm over 1 m. Reinforcement embedded into concrete panels shall exit perpendicular to the face of the panel.

Concrete for panels shall conform to the requirements of Section 300.4.2 of Schedule 15-2 – Design and Construction. Curing for panels shall conform to the requirements of Section 300.4.4 of Schedule 15-2 – Design and Construction, with the following additional requirements:

- Saturation of the face of the panels in preparation for the repair of surface cavities shall begin immediately after stripping. During repair of surface cavities, and up to the start of elevated temperature curing or moist curing, panels faces shall be kept in a continuously wet condition.
- As an alternative to moist curing with curing blankets, panels may be moist cured in an enclosure with a controlled temperature and humidity environment such that all exposed concrete surfaces remain saturated for the duration of the curing period. If stacked during curing, sufficient space shall be maintained between panels to permit airflow and inspection of surfaces.

Panels with the following defects shall be rejected:

- Units with honeycombing, cracks, spalls or broken corners;
- Units with more than 10 surface cavities per square metre with cavity diameters from 2mm up to 5 mm;

- Units with more than three surface cavities per square metre with cavity diameter from 5mm up to 10 mm; and
- Units with any surface cavities greater than 10mm in diameter.

Repair of surface cavities shall be done in a sheltered environment with a minimum ambient temperature of 10° Celsius. Panels with 10 or less surface cavities per square metre with cavity diameters from 2 mm up to 5 mm do not require repair. All exposed panel faces shall receive a Class 3 Bonded Concrete Finish in accordance with Section 300.4.2.16.4 of Schedule 15-2 – Design and Construction with the exceptions that all surface cavities shall be filled with an 'approved pre-bagged concrete patching material for bridges such that the entire panel finish texture shall be equivalent to a form finish and not a washed or rubbed finish.

300.4.7.4.2 MSE Wall Construction

Project Co shall employ qualified personnel experienced in constructing MSE walls to supervise and perform this work. The construction of the MSE wall system shall conform to the details on the shop drawings, and shall be in accordance with the supplier's recommendations. Project Co shall require the supplier of the MSE wall system to provide a full-time qualified representative on site during construction to advise Project Co's personnel regarding construction procedures and to monitor that the MSE wall construction is being done in accordance with the shop drawings and supplier's recommendations.

300.4.7.4.3 Conformance Criteria

Prior to starting wall construction Project Co's geotechnical engineer shall:

- Document details of the foundation base preparation details, and have these signed off by Project Co's geotechnical engineer.
- Document details of on-site delivery of all MSE wall components for each wall, including mill certificates. .
- Provide documentation that the backfill material meets the Technical Requirements.

Project Co shall maintain soil reinforcing placement records, soil compaction records, and panel placement records throughout wall construction.

300.4.7.4.4 Excavation and Levelling Pads

Excavation shall be done to establish grades to within reasonably close conformity to the design grades and limits shown on the drawings and shop drawings. The foundation subgrade shall be proof rolled to identify any soft spots.

Should the drainage design be affected by changes to the subgrade, the Engineer of Record shall be consulted for approval to the amended location or elevations.

The foundation for the structure shall be graded level for a width equal to the length of reinforcing strips plus 500 mm.

Any foundation soils found to be unsuitable shall be removed and replaced with compacted granular material to the satisfaction of the Engineer of Record.

Cast-in-place concrete for an un-reinforced concrete levelling pad shall meet the strength requirements for substructure concrete as listed in Section 300.5.7.5.1, Class B, and shall be screeded uniformly smooth with a variation of not more than 3 mm and without protrusions.

Elevation differences between steps shall not vary more than 5 mm from those shown in the Design Data.

Plan dimensions and step locations , if any, shall be in reasonable conformity with the Design Data and shall be located such that panels will be centred on the leveling pads that project at least 75 mm either side of the precast panel.

The levelling pad shall be cured a minimum of 12 hours before placement of wall panels.

Elevations shall be set by instrument. Tolerance on local irregularities shall be 3 mm over a 3 m length. After erection of first row of panels, any openings between levelling pad steps shall be filled.

300.4.7.4.5 Backfill

Backfill shall be placed in conformance with the wall supplier's specifications, and backfill compaction control testing of the reinforced backfill shall be done at a minimum frequency of one test per lift for every 45 m of wall or part thereof, with not less than one test per day.

Backfill placement shall closely follow erection of each course of panels. Backfill shall be placed in such a manner as to avoid any damage or disturbances of the wall materials or misalignment of the face panels. All wall materials that are damaged during backfill placement shall be removed and replaced, and any misalignment or distortion of the face panels due to placement of backfill shall be corrected before continuing with the work. MSE wall panels shall be fully supported by compacted backfill without voids on the non-exposed side.

Backfill placement shall closely follow the erection of each row of panels.

At each reinforcement strip level, backfill shall be roughly levelled and compacted before placing and connecting reinforcement to the panels.

Unless otherwise shown in the Design Data, reinforcement shall be placed perpendicular to the face of the wall.

If skewing of the reinforcement is required due to obstructions in the reinforced fill, rotatable bolted connections shall be used and the maximum skew angle shall not exceed 20° from the normal position.

Backfill shall be placed in such a manner as to avoid any damage or disturbances of the wall materials or misalignment of the face panels.

Bending of reinforcements in the horizontal plane that result in a permanent deformation in their alignment will not be allowed.

Connection of reinforcements to piles or bending of reinforcements around piles will not be allowed.

Cutting of longitudinal or transverse reinforcement bars to avoid conflicts with piles or utility obstructions will not be allowed.

A structural connection from the wall panel to the reinforcement shall be used whenever it is necessary to avoid cutting or excessive skewing of reinforcements due to pile or utility conflicts.

The maximum backfill lift thickness shall not exceed 150 mm (compacted).

Backfill shall be compacted to a minimum of 95% Standard Proctor Maximum Dry Density.

Project Co shall decrease this lift thickness if necessary to obtain the specified density.

The moisture content of the backfill during placement shall be such that temporary pore water pressure build up during compaction is avoided.

Backfill compaction shall be accomplished without disturbance or distortion of reinforcing strips and panels.

A minimum 450 mm wide strip of non-woven geotextile filter fabric shall be installed behind all face panel joints. An adhesive approved by the wall supplier shall be used to hold the fabric securely against the panels.

No equipment shall be allowed to run directly on the soil reinforcement. Backfill compaction shall be performed in such a manner that the compactor shall move in a direction parallel to the wall panels and work toward the end of the soil reinforcement away from the wall facing. Only hand operated power tampers and vibrators shall be used for compaction within 1000 mm of the wall panels. At the completion of each day's work Project Co shall slope the last level of backfill material away from the wall panels, so as to direct potential run-off away from the wall face. In addition, Project Co shall not permit any surface runoff from adjacent areas to enter the wall construction site.

300.4.7.4.6 Precast Panel Placement Tolerance

Precast panel placement tolerances after installation shall be:

- The out-of-flatness of wall surfaces measured in any direction shall not exceed 25 mm under a 3 m long straight edge.
- The step in face (offset) of adjacent panel edges at joints shall not exceed 10 mm.
- The overall out-of-vertical or near vertical alignment of the completed wall shall not exceed 4 mm/m of wall height from top to bottom of wall.
- The joint gap between any two constructed panels, measured at any point between panels and perpendicular to the line of the joint shall be within plus or minus 10 mm of the design gap for the wall system used.

Should any sections of the wall system or any individual panels be out of tolerance, the backfill shall be removed and the panels reset to the proper tolerance before continuing construction.

Should any panel crack or spall, or have a corner break during construction operations, the panel shall be removed and replaced.

To facilitate construction of the cast-in-place concrete coping, nominal-sized, pre-formed holes in the top row of precast panels are permitted providing the holes are located a minimum 100 mm above the underside of the coping.

300.4.7.4.7 Precast Panel Storage

Precast concrete panels shall be stacked on timber planks or pallets on a level graded lay-down area, and separated by timber bearing blocks as required by the MSE wall supplier. Soil reinforcing material and connectors shall be stored clear of the ground. All materials shall be covered and protected from rain, snow, dirt and ultraviolet light. The precast panels shall be stored such that the uniform color of the panels is maintained and protected from staining or discoloration. Panels with stained or discoloured front faces shall not be incorporated into the wall.

300.4.7.4.8 Concrete Coping

Cast-in-place/precast traffic barrier or coping, if required on top of the concrete face panels, shall have construction/expansion joints positioned as shown in the Design Data. Coping shall be installed in accordance with the Design Data.

The wall coping shall have a surface finish in compliance with Section 300.4.2.16.4 of Schedule 15-2 – Design and Construction.

300.4.7.4.9 Drainage Pipe Installation

Perforated drainage pipe wrapped in filter fabric shall be installed to the lines and grades shown in the Design Data.

300.4.8 Sign Structures

300.4.8.1 General

This Section 300.4.8 of Schedule 15-2 – Design and Construction is for the design, supply, fabrication, erection and all associated work pertaining to overhead and cantilevered sign structures and panels. Section 200.6.8 of Schedule 15-2 – Design and Construction provides additional design requirements for sign structures.

300.4.8.2 Submittals

The following information shall be submitted to the Ministry pursuant to Schedule 9, Review Procedure by a date that is reasonable having regard to the design and construction process and in any event no later than 21 days after request by the Ministry, acting reasonably:

- Shop drawings (two copies);
- Welding procedures for all welds;
- Proposed fabrication sequence and schedules. The Ministry shall be notified a minimum of two days prior to a component being ready for inspection at an inspection station;
- Mill certificates for all material;
- Repair procedures for unsatisfactory weldments and accidental arc strikes, if required;
- Product data sheets for coatings required between galvanized steel and concrete;
- Repair procedures for galvanizing, if required;
- The results of seam weld testing; and
- Method for forming and placing of grout.

300.4.8.3 Supply and Fabrication

300.4.8.3.1 Standards

Fabrication of sign structures shall conform to the AASHTO "*Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals*".

Where imperial/metric conversions are necessary, The CSA Standard Z234.1 shall be used as the basis of conversion.

All welding, cutting and preparation shall be in accordance with the CSA Standard W59.

300.4.8.3.2 Qualification

Fabrication shall be done in a shop certified by CWB to CSA Standard W47.1 in Division 1 or 2.

Only welders, welding operators and tackers approved by the Canadian Welding Bureau in the particular category shall be permitted to perform weldments. Their qualifications shall be current and available for review in accordance with Schedule 9 – Review Procedure by the Ministry.

300.4.8.3.3 Engineering Data

Welding Procedures

Welding procedures, including welding procedure datasheets, shall be prepared for each type of weld used in the structure. The procedures shall bear the approval of the Canadian Welding Bureau and shall also be submitted to be reviewed in accordance with Schedule 9 – Review Procedure by the Ministry prior to use on the structure.

Proposed Fabrication Sequence

Prior to commencement of fabrication, Project Co shall prepare 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 and inspection stations.

Mill Certificates

Mill certificates shall be obtained for all material before fabrication commences.

Schedules

Project Co shall prepare and keep current a complete fabrication schedule.

300.4.8.3.4 Materials

All materials shall be new.

The use of aluminum is not acceptable.

Structural steel plate material shall conform to CSA Standard G40.21 300W (silicon content less than 0.04% for the shafts, whereas for flanges and base plates the silicon content shall be either less than 0.04% or between 0.15% to 0.25%).

All bolts, nuts and washers shall conform to ASTM Specification A325/A325M. Certified mill test reports for the fastener material shall be obtained.

Anchor bolts shall be hot-dip galvanized and shall conform to the requirements of ASTM Specification F1554. Grade 380 MPa. Anchor bolts shall be the single nut type pretensioned by the turn-of-nut method on top of grouted base plates. Base plates shall be grouted with Sika 212 flowable grout or equivalent.

All steel materials including all hardware and anchor bolts shall be hot–dip galvanized.

300.4.8.3.5 Welding

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 CSA Standard W59. 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 processes will not be permitted. However, metal-cored arc welding process utilizing low hydrogen electrodes with diffusible hydrogen designation of H4 will be allowed. Metal-cored arc welding shall not be permitted in the field. The deposited weld metal shall provide strength, durability, impact toughness and corrosion resistance equivalent to base metal.

Cleaning Prior to Welding

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

Longitudinal Seams

All longitudinal seams shall be made by a semi or fully automatic submerged arc or metal-cored welding process.

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 a backing bar is used for the 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. The transitions between full and partial penetration welds shall be ground smooth; and
- Backing bar splices.

The backing bars for full penetration welds shall be properly fitted and the member prepared to a sharp edged 45° chamfer. The groove weld shall be placed in a minimum of two passes by using 100° Celsius of preheat (unless higher preheat is required as per CSA Standard W59) 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.

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.

Run-off Tabs

Run-off tabs shall be used at the ends of all welds that terminate at the edge of a member. The tabs shall be a minimum of 100mm long unless greater length is required for satisfactory work. 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.

Methods of Weldment Repair

Repair procedures for unsatisfactory weldments shall be prepared by a Professional Engineer experienced in welding prior to repair work commencing.

Arc Strikes

Arc strikes will not be permitted. In the event of accidental arc strikes, Project Co shall have a repair procedure prepared by a Professional Engineer. The repair procedure shall include the complete grinding out of the crater produced by the arc strike.

Plug and Slot Welds

Plug welds or slot welds shall not be permitted.

300.4.8.3.6 Fabrication

Fabrication shall be performed in a fully enclosed area which is adequately heated. The shop temperature shall be at least 10° Celsius. Field welding is not permitted.

Cutting of Plate

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

Corners of plates and structural sections shall be ground to a 1mm chamfer.

Additional Requirements

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

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

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.

All plate edges shall be free of notches and gouges.

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.

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

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.

Hand holes with cover plates are required on the top and bottom of columns of illuminated sign structures.

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.

Only low stress stamps shall be used for identification marks. The stamps and specific location shall be shown on the shop drawings.

Stiffeners are not allowed on column to base plate and member to flange plate connections.

Dimensional Tolerances

All fabrication shall meet the tolerances described below:

- **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.

- **Twisting** - The twist in the overall length of any column, arm, or extension shall not exceed 7°.
- **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 the unloaded condition. The tolerance for height shall be 0 to +60 mm.
- **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.
- **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.
- **Arm Rise** - Arm rises apply to unloaded structure in the standing position.

Pre-Assembly

After welding and fabrication but prior to galvanizing, Project Co shall pre-assemble all structures complete with sign clamps to check the fit and geometry. Preassembled structures may be inspected by the Ministry.

The structures shall then be disassembled for galvanizing.

Galvanizing

Galvanizing shall be by the hot-dip method, after fabrication, in accordance with the current edition of ASTM Specification A123/A123M, *Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products* and ASTM Specification A153/A153M, *Standard Specifications for Zinc Coating (Hot-Dip) on Iron and Steel Hardware* with additions and exceptions as described in this Section 300.4.8 of Schedule 15-2 – Design and Construction. Project Co shall provide a smooth finish on all edges and surfaces, and remove all weld spatter and all welding flux residue from the steel components prior to galvanizing. Lumps, globules or heavy deposits of zinc will not be permitted. All threaded holes or threaded couplings shall be retapped after galvanizing.

Repair of galvanizing shall only be done if bare areas are infrequent, small, and suitable for repair. A detailed repair procedure shall be prepared by a Professional Engineer. It should be noted that repairs may require complete removal of the galvanized coating and regalvanizing. Repair shall be in compliance with ASTM Specification A780, Method A3 Metallizing. The thickness of the metallizing shall be 180 μm, and the repair tested for adhesion. The finished appearance shall be similar to the adjacent galvanizing.

Base Plate Corrosion Protection

The bottom face of each base plate shall be protected by a barrier, to prevent contact between the zinc and the grout. The galvanized surface shall be roughened prior to application of barrier

coating. The surface preparation of the galvanized surface and the dry film thickness of the coating shall be in accordance with the coating manufacturer's recommendations. Project Co shall test the adhesion of fully cured coating as per ASTM Specification D3359. The method selected for testing (Method A or B) shall depend on the dry film thickness of the coating. The coating manufacturer's product data sheets shall be obtained prior to the application of the coating. The adhesion test result shall meet a minimum of "4B" classification, i.e. a maximum allowable flaking of 5%.

300.4.8.3.7 Testing and Inspection

Access

Project Co shall provide full facilities for the auditing of material and workmanship. Free access shall be allowed to the Ministry to all parts of the Works. When required by the Ministry, Project Co shall provide needed manpower for assistance in inspection duties.

Testing by Project Co

Project Co 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 Ministry for inspection.

All welds shall be visually inspected by an independent welding inspector certified to Level 3 of CSA Standard W178.2.

Project Co shall arrange to have all full penetration welds inspected either by ultrasonic testing or radiographic inspection methods. Partial penetration seam welds shall be inspected by ultrasonic testing. The frequency of partial penetration weld inspections shall be three random locations per weld and the length of weld for ultrasonic inspection at each location shall be 200 mm. Calibration blocks for each thickness shall be prepared for ultrasonic testing to establish sensitivity levels and acceptance criteria. The non-destructive testing shall be done by a company certified to CSA Standard W178.1. Ultrasonic and radiographic testing technicians shall be certified to Level II of CGSB.

Testing by the Ministry

The Ministry may perform visual, radiographic, ultrasonic, magnetic particle and any other testing that may be required at its own expense.

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 shall be determined by Project Co prior to commencement of fabrication.

Non-destructive Methods of Examination

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

- Radiography – CSA Standard W59;
- Ultrasonic – CSA Standard W59; and
- Magnetic Particle - ASTM Specification E709.

Inspection Schedule

All welds will be visually inspected.

Ultrasonic inspection will be performed on full penetration welds.

300.4.8.4 Erection

All product damaged in shipping, handling, and erection, shall be replaced.

Project Co 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 chains as slings shall not be permitted. Any damage to the components through overstress, scratching or denting shall be repaired or replaced.

The structure shall be set accurately on galvanized shim plates. The shim plates shall be located so that a minimum of 75 mm grout coverage is provided from shims to grout edge. The method of forming or pouring the grout shall be documented. Dry-pack methods of constructing grout pads will not be allowed.

Hand hole bolts shall be coated with anti-seize lubricant.

300.4.8.4.1 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.

300.4.8.4.2 Bolt Tension

All structural bolts shall be tightened by using turn-of-nut method to provide bolt tension specified in Table 1 set out at the end of this Section 300.5.12.6 (Erection). 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. 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 4 bolt diameters or less.
- 1/2 turn where bolt length is over 4 bolt diameters and not exceeding 8 bolt diameters.
- 2/3 turn where bolt length exceeds 8 bolt diameters.
- Tolerance of 1/6 turn (60°) over, nothing under.
- Length of bolt measured from underside of head.

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

300.4.8.5 Foundations

Where detailed and specified, concrete work shall be constructed as shown in the Design Data and in accordance with the relevant sections of Section 300.4 of Schedule 15-2 – Design and Construction:

- Section 300.4.2 - Cast-In-Place Concrete
- Section 300.4.9 - Piling
- Section 300.4.10 - Reinforcing Steel

300.4.8.5.1 Material

Reinforcing steel and concrete shall comply with Sections 200.7.6, 200.7.7 and 300.4.10 of Schedule 15 2 – Design and Construction.

300.4.8.5.2 Anchor Bolt Installation

Anchor bolt assemblies shall be supplied and installed in one complete assembly and consist of, but not be limited to, anchor bolts, complete with plate washers, full length sleeves filled with corrosion inhibiting paste, top temporary templates, bottom anchor plates, bottom anchor nuts, thin clamping nuts, and all necessary hardware for post-tensioning and future de-tensioning. No welding of any component is allowed. Anchor bolts shall be true and plumb. Anchor bolts shall be post-tensioned to 70% of the ultimate strength after the grout pads have attained design strength. The top anchor nuts shall have plastic caps, and all voids including annular space in the base plate shall be filled with corrosion inhibiting paste. Sufficient anchor bolt projection shall remain for future work. All post-tensioning work and materials shall meet the requirements of Chapter 3 - Specifications of the Post Tensioning Institute Post-Tensioning Manual.

300.4.8.5.3 Grout Pockets and Grout Pads

Project Co shall fill the grout pockets and construct the grout pads using Sika 212 flowable grout or equivalent. Filling of grout pockets and construction of grout pads shall be done by workers competent in this work. The grout pocket shall be 25 mm deep and the total grout thickness shall not be less than 75 mm.

Grout shall be packaged in waterproof containers with the production date and shelf life of the material shown. It shall be mixed, placed, and cured in strict accordance with the manufacturer's recommendations.

The method of forming and pouring the grout shall be documented. Dry-pack methods of constructing grout pads will not be allowed.

300.4.8.5.4 Grouting in Cold Weather

When the daily minimum air temperature, or the temperature of the girders, bearings or substructure concrete, in the immediate area of the grouting, falls below 5° Celsius, the following provisions for cold weather grouting shall be affected:

- Before grouting, adequate preheat shall be provided to raise the temperature of the substructure concrete to at least 10° Celsius.

- Temperature of the grout during placing shall be between 10° Celsius and 25° Celsius.
- The grout pads shall be enclosed and kept at 10° Celsius to 25° Celsius for at least 5 days. The system of heating shall be designed to prevent excessive drying-out of the grout.

300.4.8.5.5 Clean-Up

All steel shall be left clean and free of oil, grease, mud, dust, road spray or other foreign matter.

300.4.9 Piling

300.4.9.1 General

This Section 300.4.9 of Schedule 15-2 – Design and Construction is for the supply and installation of steel H-piles, plain and galvanized steel pipe piles, precast concrete piles, and cast-in-place concrete piles. It includes driven bearing piles, drilled cast-in-place concrete bearing piles, and drilled cast-in-place concrete/steel pipe composite bearing piles.

All piling shall be driven or constructed to the tip elevation shown in the Design Data, or as approved otherwise by the Engineer of Record.

Pre-drilling to facilitate driving of piles shall not be permitted.

300.4.9.2 Submittals

The following information shall be submitted to the Ministry by a date that is reasonable having regard to the design and construction process and in any event no later than 21 days after request by the Ministry:

- Mill certificates for piling materials.
- Pile driving equipment and procedures to be used for the installation of driven piles.
- Pile drilling equipment and procedures to be used for the installation of drilled piles.
- Non-destructive testing results for steel pile splices.

300.4.9.3 Reference Drawings

- Pipe Pile Field Splice and Concrete Plug – MABUT003
- Pipe Pile Field Splice – MABUT003A
- Splice Collar – MABUT004
- Pile Tip Reinforcement – MABUT005
- H-Pile Field Splice - SPILE001

300.4.9.4 Materials

300.4.9.4.1 Steel "H" Piling

Steel "H" piling shall meet the requirements of CSA Standard G40.21. Grade size and weight shall be as specified in the Design Data. Where piling is designated in metric dimensions, imperial equivalent piling will be acceptable. Mill certificates shall be obtained prior to pile installation.

300.4.9.4.2 Steel Pipe Piling

Steel pipe piling shall meet the requirements of ASTM Specification A252 Grade 2 or better. Grade, size and wall thicknesses shall be as specified in the Design Data. Although piling is designated in metric dimensions, imperial equivalent piling will be acceptable. Mill certificates shall be obtained prior to pile installation. Some out-of-roundness of the pipe is acceptable provided an acceptable splice can be completed.

Galvanized piling shall be galvanized by the hot-dip method, in accordance with the ASTM Specification A123/A123M, *Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products*.

Exterior protective coating of coal tar epoxy shall conform to the requirements of CAN/CGSB-1.184.

Splice collars and closed pipe pile end plates shall be fabricated as shown on Ministry standard drawings MABUT003A and MABUT004 (Pipe Pile Field Splice, Splice Collar) and Ministry standard drawing MABUT005 (Pile Tip Reinforcement).

300.4.9.4.3 Timber Piling

The use of timber piling will not be permitted.

300.4.9.4.4 Pile Concrete

Concrete shall meet the requirements of pile concrete as specified in Section 300.4.2 of Schedule 15-2 – Design and Construction.

300.4.9.4.5 Reinforcing Steel

Steel reinforcement incorporated in the pile concrete shall comply with Sections 200.7.6, 200.7.7 and Section 300.4.10 of Schedule 15-2 – Design and Construction.

300.4.9.4.6 Concrete Filled Steel Pipe Piles

Concrete filled steel piles shall be constructed to the details shown in the Design Data.

They shall consist of steel pipes, closed at the bottom, driven to depths shown in the Design Data or as otherwise accepted by the Engineer of Record, and filled with concrete.

Concrete shall conform to the requirements of Section 300.4.2 of Schedule 15-2 – Design and Construction.

Exposed steel pipe piles extending above ground to act as columns shall be galvanized to a minimum of 2.0 m below groundline.

When required, Project Co shall weld the circular base plates and additional bracing to the bottom of the piles.

Welding shall conform to the requirements of CSA Standard W59.

Piles shall be checked immediately following driving and attempts made to seal any leaks which develop by dumping a dry mixture of sand and cement into the piles.

Any water in the piles shall be removed before placing the concrete.

No concrete shall be placed until all pile driving within a foundation unit has been completed.

300.4.9.4.7 Precast Concrete Piles

Precast concrete piles shall be constructed to the details shown in the Design Data.

A suitable cushioning material of adequate thickness shall be provided between the cap and the pile top.

The cushioning material shall be replaced when it becomes highly compressed, charred or burned.

When driving resistance of the pile is low, the energy developed during the driving shall be kept low so as not to develop tension cracking of the pile.

The energy output shall be increased as the driving resistance increases.

When predrilling or jetting is permitted to facilitate placing the piles, the pile tip shall be well seated with reasonable soil resistance at the tip before full driving energy is used.

Driving and jetting shall not be done simultaneously.

Precast concrete piles shall not be spliced.

300.4.9.5 Transportation, Storage and Handling

Piling shall be handled, hauled and stored in a manner that avoids damage to the piling materials. Loading and unloading shall be by crane, loader or other appropriate hoisting equipment.

Care shall be taken in order to prevent damaging the galvanized surface on galvanized piling. Fabric slings, wood blocking or other approved methods shall be used to support and separate galvanized piling when handling, hauling or storing. Piling on which the galvanized coating has been damaged shall be replaced or repaired. Where repair of damaged galvanizing is required, the repair shall be by metallizing in conformance with ASTM Specification A780, Method A3, to a thickness of 180 µm.

300.4.9.6 Driven Piles

300.4.9.6.1 Equipment and Driving Methods

Acceptable driving equipment includes diesel hammers, hydraulic hammers, vibratory hammers, and driving frames. Drop hammers shall not be used under any circumstances.

Piles shall be driven using a hammer having sufficient mass or energy capacity to obtain the specified pile penetration without unacceptable damage to the piles.

The driving of piles with driving extensions shall be avoided if practicable. When driving extensions are used, one 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 bearing power of the group.

For the special types of piling, driving heads, mandrels, or other devices in accordance with the manufacturer's recommendations shall be provided so that the pile may be driven without damage and without unnecessary trimming.

For pile installation purposes, Project Co shall paint markings on each pile at 0.1 m intervals, with a label at each 1.0 m interval, starting from the toe of the pile.

Adequate precautions shall be taken to ensure that the piles are in proper alignment, including the use of installation frames, fixed leads or other means as are necessary.

The tops of all piles shall be held in position and protected by caps of approved design. Caps shall incorporate suitable shock blocks.

The top surface of the piles shall be square to the longitudinal pile axis, and for wood piles, the butt end shall be shaped or chamfered to prevent splitting at its periphery.

Piles shall be supported in alignment and position with leads while being driven.

Leads shall be so designed and constructed to afford freedom of movement of the hammer and to permit proper placing of batter piles.

Leads shall preferably be of sufficient length to be firmly supported on the ground space.

Hanging or swinging leads may be permitted provided they are so constructed that they can be held in a fixed position during the driving operations.

Tolerances

Piles shall be driven with a variation of not more than 20 mm per metre from the vertical or from the batter shown in the Design Data, except that piles in exposed bents (extending above the ground to act as columns) shall not be out of position at the ground line by more than 75 mm after driving or construction.

Foundation piles shall not be out of the position shown in the Design Data more than 150 mm after driving. Should the pile location exceed the tolerance, the Engineer of Record shall address the specific issue and may choose to accept the pile, or replace the pile in a suitable alternative location. Should the pile be relocated, its impact on other elements, such as MSE wall performance, will require review and approval by the appropriate element's Engineer of Record.

In the event that these tolerances are not met, immediate changes shall be made to pile driving procedures, or other operations deemed to have caused this issue.

Manipulation of a pile to force it into proper position or alignment shall not be permitted.

Redriving of Piles

After all piles in any group have been driven, any pile which has lifted due to driving of adjacent piles shall be redriven to the proper elevation.

Cutting Off Piles

The tops of all piling shall be cut to a true plane at the elevation shown in the Design Data. After driving, the length of pile remaining above the elevation of cut-off shall be sufficient to permit the complete removal of all damaged material. This would include any holes cut in the pile for handling.

Water Jets

When water jets are used, the number of jets and volume and pressure of water at the jet nozzles shall be sufficient to freely erode the material adjacent to the pile.

The equipment shall have sufficient capacity to deliver at all times at least 700 kPa pressure at 2-20 mm diameter jet nozzles.

Before the desired penetration is reached, the jets shall be withdrawn and the piles shall be driven at least 1.5 m with the hammer to secure the final penetration.

300.4.9.6.2 Bearing Values

The piles shall all be driven to the tip elevations shown in the Design Data, or lower, to achieve the required stability and specified minimum bearing capacity. The pile bearing capacities shall be estimated by the bearing formula given below, or by the methods given in 300.4.9.8 of Schedule 15-2 – Design and Construction.

In the case of friction piles, the piles shall be driven to the tip elevations shown in the Design Data, or lower, in order to achieve the required stability and design load carrying capacity.

300.4.9.6.3 Steel Piles

Steel piles shall consist of structural steel shapes or pipes of the section shown in the Design Data or otherwise specified. Full length piles shall be provided wherever possible to avoid field splicing.

When pipe piles are to be driven closed-ended, pile tip reinforcement shall be in accordance with Ministry standard drawing MABUT005 (Pile Tip Reinforcement).

When pipe piles are to be driven open-ended and the interiors cleaned out, a power screw rotary auger shall be used to remove the required material. All loose material and all material adhering to the walls of the piles shall be removed.

After installation, closed ended or open ended pipe piles shall be filled with Type P1 concrete.

The total energy developed by the hammer shall be sufficient to achieve the required bearing value or tip elevation, but in no case shall the total energy developed be less than 35 kJ per blow.

The head shall be cut squarely and a driving cap or follower shall be provided to hold the axis of the pile in line with the axis of the hammer. The follower shall be of adequate dimensions to allow driving the pile without trimming or reducing the cross-section of the pile. When damage or buckling is evident at the driving end of the pile, in order to obtain the desired bearing capacity or penetration of the pile, the driving end of the piling shall be reinforced, or, other suitable equipment or procedures provided, to prevent such damage.

Piles shall be cut off level at the required elevation. If capping is required, the connection shall be made according to details shown in the Design Data.

300.4.9.6.4 Steel Pile Splices

When splicing, whatever means necessary shall be employed to match out-of-round piling. Exposed pile splices shall be avoided. Refer to Ministry standard drawing SPILE001 (H-Pile Field Splice) and Ministry standard drawings MABUT003A (Pipe Pile Field Splice) and MABUT004 (Splice Collar). All field welding shall be in accordance with Section 300.4.3.3.5 in Schedule 15-2 – Design and Construction.

Welding materials shall conform to the requirements of CSA Standard W48.1.

Steel plates shall conform to the requirements of CSA Standard G40.21. Grade, size and wall thicknesses shall be as specified in the Design Data.

Splicing Piles

Full length piles shall be used where practicable.

When splicing of the piles is required, the method of splicing shall be as shown in the Design Data.

The manual shielded metal arc welding process shall be used for welded splices.

All welding of steel piles shall conform in quality and workmanship to the latest edition of CSA Standard W59.

The welder and the work area shall be protected from the effects of weather during welding and cooling rates shall comply with CSA Standard W59.

The welding shall be undertaken by a company certified by the Canadian Welding Bureau (CWB) to the requirements of CSA Standard W47.1 Division 2 or better.

Piling, if spliced, shall be aligned so that the finished piles are straight from end to end.

Where the upper portions of piling are specified to be galvanized, excess piling shall be removed from the ungalvanized portion of the piling to ensure that the galvanized portion extends to the elevation shown in the Design Data. Splicing within the galvanized portion of the piling shall be avoided; however if splicing becomes necessary due to unforeseen circumstances, the damaged galvanized area shall be metallized in accordance with ASTM Specification A780 method A3 to a minimum thickness of 180 µm.

Site welding personnel shall be advised of the hazardous fumes which are generated during welding or cutting of the galvanized steel.

Temporary caps shall be supplied and secured on all open pipe piles.

Inspection

Project Co shall perform ultrasonic testing for a minimum of 20% of all full penetration compression splice welds for all piles at each bridge component. Ultrasonic testing shall be done for welds where visual inspection indicates a possible defect. Additional testing may be required for the full penetration compression splice welds to ensure the integrity of the structure. In addition, Project Co shall inspect 100% of the full penetration tension splice welds, as defined on the Design Data. The ultrasonic testing shall be done by a company certified to CSA Standard W178.1. Ultrasonic testing technicians shall be certified to Level II by the Canadian General Standards Board. Welds shall be repaired if full penetration has not been achieved.

300.4.9.6.5 Defective Piles

The procedure incident to the driving of piles shall not subject them to excessive and undue abuse producing deformation of the steel, or crushing and spalling of the concrete. Piles damaged by improper driving, or driven out of proper location, or driven below the cut-off elevation, shall be corrected by one of the following methods:

- The piles shall be withdrawn and replaced by new and, if necessary, longer piles, or
- Replacement piles shall be driven adjacent to defective or low piles, or
- The piles shall be spliced or built up, as otherwise provided herein, or a sufficient portion of the footing extended to properly embed the piles. All piles, pushed up by the driving of adjacent piles or by any other cause, shall be driven down again.

In case the required penetration and bearing capacity are not obtained, Project Co may provide a hammer of greater energy or resort to pre-drilling.

300.4.9.7 Drilled Cast-in-Place Concrete Piles

300.4.9.7.1 General

Cast-in-place concrete piles shall be constructed to the details shown in the Design Data. They shall consist of concrete cast in holes drilled to the required elevation.

In addition to drilled cast-in-place concrete piles this Section 300.4.9.7 of Schedule 15-2 – Design and Construction shall include drilled cast-in-place concrete/steel pipe composite piles. The work shall include drilling and belling the holes, as required, supplying and placing the steel pipe and reinforcing steel, and supplying, placing, protecting and curing the concrete.

Where cast-in-place piles are designed based on the use of semi-empirical methods, supported by geotechnical investigation with soil parameters determined by laboratory, field testing and local experience, and with appropriate levels of construction monitoring and verification, the ultimate bearing capacity may be adjusted for limit states design by a geotechnical resistance factor of 0.4.

300.4.9.7.2 Equipment and Drilling Methods

Due to the nature of the work, the drilling subcontractor shall have adequate equipment and a proven record of competence in this work.

Only powered screw rotary type augers will be acceptable for drilling.

The installation of further piling shall not proceed if for any reason, the quality of the adjacent piling is compromised due to the effects of vibration or other reasons.

300.4.9.7.3 Drilling Pile Holes

The drilled pile holes shall be stabilized and sealed by means of temporary casings or other methods to prevent the possible collapse of the pile holes or ingress of water. Every attempt necessary shall be made to obtain "dry" pile holes prior to placing the pile concrete.

All holes for piles shall be drilled dry without the addition of water. Suitable casings shall be furnished and installed when required to prevent caving of the hole before concrete is placed, and to provide protection for workers and inspectors.

Removal of a casing shall be co-ordinated with the concrete placement.

The head of concrete shall exceed the external soil and water pressure at all times.

Specially designed high slump concrete may be used to prevent arching of the concrete during the casing withdrawal.

The concrete shall not be vibrated internally before the casing is withdrawn, although vibrating the casing will be permitted.

The casing shall be withdrawn before the concrete attains its initial set.

The elevations shown in the Design Data of the bottoms of the pile holes shall be considered approximate only, and further drilling may be required as necessary to secure satisfactory bearing of the piles.

Where belling of the piles is specified, belling shall proceed only after the pile hole has been drilled to the specified elevation.

The walls and bottoms of the pile holes shall be cleaned to remove all loose and extraneous material. The presence of any gas shall be determined and appropriate means and equipment shall be employed to ensure a safe work site.

Pile reinforcement and pile concrete shall not be placed until the pile hole is deemed acceptable.

The holes shall be examined for straightness, and any hole which, on visual inspection from the top, shows less than ½ of the diameter of the hole at the bottom will be rejected.

All loose material existing at the bottom of the hole after drilling has been completed shall be removed.

Open Drilled Holes

All open drilled holes on the site shall be covered until the time they are filled with concrete or otherwise properly backfilled. The covers shall be of adequate strength and securely fitted so that machinery and workmen are protected against cave-in and surface water is prevented from running into the pile hole.

Free water present in quantities sufficient to affect concrete strength shall be removed before placing concrete.

Reinforcement

Steel reinforcement shall be fabricated in the sizes and to the dimensions shown in the Design Data and shall be placed, centered and braced in the pile hole as detailed.

Particular care shall be taken in locating projecting column dowel bars, to a tolerance not exceeding 10 mm in any direction, and pouring shall not be permitted until provisions are made to confirm to this requirement.

Adequate "shoes" or spacers shall be firmly anchored to the reinforcement to ensure the reinforcement is kept centered in the concrete.

300.4.9.7.4 Concrete Placement

When the reinforcement has been acceptably placed, concrete shall be immediately deposited in the pile hole. The concrete shall be Type P2 and the provisions of Section 300.4.2 of Schedule 15-2 – Design and Construction shall apply.

Holes shall be filled with concrete on the same day that they are drilled.

Concrete shall be placed through a hopper with a downpipe centered on the drilled hole to provide for free unobstructed fall which does not hit the reinforcing steel or the side of the hole.

Long downpipes or other approved equipment shall be used for placing concrete in battered piles and on other occasions where the free fall is not appropriate.

The top 2 m of concrete in the piles shall be consolidated by mechanical vibrators.

Where piles are to be extended above ground line as circular columns, the top 0.5 m below ground line shall be formed to maintain the proper cross-section of the pile.

Contaminated concrete and laitance shall be removed from the top of the piles before placing fresh concrete upon them.

Suitable forms shall be used to maintain the specified dimensions of concrete piles above ground level.

Pile concrete placed under water will require validation by "Crosshole Sonic Logging ("**CSL**") in accordance with Section 300.4.2.10.3 of Schedule 15-2 – Design and Construction.

300.4.9.7.5 Cold Weather Conditions

In cold weather, which shall be considered to exist if night-time low temperatures are expected to be below 0° Celsius, heated concrete shall be used. Such concrete shall have a temperature of between 15° Celsius and 25° Celsius when placed.

When the ground against which pile concrete is placed is below -5° Celsius, the concrete shall be protected from heat loss. The pile boring shall be made oversize down to the depth of 2 m, and the concrete shall be poured in an insulated form. Concrete at the top of the pile is to be insulated. After 4 days the form and insulation may be removed, and the space is to be backfilled immediately with compacted non-granular fill or lean concrete to the elevation of top of pile.

In a region where the ground temperature is above -10° Celsius but below -5° Celsius, the hole may be bored 100 mm diameter oversize, and filled directly with pile concrete, as an alternative to the procedure described above. Concrete at the top of the pile is to be insulated.

If the top of the pile extends above the existing ground surface, in cold weather, it is to be adequately protected from the cold for a period long enough to ensure proper curing.

300.4.9.7.6 Pile Tolerance

Piles shall be accurately located, and shall be installed plumb or at the batter specified in the Design Data. The maximum tolerance allowed shall be 50 mm for variation off the centre of any pile at the cut-off elevation, and no pile shall be out of plumb or specified batter by more than 20 mm per metre. Any pile out of centre or plumb beyond the tolerances specified shall be corrected.

300.4.9.8 Pile Capacity Testing

300.4.9.8.1 Static Load Testing

When specified, the load carrying capacity of piles shall be determined by static load tests.

In general static load tests can be performed on any pile type. Static load tests shall consist of the application of a test load on a suitable platform supported by the pile, or through the use of adjacent reaction piles, with suitable apparatus for accurately measuring the test load and the settlement of the pile under each increment of load. The tests shall be in general conformance with ASTM Specification D3689. Osterberg or Statnamic tests may be used in place of static load tests.

Where sufficient static load testing has been done to satisfy Limit State Design, Load and Resistance Factor Design ("**LRFD**"), or reliability-based design statistical requirements, the factored geotechnical resistance may be taken as 0.6. Where allowable or working state design methods are used in the design, or where the requirements of Limit State Design are not fulfilled, the allowable load shall be considered as 50% of that load which, after a continuous application of 48 hours, produces a permanent settlement not greater than 6 mm measured at the top of the pile. This maximum settlement shall not increase by a continuing application of the test load for a further period of 60 hours or longer.

At least one pile for each group of 100 piles shall be tested. The frequency of testing shall be increased to account for changing soil conditions, pile sections and types, and construction methods.

300.4.9.8.2 Dynamic Load Testing / Pile Driving Analysis (PDA) Testing

Dynamic load testing may be used as part of a quality control method during pile installation. Pile Driving Analyzer ("**PDA**") testing can be used as an alternate or supplemental test method to static load tests for the determination of pile capacity. This method involves installing instruments on the pile head with accelerometers and strain gauges, then impacting the pile head using a pile driving hammer or similar device over a very short period of time (3-4 milliseconds). The impact imparted on the pile shall be sufficient to fully mobilize the pile skin friction and end bearing resistances of the pile, and shall result in a net permanent set per blow between 3 mm and 8 mm upon impact from the pile hammer.

The PDA test may be conducted on either driven or cast-in-place piles. For driven piles, the PDA test shall be conducted at the end of the initial driving stage, such that the end bearing and skin friction resistances can be determined upon initial installation of the pile. Where time dependant changes in the soil conditions are anticipated, such as pile setup or relaxation, additional tests shall be conducted upon re-strike on a sample of previously tested piles to determine the bearing parameters after driving induced pore pressures have dissipated. The re-strike shall be conducted no sooner than one week after initial driving, or longer as directed by Project Co's Geotechnical Engineer. It is permissible to initially drive piles to a capacity below the required ultimate capacity and rely on pile setup to produce the required capacity.

Where the capacity of the pile at re-strike is relied upon for design, a minimum of one third of piles tested during initial drive shall be tested again during re-strike. If dynamic testing is only undertaken upon re-strike, then a minimum of 10% to15% of all piles shall be PDA tested on re-strike.

The hammer energy used during PDA tests at the end of initial drive and during re-strike driving shall be such that the required ultimate pile capacity can be mobilized in a single blow without additional data interpretation.

For cast-in-place piles, the PDA test shall not be conducted within one week after the installation of the pile.

The results of the test can be processed in the short term using the Wave Equation Analysis of Piles ("**WEAP**") method to provide real time monitoring of pile stresses, pile integrity, hammer performance, and pile capacity; and in some cases can be used to confirm pile termination depths when borehole information is not available. However, this method shall only be used as an initial determination of bearing capacity, and where the test is being used to determine the capacity of the pile for design methods, a signal matching analysis using a Case Pile Wave Equation Program ("**CAPWAP**") shall be utilized.

ASTM Specification D4945-08 shall be followed. In addition, at least two accelerometers on a driven pile and four accelerometers on a cast-in-place pile shall be installed. All accelerometers and transducers shall be calibrated and inspected to ensure proper attachment to the pile.

Where the PDA methods are used strictly as a Quality Assurance/Quality Control tool, a minimum of 5% of production piles shall be monitored dynamically. When used as a design or confirmatory tool, a minimum of 10% of piles shall be tested, including tests at each substructure element associated with the project and where soil conditions are expected to vary, or as required for statistical validation of a LRFD design, whichever is greater. The piles selected for testing shall be representative of other piles in the same structure. Where driven piles exhibit lower driving resistances and/or shorter penetrations than normal, or where cast-in-place piles experience extraneous soil, ground water, and/or installation conditions, additional tests over and above minimum number of tests specified earlier shall be required. Further, additional tests shall accompany changes in piling equipment, procedure and pile requirements.

In the situation where one pile in a pile group does not meet capacity requirements, additional tests shall be done to confirm that this pile is an isolated case. In such case, it may be permissible to rely on group effects to compensate for the lower pile capacity. Project Co's geotechnical engineer shall have the final say in this situation. Under no circumstances shall superposition of axial and shaft capacity from different strikes, re-strikes or any combination thereof be permitted.

Where sufficient dynamic load testing has been done to satisfy Limit State Design, LRFD or reliability-based design statistical requirements, the geotechnical resistance factor for design of pile foundations may be taken as 0.5.

Pile driving equipment shall be sized such that piles can be driven with reasonable effort to the specified ultimate bearing capacity without damaging the pile. Approval of the pile driving equipment shall be based on the WEAP analysis and/or PDA testing. Project Co shall submit details of the proposed pile driving equipment for review by the Field Review Engineer a minimum of 14 days prior to the commencement of pile installation. The information provided shall include the following:

- **Hammer Data**: hammer 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, modifications;
- **Striker Plate Data**: weight, diameter, thickness, composition;
- **Hammer Cushion Data**: manufacturers, area, thickness per plate, number of plates, total thickness, and composition;
- **Helmet Data**: weight, composition; and
- **Pile Cushion Data**: material, area, thickness per sheet, number of sheets, total thickness of cushion.

The PDA testing agency shall prepare a daily field report summarizing the preliminary test results including driving stresses, transferred energy and estimated pile capacity within 24 hours of testing. The final test results shall be presented to the Ministry within seven days of testing. The testing report shall be prepared in accordance with the requirements of ASTM Specification D4945. As a minimum, the report shall include the following:

- Pile and driving system information;
- Pile installation data;
- PDA testing equipment and procedure;
- Energy imparted;
- Maximum driving stresses;
- Hammer blow rate;
- CAPWAP input parameters including quake and damping factors; and
- Shaft friction, end bearing and total pile capacity.

The test results shall be used to determine the subsequent termination criteria, requirements for modification of driving procedures or equipment, and pile acceptance. No work shall be done on the foundation elements (pile caps, cut-off, welding, etc) prior to this testing report being reviewed by the Field Review Engineer.

300.4.9.9 Quality Management

300.4.9.9.1 General

Project Co shall be fully responsible for hiring, scheduling, overseeing, performing and documenting all quality control and quality assurance testing and inspection.

The Ministry may perform on-site sampling and testing as a function of the Ministry's quality audit. Any Ministry quality testing shall not relieve Project Co of responsibility for providing quality control and quality assurance.

300.4.9.9.2 Sampling and Testing

Project Co shall provide all records pertaining to the pile driving operation which shall include, but is not limited to, the following.

- Mill certificates for all steel material.
- Concrete mix design and test results as required by Section 300.4.2 of Schedule 15-2 – Design and Construction.
- CWB Certification, welding procedures, and welding procedure data sheets.
- Pile driving logs shall be provided to the Ministry within seven days of completion of a pile group.
- Pile driving logs shall include the type and energy rating of the pile driving equipment.
- As-built pile accuracy indicating variances from the Technical Requirements as well as cut-off elevations.
- Welding inspection reports.
- Cold weather welding documentation report, if applicable.

300.4.10 Reinforcing Steel

300.4.10.1 General

For the purposes of this Section 300.4.10 of Schedule 15-2 – Design and Construction, carbon steel reinforcing bar, stainless steel reinforcing bar and low carbon/chromium steel reinforcing bar will be referred to collectively as reinforcing steel. For the purposes of this section, both stainless steel reinforcing bar and low carbon/chromium steel reinforcing bar will be referred to collectively as corrosion resistant reinforcing steel ("**CRR**").

Reinforcing steel shall be supplied in the lengths and shapes, and installed as indicated in the Design Data.

The Work shall consist of the supply, fabrication and installation of reinforcing for concrete structures.

The requirements of the Bridge Design Code shall apply unless specified otherwise herein or in the Design Data.

For items not covered by the Bridge Design Code, or the Design Data, CSA Standard A23.1 shall apply.

Only one type of stainless steel reinforcing bar and one type of low carbon/chromium steel reinforcing bar shall be used in any one bridge structure.

300.4.10.2 Materials

All reinforcing bars shall be deformed. The type and grade required shall be as specified in the Design Data. Reinforcing steel shall conform to the requirements of CSA Standard G30.18.

300.4.10.2.1 Uncoated Reinforcing Steel

Concrete reinforcement shall conform to the requirements of the ASTM Specifications and CSA Standards shown in Table 300.4.10.2.1 as applicable.

Table 300.4.10.2.1 Requirements for Reinforcing Steel

Standard / Specification	Description
ASTM Specification A82/A82M	Standard Specification for Steel Wire, Plain, for Concrete Reinforcement
ASTM Specification A185/A185M	Standard Specification for Steel Welded Reinforcement
ASTM Specification A496/A496M	Standard Specification for Steel Wire, Deformed, for Concrete Reinforcement
ASTM Specification A497/A497M	Standard Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete
CSA Standard G30.18	Billet Steel Bars for Concrete Reinforcement
ASTM Specification A767M	Standard Specification for Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement
CSA Standard S806	Design and Construction of Building Structures with Fibre-Reinforced Polymers
ASTM Specification A276 and ASTM Specification A955/A955M	Standard Specification for Stainless Steel Bars and Shapes and Standard Specification for Deformed and Plain Stainless Steel Bars for Concrete Reinforcement

300.4.10.2.2 Galvanized Reinforcing Steel

Galvanized reinforcing bars shall be used only where shown in the Design Data.

Hot-dip galvanized reinforcing bars shall conform to the requirements of ASTM Specification A767M – Class 1 Coating

Only Grade W bars shall be galvanized.

Galvanized bars shall be bent after galvanizing or heat treated for stress relief if bent before galvanizing. .

Stress relief shall be at temperature from 480° Celsius to 560° Celsius for 1 hour per 25 mm of bar diameter as per ASTM Specification A767M.

Galvanized reinforcing bars shall not be placed in contact with uncoated reinforcing bars.

300.4.10.2.3 Fibre Reinforced Polymer (FRP)

FRP components and FRP reinforcing bar shall conform to CSA Standard S806.

All FRP products shall comply with *Specifications for Product Certification of Fibre Reinforced Polymers (FRPs) as Internal Reinforcement in Concrete Structures* developed by ISIS Canada.

300.4.10.2.4 Stainless Steel

Stainless steel reinforcing steel shall conform to the requirements of ASTM Specification A276 and ASTM Specification A955/A955M Table 2– UNS designations S24100, S31653, S31603, S31803, S30400, or S32304.

300.4.10.3 Fabrication

All bars requiring bends shall be cold bent at the fabrication facility. Heating of bars to facilitate bending shall not be permitted. Bars shall be cut by shearing or with fluid-cooled saws. Torch cutting shall not be permitted. Bars showing evidence of torch cutting shall be rejected.

Unless otherwise specified, all hooks and bends shall be fabricated using the pin diameters and dimensions as recommended in the Reinforcing Steel Institute of Canada ("RSIC"), Manual of Standard Practice. Bars shall conform accurately to the dimensions shown on the drawings and be within the fabricating tolerances detailed in the RSIC, Manual of Standard Practice.

Fabrication of stainless steel reinforcing bars shall be carried out in such a manner that bar surfaces are not contaminated with deposits of iron and other non-stainless steels, or suffer damage due to straightening or bending.

Reinforcing steel shall be fabricated without laminations or burrs.

Mesh reinforcement shall be supplied in flat sheets only.

300.4.10.3.1 Order Lists and Bending Diagrams

All order lists and bending diagrams shall be submitted to the Engineer of Record, and if requested, to the Ministry for review in accordance with Schedule 9 – Review Procedure before material is ordered.

The review of order lists and bending diagrams by the Engineer of Record or the Ministry shall not relieve Project Co or suppliers, as applicable, of responsibility for the correctness thereof.

300.4.10.3.2 Bending

Reinforcement bars shall be cut and bent to the shapes shown in the Design Data. Bending shall be sufficiently accurate that the placing tolerances can be met in accordance with the table below. All bars shall be bent cold. Bars partially embedded in concrete shall not be field bent except as shown in the Design Data.

Galvanized bars shall be bent after galvanizing or heat treated for stress relief if bent before galvanizing.

Field bending of galvanized steel reinforcing and fibre reinforced polymer is not allowed.

Hooks and Bend Dimensions

Where hooks are shown in the Design Data, they shall have the following dimensions, unless shown otherwise:

- 180° bend plus extension of at least 4 bar diameters, but not less than 60 mm.
- 90° bend plus extension of at least 12 bar diameters.

For stirrups and ties only, either a 90° or a 135° bend plus extension of at least 6 bar diameters at the free end of the bar.

Minimum inside diameters of bends shall be as shown in the table below. For galvanized and fibre reinforced polymer bars, the bend diameters shall be the same as required for epoxy coated bars.

Exceptions to the above shall be as follows:

- Minimum inside diameters of bends and 90° and 135° hooks for stirrups and ties shall be 4 bar diameters for uncoated bars and 8 bar diameters for epoxy-coated bars.
- Minimum inside diameters of bends in welded wire fabric, plain or deformed, for stirrups and ties shall not be less than 4 wire diameters for deformed wire larger than 7 mm and 2 wire diameters for all other wires, except that bends with an inside diameter of less than

8 wire diameters shall be not less than 4 wire diameters from the nearest welded intersection.

Minimum Inside Diameter of Bends

BAR SIZE	UNCOATED BARS (mm)			GALVANIZED BARS (mm)
	300R	400R or 500R	400W or 500W	
10M	60	70	60	80
15M	90	100	90	120
20M	-	120	120	160
25M	-	150	150	200
30M	-	250	240	240
35M	-	300	280	350
45M	-	450	450	450
55M	-	600	550	550

300.4.10.4 Transportation, Storage and Handling

Reinforcing steel shall be covered and protected at all times during transportation.

Reinforcing steel of differing material types shall be stored separately. Bar tags identifying the material type shall be clearly visible and shall be maintained in-place until installation of the material.

Reinforcing bars shall be stored on platforms, skids or other suitable supports clear of the ground and shall be protected as practicable from mechanical injury and surface deterioration caused by exposure to conditions producing rust.

When placed in the Works, reinforcement shall be free from dirt, loose rust or scale, mortar, paint, grease, oil, or other materials that would reduce bond.

Stainless Steel bars shall be stored separately from carbon steel bars.

Project Co shall take all precautions necessary to prevent damage to the material during handling operations. Bundles shall be handled with spreaders and non-metallic slings.

CRR bars stored on site shall be protected with polyethylene sheeting or an equivalent protective material.

300.4.10.5 Concrete Cover

Concrete cover for reinforcing steel shall conform to the requirements of Section 200.6.6 of Schedule 15-2 – Design and Construction.

300.4.10.6 Placing and Fastening

Before any concrete is placed, the placing and securing of reinforcing steel including dowels, within the area of concrete placement shall be complete. Tying in place of all dowels projecting from the area of concrete placement shall be acceptable to the Quality Manager before any concrete is placed. The reinforcing steel shall be free from dirt, detrimental rust, loose scale, paint, oil or other foreign material.

Reinforcement shall be placed in the positions shown in the Design Data, within the tolerances specified below, adequately supported and secured against displacement. All splices of adjacent bars shall be securely tied together.

All bar intersections shall be tied except when e spacing is less than 300 mm in each direction, then alternate intersections may be tied.

The locations of the top reinforcing steel in bridge decks shall be checked by running a full deck-width template along the longitudinal screeds. The lower edge of the template shall be set at the nominal cover dimension in accordance with the Design Data below the level of the deck surface. No steel shall touch the template or be more than 6 mm distant from it. The use of the deck machine for this purpose in accordance with Section 300.4.2.11.4 in Schedule 15-2 – Design and Construction is a suitable alternative.

The location of reinforcing steel near deck joint anchors shall be adjusted so that there will be no interference with the deck joint anchors.

Tack welding of reinforcement for cage assembly or securing of reinforcement will be permitted only with the written acceptance of the Engineer of Record. In no cases shall stirrups be welded to tensile reinforcement.

Tolerances for placing reinforcement shall, unless otherwise specified, be as shown in the following table.

Tolerances for Placing Reinforcement

Concrete cover to top reinforcing steel in bridge decks	+ 6 mm – 0 mm
Concrete cover to reinforcement, other than top reinforcing steel in bridge decks	± 8 mm
Bar location, except cover, when depth of a flexural member, thickness of a wall or smallest dimension of a column is 200 mm or less	± 8 mm
Bar location, except cover, when depth of a flexural member, thickness of a wall or smallest dimension of a column is larger than 200 mm but less than 600 mm	± 12 mm
Bar location, except cover, when depth of a flexural member, thickness of a wall or smallest dimension of a column is 600 mm or larger	± 20 mm
Longitudinal location, except cover, of bends and ends of bars	± 50 mm
Longitudinal location, except cover, of bends at ends of bars at discontinuous ends of members	± 10 mm

300.4.10.6.1 Bar Supports and Spacers

Bar supports and spacers shall be adequate to ensure concrete cover and bar spacings are maintained within the specified tolerances.

Bar supports and spacers shall be sufficient in number and strength to support the reinforcement and prevent displacement by workers or equipment before and during the placement of the concrete and shall be adequately spaced to ensure that any sagging between supports does not intrude on the specified concrete cover.

Bar supports and spacers shall be of a type and material that will not cause rust spots, blemishes or spalling of concrete surfaces.

Bar supports and spacers shall be precast concrete, plastic, steel wire, stainless steel or steel bar, except that, supports or spacers over 200 mm in height shall be precast concrete or steel bar.

Bright wire and uncoated steel supports and spacers may only be used where they are not in contact with soil surfaces or finished concrete surfaces.

Where concrete surfaces are to be exposed to sandblasting or de-icing chemicals the bar supports and spacers shall be either stainless steel, hot-dip galvanized steel, plastic or precast concrete.

Precast concrete supports shall have a compressive strength, concrete mix type, and quality not less than that of the concrete in which they are embedded. For finished surfaces, the face of the support in contact with the forms shall not exceed 50 mm in any dimension and shall have a colour and texture to match that of the finished concrete surface. For Type DC concrete or Type DC concrete with steel fibres, precast concrete supports shall be "TotalBond" manufactured by Con Sys Inc. or an approved equivalent.

Supports and spacers fabricated from alternate material types may be used with written prior approval from the Engineer of Record. Bar supports and spacers for approach slabs and formed horizontal slabs such as bridge decks, bridge sidewalks, and top slabs of culverts shall meet the following additional requirements:

Supports or spacers up to 200 mm in height shall be either precast concrete or plastic.

Supports and spacers over 200 mm in height shall be either:

- Precast concrete.
- Bent or welded steel bar that has been hot-dipped galvanized after fabrication.
- Stainless steel bar.

Plastic supports or spacers shall have an individual minimum breaking strength of 4.5 kN (1000 lbs) and shall be capable of maintaining strength and dimensional properties for the range of temperatures encountered on Site.

Maximum spacing between supports, for each mat of bars, shall be 1 200 mm, except that the maximum spacing between plastic supports, for each mat of bars, shall be 1 000 mm.

Each support shall carry the load from not more than 1 mat of reinforcing steel, except as provided below:

- Where a support is used that is specifically designed by the manufacturer to carry 2 mats at 2 separate positions.
- If the top mat of reinforcing steel is more than 200 mm above the slab soffit, then the top mat may be supported by epoxy coated reinforcing steel spreader bars secured between the top and bottom reinforcing mats, provided that, the bottom reinforcing mat is supported on precast concrete chairs which are sufficient in number and adequately spaced to carry the additional weight of the top mat of reinforcing steel.

300.4.10.6.2 Spirals

Spirals shall be held in place and to line by vertical spacers.

For spiral rods less than 15M spacing shall be as follows:

- 2 spacers per loop for spirals less than 500 mm in diameter.
- 3 spacers per loop for spirals 500 mm to 800 mm in diameter.
- 4 spacers per loop for spirals over 800 mm in diameter.

For spiral rods 15M and larger spacing shall be as follows:

- 3 spacers per loop for spirals up to 600 mm in diameter.
- 4 spacers per loop for spirals over 600 mm in diameter.

If vertical reinforcements are to serve as spacers, spirals shall be securely tied to vertical reinforcement at the spacing required for spacers.

300.4.10.7 Splicing

300.4.10.7.1 General:

Splicing of bars, unless shown in the Design Data is prohibited.

Splices, where permitted, shall be staggered. For lapped splices, bars shall be placed in contact and wired together while maintaining the minimum required clear distance to other bars, and the required minimum distance to the surface of the concrete.

Sheets of mesh or bar mat reinforcement shall overlap each other sufficiently to maintain a uniform strength and shall be securely fastened at the ends and edges. The edge lap shall not be less than one mesh in width.

Special requirements for splicing, such as particular locations for splices, use of over-length bars or special lap lengths, shall be as shown in the Design Data.

Splices in bars larger than 35M shall be mechanical coupler splices or welded. The detail of such splices shall be subject to acceptance by the Engineer of Record.

300.4.10.7.2 Lapped Splices:

Horizontal bars shall not be spliced unless greater than standard mill lengths – 12 m for 10M bars and 18 m for larger bars – would otherwise be required.

Splices shall be staggered so that no more than 1/3 of the reinforcing steel in a member shall be spliced in any transverse section that is within the required lap length.

The length of lapped splices shall be in accordance with the Bridge Design Code, Clause 8.15.9.1 and shall be shown in the Design Data.

Adjacent reinforcing bars shall not be spliced at the same locations unless shown in the Design Data or authorized by the Engineer of Record.

Column spirals shall have a minimum 50 bar diameter lap plus 90° hook around a longitudinal bar.

300.4.10.7.3 Welded Splices

Welded splices or joints in reinforcing steel will not be permitted.

300.4.10.7.4 Mechanical Coupler Splices

Mechanical couplers shall be used for splices only if pre-approved or detailed in the Design Data. Such couplers shall develop in tension or compression, as required, at least 120% of the specific yield strength of the bars, but not less than 110% of the mean yield strength, representative of the bars to be used, in the test of the mechanical connection.

Wedge couplers shall not be used in bars greater than 15 mm diameter.

When mechanical couplers are used Project Co shall ensure that the minimum concrete cover as specified is maintained.

The total slip of the reinforcing bars within the splice sleeve of the connector after loading in tension to $0.5f_y$ and relaxing it to $0.05f_y$ shall not exceed the following measured displacements between gauge points straddling the splice sleeve:

- Up to and including 45M bars..... 0.25 mm
- 55M bars ..... 0.75 mm

300.4.10.8 Repair of Stainless Steel Reinforcing Bars

Individual stainless steel reinforcing bars exhibiting any of the following defects shall be repaired or replaced:

- Any single area of iron contamination greater than 100 mm in length;
- Two or more areas of iron contamination greater than 50 mm in length;
- Frequent small occurrences of iron contamination along the full length of the bar.

Material exhibiting excessive staining shall have contaminants identified by energy dispersive X-ray analysis (EDXA).

Stainless steel reinforcing bars exhibiting mechanical damage shall be replaced.

300.4.10.9 Quality Management

Project Co shall provide mill test certificates for each lot or part of lot of reinforcing steel to verify that the reinforcing steel supplied was produced and tested in accordance with the applicable specification requirement as noted in Section 200.7.7 of Schedule 15-2 – Design and Construction.

The identification of reinforcing bars shall be maintained throughout the fabrication, coating (if required) and shipping processes to the installation on the job.

Project Co shall, as part of its quality control program, have random samples (selected by the Quality Manager) of reinforcing steel, both coated and uncoated, tested for bending and tension. Each size and grade of bar used in the work shall have 2 samples taken.

Testing shall be in accordance with CSA Standard G30.18 unless otherwise specified.

Testing shall be performed by an approved testing agency.

300.4.11 Waterproofing Membrane

300.4.11.1 General

This Section 300.4.11 of Schedule 15-2 – Design and Construction shall include the supply and installation of an approved deck waterproofing system as shown on drawing SK-4(Deck Water Proofing System with 80 mm Two Course Hot Mix ACP). The area to be covered by the waterproofing system shall be as shown in the Design Data.

- The work shall consist of deck preparation, supply and installation of a "two ply, fully reinforced" hot applied rubberized asphalt membrane waterproofing system and installation of wick drains.
- The waterproofing system shall be applied by an applicator approved by the manufacturer of the rubberized asphalt membrane. Waterproofing work shall be performed only by skilled applicators using the appropriate equipment to properly complete the work.

300.4.11.2 Reference Drawings

Drawing SK-4 (Deck Water Proofing System with 80 mm Two-Course Hot-Mix ACP).

300.4.11.3 Materials

All materials for this application shall be from the Ministry Approved Products List.

300.4.11.3.1 Tack Coat

The tack coat used in conjunction with the asphalt membrane shall be primer, cut back with an equal volume of gasoline type solvent, or an acceptable alternative cut-back asphalt product and be compatible with the asphalt membrane.

Primer shall conform to requirements of the rubberized asphalt membrane manufacturer and meet the requirements of CAN/CGSB-37-GP-9MA.

300.4.11.3.2 Asphalt Membrane

All material for the asphalt membrane shall be hot applied rubberized asphalt meeting the requirements of the Ontario Ministry of Transportation's OPSS 1213 Specification. Asphalt membrane materials shall be selected from the products listed on the Ministry of Transportation Ontario DSM List 9.90.15 (http://www.roadauthority.com) at the time of installation.

The asphalt membrane shall be supplied in cakes ready for melting and application.

300.4.11.3.3 Rubber Membrane

Preformed rubber sheet shall be 300 mm wide, and consist of 1.2 mm thick butyl and ethylene propylene diente monomer ("EPDM") rubber. The membrane shall meet the requirements of CAN CGSB 37-52M.

300.4.11.3.4 Membrane Reinforcing Fabric

Membrane reinforcing fabric shall be spun bonded sheet structure composed of 100% continuous filament polyester fibres bonded together at their crossover points. The membrane shall be supplied in minimum widths of 900 mm. The performance of the material shall be unaffected by the heat generated by the waterproofing processes.

300.4.11.3.5 Wick Drain

Wick drain shall be composite polypropylene with a total thickness of 3.6 mm and supplied in 100 mm widths. The puncture strength shall be a minimum of 45 N measured in accordance with ASTM Specification D4833. The minimum permittivity shall be $0.5s^{-1}$ measured in accordance with ASTM D4491. The performance of the material shall be unaffected by the heat generated by the waterproofing processes.

300.4.11.3.6 Waterproofing Protection Board

The protection board shall be 3.6 ± 0.4 mm in thickness, and meet the requirements of the Ontario Ministry of Transportation's OPSS 1215 Specification. Waterproofing protection board materials shall be selected from those listed on the Ministry of Transportation, Ontario DSM List 9.90.60 (http://www.roadauthority.com) at the time of installation.

The board shall have straight edges, square corners, and edges free of burrs and breakaways. Notwithstanding the size tolerance above, all sheets in a shipment shall be of the same length and width within a tolerance of +/- 5 mm and of uniform thickness within a tolerance of +/- 0.25 mm. It shall meet with the Ontario Ministry of Transportation Specification OPSS 1215 for Protection Board.

300.4.11.4 Equipment

300.4.11.4.1 Kettle

A heating and mixing kettle shall be used to heat the hot applied rubberized asphalt membrane.

The kettle shall be the double boiler, indirect fired, oil transfer type with a built-in mechanical agitator and equipped with accurately calibrated thermometers to register the temperatures of both the heating oil and the membrane.

The kettle shall have a minimum capacity of 270 imperial gallons.

300.4.11.4.2 Air Compressor

The applicator shall have an air compressor on site with a minimum discharge capacity of 150 cubic feet per minute for blast cleaning and cleaning of the surface to be waterproofed.

Use of rotary air blowers will not be accepted.

300.4.11.4.3 Surface Preparation Equipment

Concrete surfaces shall be prepared by blast cleaning. The surface preparation equipment shall be able to strip, clean and profile simultaneously, and shall remove all surface laitance and contamination to expose sound mortar and aggregate.

The concrete surface shall be surface dry and chemical free following completion surface preparation.

The blast media provided for the blast cleaning operation shall provide a surface profile acceptable to the waterproofing membrane manufacturer.

300.4.11.4.4 Thermometers

A separate calibrated thermometer, with an accuracy of ± 2° Celsius, to verify the material temperature shall be available on site.

300.4.11.5 Installation

300.4.11.5.1 Traffic Restrictions

Traffic restrictions apply to all traffic other than the construction equipment directly associated with the waterproofing operations and the paving operations that follow.

After blast cleaning operations have commenced, construction traffic will not be allowed on the prepared area until the ACP has been placed and cooled to ambient temperature.

300.4.11.5.2 Procedure

All of the operations involved in waterproofing shall be performed in sequential order, such that there are no delays between individual operations except those necessary to meet the requirements of this section.

300.4.11.5.3 Surface Preparation

The deck concrete, including curbs, sidewalks and medians shall be completely surface dry and cured at least 14 days before application of tack or membrane can proceed.

The surface shall meet all surface smoothness requirements prior to application of primer. Mapping and repair of cracks shall be undertaken and the entire surface shall be reviewed and accepted by the Engineer of Record.

The surface preparation shall consist of blast cleaning the concrete deck, abutment slabs and approach slabs and blast cleaning up the vertical face of concrete traffic barriers or curbs to a height 100 mm above the slab surface.

Blast cleaning shall provide a surface profile compatible to the waterproofing membrane system.

All loose material shall be removed with a jet of oil free compressed air.

At the end of shot and sand blasting each day, the debris material left on the deck shall be removed and disposed of appropriately. Project Co shall dispose of all waste materials in an environmentally acceptable manner, and in compliance with all local and provincial laws and regulations.

The applicator shall apply the primer to the clean, dry concrete slabs and up the vertical face of concrete traffic barriers or curbs to the top of surfacing, at a rate of not less than 0.25 litres per square metre. 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. The application of an excessive amount of tack as indicated by a shiny black surface shall be avoided.

Primer shall not be applied to wet or damp concrete surfaces, or to surfaces which have not been sufficiently dried to prevent egress of water vapor which would prevent development of a good bond to the surface. The "Poly Patch Test" (ASTM Specification D4263) shall be used to confirm the dryness of surface.

Drying of the concrete surface shall not be expedited by application of a torch or by other means.

Any surface contamination which accumulates in the interim between blast cleaning and priming shall be removed prior to priming.

The structure shall be primed as soon as possible following the blast cleaning operation to minimize contamination of the deck in the interim.

The tack coat shall be applied only when the concrete is dry and clean, and when the air and concrete surface temperatures are above 5° Celsius. Waterproofing equipment or material shall not be permitted on the tack coat until it has fully cured and is completely tack-free.

300.4.11.5.4 Waterproofing of Joints

Construction Joint Treatment

All construction joints between the approach slabs and the abutment slabs shall be protected with a preformed rubber sheet.

Joint filling compound for barrier and other joints shall be suitably cured prior to application of the primer and membrane, to avoid the possibility of damage or deformation.

Installation of the preformed rubber sheet shall be performed as follows:

- Spread a 3 mm thick layer of hot applied rubberized asphalt membrane in a 400 mm wide strip, centered on the construction joint, across the prepared deck width and continue up the face of the traffic barriers or curbs to 10 mm below the top of surfacing.
- Place a 300 mm wide preformed rubber sheet into the membrane, while the membrane is still tacky.
- The sheet shall extend across the prepared deck width and 30 mm up the face of the traffic barriers or curbs.
- Apply an additional 3 mm thick layer of hot applied rubberized asphalt membrane over the rubber sheet and extending 50 mm beyond the edges of the rubber sheet.

300.4.11.5.5 Installation of Interface Drains

Interface Drainage

Seepage and/or wick drains shall be installed to drain the water from between the bottom of the asphalt wearing surface and the top of the waterproofing membrane

Wick Drains

Wick drains shall be placed along the full length of curbs and barriers and installed when the asphalt membrane is still hot and tacky. Special attention shall be given to waterproofing and wick drain modifications at deck drain pipe locations.

Wick drain details shall be in conformance with Drawing SK-4 (Deck Water Proofing System with 80 mm Two Course Hot Mix ACP).

The ends of wick drains shall be extended a minimum of 200 mm into the seepage drains or drain boxes.

The length of wick drains shall be limited to a single span to ensure positive drainage, but in no case shall the length exceed 36.0 m.

At abutments, the wick drains shall extend along the concrete traffic barriers or curbs from the rear face of the expansion joint dam to the nearest seepage drain or drain box if used.

Where it is necessary to splice the wick drain, top and bottom splices shall be laterally offset by a minimum of 300 mm.

The wick drain shall be placed directly on top of the hot applied rubberized asphalt membrane.

The applicator shall temporarily seal all deck drains during operations to ensure that none of the primer or rubberized asphalt material is lost during application.

The applicator shall unseal all deck drains, when operations are delayed or temporarily shut down, so as to allow for unrestricted drainage of water from the deck.

Seepage Drains

Seepage drains, if used, shall have a maximum spacing of 1.2 m and shall not be installed within 2.0 m of substructure elements or over traffic.

The applicator shall be responsible to temporarily seal the seepage drains during priming and waterproofing operations to ensure that none of the primer or rubberized asphalt material is lost during their application.

After completion of the waterproofing operation, the applicator shall remove the protection board and waterproofing membrane from directly over the seepage drain and remove the temporary seals.

The diameter of the access hole through the protection board and the waterproofing membrane to the seepage drains shall be equal to the inside diameter of the seepage drain ± 3 mm.

Great care shall be taken not to damage the rubberized waterproofing membrane at the outside perimeter of the seepage drains.

300.4.11.5.6 Application of Asphalt Membrane

Cakes of asphalt membrane shall be melted in the mechanically agitated heating and mixing unit specified. This unit shall keep the contents continuously agitated until the material can be drawn free flowing and lump-free from the mixing unit at a temperature not exceeding that recommended by the manufacturer.

Membrane shall not be applied until the tack coat has cured completely. The asphalt membrane shall be applied within the temperature range recommended by the manufacturer, to the clean, tack-coated concrete deck, to form a base coat and then a top coat.

The laying operation shall commence at the low end of the bridge and shall be such that discontinuities in the membrane are avoided and any joints lapped 150 mm. The membrane shall be applied over all waterproofed joints and cracks, and shall extend up the face of curbs, barrier walls, and deck drains, to the height of the top of the hot mix surface course. Deck drains and drainage tubes shall not be plugged.

Hot Applied Rubberized Asphalt Membrane Base Layer

The primer shall be completely dry before the rubberized asphalt membrane may be applied.

A base layer of hot applied rubberized asphalt membrane shall be applied to the clean, dry, blast cleaned and primed deck surface.

The base layer shall be carried up the vertical face of the barriers to the top of the surfacing.

The base layer of hot applied rubberized asphalt membrane shall not be applied to wet surfaces, or to surfaces which have not been sufficiently dried to prevent egress of water vapour which would prevent development of a good bond to the surface.

The base layer shall have a minimum thickness of 2 mm with a maximum local variation of ± 1 mm.

The base layer shall be applied over all reinforcing details.

Reinforcing Sheet

The reinforcing sheet shall be tight and wrinkle free and shall come in full contact with the membrane base layer.

All edges of the reinforcing sheet shall be lapped a minimum of 50 mm.

The reinforcing sheet shall extend up the vertical face of concrete traffic barriers or curbs to 10 mm below the top of surfacing.

Hot Applied Rubberized Asphalt Membrane Top Layer

A second layer of hot rubberized asphalt membrane shall be applied over the reinforcing sheet and shall extend up the vertical face of concrete traffic barriers or curbs to the top of the surfacing.

The top layer shall be approximately equal in thickness to the base coat.

The top layer in combination with the base coat and the reinforcing sheet shall provide a minimum total membrane thickness of 5 mm with a maximum local variation of + 1 mm.

At no point shall the combined thickness of the 2 layers of the hot applied rubberized asphalt membrane and the reinforcing sheet be less than 5 mm.

300.4.11.5.7 Application of Protection Board

The asphalt membrane thickness and its corresponding location along the deck surface shall be checked and recorded at a minimum of every 50 m^2 to ensure conformance to the Technical Requirements, prior to placing the protection board. Protection boards shall be laid on the asphalt membrane, commencing at the low end of the bridge and overlapping to produce a shingling effect, while the membrane is still hot, with the length of the board running transversely, on the deck.

The protection boards shall be placed with edges overlapping a minimum of 12 mm to a maximum of 25 mm both longitudinally and transversely. The protection board edge shall be within 5 mm of all wick drains, vertical faces of drains and vertical or near vertical faces at deck joints.

Protection boards shall be placed such that the longitudinal (direction of traffic flow) joints are staggered at least 150 mm. It shall be rolled by means of a linoleum or lawn type roller while the membrane is still warm, in order to ensure good contact with the membrane. Holes shall be cut through the protection board to allow water to drain freely through the drainage tubes. In instances where edges of the protection board curl up, the edges shall be cemented down using hot membrane material. Protection boards that are warped, distorted or damaged in any way, by manufacture, storage, handling or exposure to weather, shall be rejected.

300.4.11.6 Quality Management and Warranty

If requested by the Ministry, sufficient quantities of the asphalt membrane, rubber membrane, membrane reinforcing fabric and protection board being used on the Project shall be sent for immediate testing in accordance with Ontario Provincial Standard Specifications OPSS 1213 and OPSS 1215, and all test results shall be provided to the Ministry forthwith.

Project Co shall submit, if requested, to the Ministry prior to start of operations, a product data sheet and MSDS for all materials used in the installation of the waterproofing membrane.

A copy of the MSDS shall be kept on site by Project Co while the products are being applied and/or stored on site.

A coverage test shall be conducted periodically throughout the operation to ensure compliance with the Manufacture's required application rate.

300.4.11.6.1 Warranty

Project Co shall obtain from the waterproofing system applicator a written and signed warranty, certifying that all Work completed shall remain, as installed, free from any defect, for a period of five years from the date of acceptance. Project Co shall submit a copy of the warranty to the Ministry.

300.4.11.7 List of Approved Materials

Hot Applied Rubberized Asphalt Membrane

- "Bakor" 790-11
- "Beamalastic 1213 BDM"
- "Ultraseal 3750"

Rubber Membrane

- "Elastosheet 6147"
- BP47 Elastometric Reinforcement
- Bakor 990-25"

Waterproofing Protection Board

Test results and samples of proposed protection board shall be submitted to the Ministry for review in accordance with Schedule 9 – Review Procedure. Additional testing may be required to confirm test data provided.

Acceptable products of protection board shall consist of spun glass fibres and not cellulose reinforcing fibres. Products which currently meet the 5% or less water absorption requirement are:

- "Vibraflex MTO Protection Board"
- "Bakor Asphalt Protection Board"
- "IKO Protectboard"

Membrane Reinforcing Fabric

- "Remay 2016"
- Bakor Polyester Fabric

Wick Drain

- "Nilex MD/7407"
- Amerdrain 407
- Terrafix270R

300.4.12 Paving On Bridge Structures

300.4.12.1 General

Equipment and methods used for asphalt concrete pavement on bridge deck waterproofing membranes shall be adequate to produce and place the material as specified.

300.4.12.2 Equipment

300.4.12.2.1 Paver

Pavers shall be self-propelled and operated to maintain required levels, cross-falls and joint matching.

300.4.12.2.2 Compaction Equipment

Sufficient self-propelled equipment shall be provided to obtain the required degree of compaction of the asphalt concrete mixture. The compaction capability of the equipment used shall equal or exceed the placing rate of the spreading operations and shall be capable of obtaining the required compaction before the temperature of the mat falls below specified levels. Compaction equipment shall be of a suitable size, weight and type, such that displacement of the mat and/or disruption of underlying materials do not occur. Specialized equipment may be required to achieve adequate compaction and smoothness in tight corners, such as adjacent to expansion assemblies and deck joints.

A minimum of two pieces of compaction equipment shall be provided. They shall be rollers of at least 10 tonnes mass, one rubber tired and one smooth steel drum type. Vibrators on vibratory rollers shall not be activated.

The compaction equipment shall be in proper mechanical condition and shall be operated such that uniform and complete compaction is obtained throughout the entire width, depth and length of the pavement being constructed. Rollers provided shall leave a smooth, properly finished surface, true to grade and cross-section without ruts or other irregularities. All compaction equipment shall be equipped with methods of wetting the tires or drums to prevent adhesion or pickup of the asphalt mixture.

300.4.12.3 Placement of Asphalt Concrete Pavement

300.4.12.3.1 Protection of Adjacent Bridge Components

Project Co shall protect curbs, deck joints, and expansion assemblies to prevent splatter or spillage of asphaltic materials.

300.4.12.3.2 Tack Coat

Asphalt tack coat shall be applied to the existing protection board and between lifts of asphalt concrete pavement.

The surface to be tacked shall be dry and free of loose or deleterious material when the tack is applied.

The asphalt tack coat shall be applied in a uniform manner at an application rate of 0.5 ℓ/m² and suitable asphalt temperature. Air temperature in the shade at the time of application shall be 5° Celsius or higher.

On areas where traffic is to be accommodated, the tack coat shall be applied in two operations. In the first operation one half of the width shall be tacked with the remaining half being tacked after the first half has cured.

The tack coat shall be protected from traffic or other damage. Areas on which the tack has been damaged by traffic shall be re-tacked.

300.4.12.3.3 Spreading and Compaction

300.4.12.3.3.1 General

The mixture shall be placed only upon a dry, frost free substrate on which the tack coat has cured, and under suitable weather and temperature conditions. Prior to the delivery of the mixture on the work, the base shall be cleaned of all loose or foreign material. The mixture shall be spread and compacted during daylight hours only, unless artificial light is provided.

During spreading and compaction operations, care shall be taken at all times to ensure that:

- Asphalt mixture is not wasted over the side or onto the adjacent surface mat.
- Damage is not done to the waterproofing membrane, curbs, manholes, drains or medians.
- Damage is not done to guide posts, guardrails, signs, power conduits or any other roadside installations.

Immediate and adequate repair shall be made of any damage resulting from construction activities.

300.4.12.3.3.2 Placement of Asphalt on Hot-Applied Rubberized Membrane Waterproofing

The first layer of the ACP wearing surface shall be spread by the asphalt paver moving with the laps in the protection board.

With the possibility of damage to the waterproofing membrane, the paver shall not push the delivery trucks and all equipment shall perform all turning movements off the bridge deck. Dumping of the asphalt mixture onto the protection board ahead of the paver will not be permitted.

The prepared material shall be placed and compacted in two nominal 40 mm layers.

To avoid displacement of the mixture the first lift shall be compacted only after the spread asphalt mixture has cooled to 105° Celsius. The second lift shall be compacted when the spread asphalt mixture is within the following temperature ranges:

ASPHALT GRADE	COMPACTION TEMPERATURE RANGE	
	FIRST LIFT	SECOND LIFT
150 - 200 (A)	MAX. 105° Celsius	128° Celsius – 138° Celsius

Due to the cooler compaction temperature (105° Celsius) of the first lift, it may not be possible to achieve the 97% average density.

300.4.12.3.3.3 Spreading

The mix shall be spread at a temperature sufficient for specified compaction and finishing at the final placement area.

The manner of placing shall ensure safe accommodation of traffic, quality control and drainage. The longitudinal and transverse edges of each lane shall be straight in alignment, uniform, and of

the same thickness as the adjoining pavement layer. Adequate measures for the protection of the exposed edges shall be maintained throughout the work.

Each layer shall be placed, finished and compacted for the full width, and then allowed to cool down to 50° Celsius or colder prior to commencing the subsequent layer.

In the placing of successive layers, the individual mixture spreads shall be aligned in a manner such that the longitudinal joints in successive layers do not coincide. Unless otherwise directed, the lateral distance between the longitudinal joints in the successive layers shall be not less than 0.30 m. The longitudinal joint of the final lift of asphalt concrete pavement shall not be located within the wheel path areas.

The surface of all lifts shall not exhibit evidence of segregation, such as pockets of fine and coarse material.

All longitudinal and transverse joints shall be of the vertical butt joint type, made in a careful manner, well bonded and sealed, and shall be finished to provide a continuous, smooth profile across the joints.

300.4.12.3.3.4 Compaction

The compaction process shall be monitored using a control strip method. Control strips are generally established on each mat placed.

The control strip lift shall be compacted using at least the following equipment:

- One steel roller weighing not less than 10 t; and
- One self-propelled pneumatic rollers, ballasted to its maximum capacity, weighing not less than 10 t.

Once the mix has been spread by the paver and the initial pass of the breakdown roller has been done, moisture and density measurements for determining the control density will commence at five locations within the control strip area, and will continue following repeated passes of the compaction equipment until the apparent maximum density is attained. These measurements will be taken using nuclear testing equipment.

The pavement shall be compacted to a minimum average density of 97% of Marshall density, with no individual density less than 95%.

When the compaction methods and procedures are not achieving the desired compaction specifications, cores of the top lift pavement shall be taken. The number of cores will be determined by the Engineer of Record in conjunction with the Quality Manager. The cores will be tested by Project Co and the results provided to the Ministry as soon as they become available.

Percent compaction will be expressed in percent of Marshall standard density. The Marshall standard density used for determining pavement compaction shall be as follows:

- Marshall densities determined on field sampled mix, or if not available then;
- Marshall design density as reported in the accepted mix design.

Coring shall be done using methods which will not damage the rubberized asphalt membrane or protection board. Core holes shall be completely de-watered and dried. A generous application of liquid asphalt shall be applied to the bottom and sides of the core hole and allowed to cure. Asphalt mix shall then be tamped in lifts into the core hole until flush with the surface of the surrounding pavement.

Project Co shall give reasonable notification to the Ministry prior to undertaking any coring to enable the Ministry to attend coring activities.

In order to maintain the crown of the bridge deck and approaches, Project Co shall avoid operating the compaction equipment on or across the crown. Compaction procedures and equipment shall be such that displacement of the mixture does not occur. Roller wheels shall be kept slightly moistened by water or oil to prevent picking up the mixture, but an excess of either water or oil will not be permitted.

In cases where the asphaltic mixture is placed under weather and temperature conditions which may be considered less than ideal, normal operations shall be modified to provide special attention to these situations such that specified compaction results are achieved.

300.4.13 Deck Systems Using Precast Concrete Partial Depth Deck Panels

300.4.13.1 General

This Section 300.4.13 of Schedule 15-2 – Design and Construction is for the design, fabrication and construction of deck systems using precast concrete partial depth deck panels.

Unless otherwise noted in this section, all the requirements of Section 200.6 (Structures Design) shall apply to the design of deck systems using precast concrete partial depth deck panels.

Unless otherwise noted in this section, all the requirements of Section 300.4.4 of Schedule 15-2 – Design and Construction shall apply to the supply, manufacture, delivery and erection of precast concrete partial depth deck panels.

Unless otherwise noted in this section, all the requirements of Section 300.4.2 of Schedule 15-2 – Design and Construction shall apply to the construction of deck systems using precast concrete partial depth deck panels.

300.4.13.2 Fabrication

The panels shall be cast flat.

All edges of the panel shall have a minimum 20x20 mm chamfer, except the transverse joint which shall have a 55x55 mm chamfer along the top edges.

300.4.13.2.1 Stressing Strand

Strand termination recesses for the panels are not required.

All projecting strand shall be detailed as per the Design Data.

Where the strands are not projecting, the ends shall be covered with a thixotropic epoxy to provide at least 3 mm cover for a band width of 50 mm on all sides of the strands.

300.4.13.2.2 Surface Finish

The top surface of panels shall be clean, free of laitance, and roughened to 3 mm amplitude with spacing not greater than 15 mm with grooves parallel to strands.

Formed chamfer surfaces that will be in contact with the cast in place concrete shall be sandblasted to remove all laitance and uniformly expose aggregate particles.

300.4.13.2.3 Tolerances for Panels

Precast concrete deck panels shall meet the following tolerances:

- Panel lengths ..... ± 5 mm (as measured perpendicular to the girder lines).
- Panel widths ..... ± 10 mm (as measured parallel to the girder lines).
- The maximum difference in plan view diagonal dimensions (squareness) of rectangular panels shall be not greater than 3.5 mm per meter of diagonal length.
- Thickness of panel..... + 5 mm, - 3 mm.
- For prestressed panels, strands shall be located at the centroid of the panel with a vertical tolerance of + 0 mm, - 3 mm, measured from the soffit and a horizontal tolerance of ±10 mm.
- Deviation from straightness of panel edges along the transverse joint between adjacent panels shall not exceed 1.5 mm per metre length.
- Vertical bowing of panels out of plane, after casting and immediately prior to erection, in the direction of measurement, shall not be greater than the panel length/360 or the panel width/360, whichever is less, and in no case shall it exceed 10 mm maximum.
- Warping of the panel shall not be greater than 5 mm per metre of distance from the nearest adjacent corner.

Tolerance measurement results shall be provided to the Ministry forthwith, upon its request. If any of the tolerances listed above is not met, the panel unit shall be considered unacceptable and shall be rejected.

300.4.13.2.4 Defects and Deficiencies Causing Rejection

A panel having any one of the following defects or deficiencies shall be rejected:

- Panels with honeycombing, voids, cavities, spalls when the depth exceeds 15 mm or when the area of defect exceeds 25 mm x 25 mm.
- Panels with any crack located parallel to or over the strands or reinforcing steel.
- Panels with any crack at the edges and / or with cracks at the bottom.
- Panels with cracks deeper than 25 mm and/or wider than 0.1 mm.
- Panels with any voids or spalls in the bottom of the panel.

300.4.13.3 Erection and Construction

The precast panels shall be erected on temporary supports on the girders. The precast panels shall be erected so that the transverse joint between adjacent panels is never greater than 5 mm.

All lifting hooks for the precast panels shall be removed after erection.

All transverse joints shall be sealed with Sikaflex LM or an approved equivalent to prevent mortar leakage.

The cast-in-place haunches shall be cast monolithically with the deck. The haunches shall be formed to be flush with the edge of the girder flanges.

When casting the deck, place the girder haunch concrete first in continuous strips not to exceed more than 5 meters ahead of the rest of the concrete. Carefully vibrate the concrete along the panel to girder interface to ensure that the concrete completely fills the area under the precast panel overhangs.

Then place and vibrate the remaining deck concrete. This process shall be completed within a sufficiently short timeframe to ensure that a cold joint does not form between the haunch concrete and the rest of the deck concrete.

All haunch forming material shall be completely removed after casting the deck to fully expose the haunches.

All surfaces shall be finished as per Section 300.4.2.16 of Schedule 15-2 – Design and Construction.

300.4.14 Stone Riprap

300.4.14.1 Material

Stone riprap shall be hard, durable, angular field stones, boulders or angular quarry rock of a quality that will not degrade on exposure to water or the atmosphere. Stone shall be resistant to weathering and water action, free from overburden, spoil, shale or shale seams and organic material, and shall meet the gradation requirements for the class specified. No sandstone is permitted.

The gradation of stone sizes (mass in kg) in each class of riprap, as specified or directed, shall conform to the table below.

Individual stones shall have a thickness greater than one-third their length and none shall have a mass greater than five times that of the specified class mass.

Project Co shall provide evidence of the acceptability of the riprap material. Reliable performance records of proposed material, other than fieldstone, will be considered evidence of acceptability. Angular fieldstone shall be considered to have a reliable performance record, and will be accepted.

Tests are based on the Durability Index and Durability Absorption Ratio as developed by the State of California, Department of Transportation. Project Co shall submit representative samples of the proposed material to an independent certified testing laboratory, and test reports shall be stamped by a Professional Engineer. A representative sample of not less than 70 kg is required for each type and source of stone to be tested, and shall contain a number of pieces ranging up to 25 kg mass. Additional testing shall be carried out in the event of material difference between supplied material and the tested sample.

The material provided for each class specified shall have a gradation that conforms to the following:

Gradation of Stone Riprap

CLASS OF RIPRAP	***NOMINAL THICKNESS OF RIPRAP**	**STONE GRADATION PERCENTAGE LARGER THAN GIVEN STONE MASS (kg) OR APPROX. DIAMETER (mm)**							
	(mm)	**kg**	**mm**	**kg**	**mm**	**kg**	**mm**	**kg**	**mm**
		80%	**80%**	**50%**	**50%**	**20%**	**20%**	**0%**	**0%**
A	350	5	150	10	200	25	250	70	350
B	450	10	200	40	300	70	350	130	450

*The minimum thickness of riprap, measured at right angles to the slope, for the class specified, shall be the nominal thickness stated. Percentages quoted are by mass.

Sizes quoted are equivalent spherical diameters, and are for guidance only.

Stone riprap shall meet the following minimum requirements for specific gravity, absorption and durability:

Method of Test	**Requirements**
California Department of Transportation Method of Test for Specific Gravity and Absorption of Coarse Aggregate (California Test 206)	Minimum Specific Gravity = 2.60 Maximum Absorption = 2.0%
California Department of Transportation Method of Test for Durability Index (California Test 229)	Minimum Durability Index = 52 (unless DAR* > 23)

* Durability Absorption Ratio (DAR) = Durability Index / (Absorption % + 1%)

300.4.14.1.1 Geotextile Filter Fabric

Where geotextile filter fabric is specified, the slope shall be graded to provide a smooth, uniform surface. All stumps, large rock, brush or other debris that could damage the fabric shall be removed. All holes and depressions shall be filled so that the fabric does not bridge them. Loose or unstable soils shall be replaced.
Non-woven geotextile filter fabric shall be used under all riprap in accordance with the following table of minimum average roll value properties (MARV's) for each specific Class of riprap:

Property	**Class A and B**
Grab Strength	800 N
Elongation (Failure)	50%
Puncture Strength	275N
Burst Strength	2.1 MPa
Trapezoidal Tear	250 N

The non-woven geotextile filter fabric shall meet the specifications and physical properties as listed above.

The fabric shall be laid parallel to the slope direction. It shall be placed in a loose fashion, however folds and wrinkles shall be avoided. Adjacent strips of fabric shall be overlapped a minimum of 300 mm, except where placed underwater, the minimum lap width shall be 1 m. Overlaps shall be pinned using 6 mm diameter steel pins fitted with washers and spaced at 1 m intervals along the overlaps.

All edges of the filter fabric shall be anchored by digging a 300 mm deep trench, inserting the edge of the fabric and backfilling with compacted soil.

Care shall be taken to prevent puncturing or tearing the geotextile. Any damage shall be repaired by use of patches that extend at least 1 m beyond the perimeter of the tear or puncture.
The fabric shall be covered by rock riprap within sufficient time so that ultraviolet damage does not occur; in no case shall this time exceed 7 days for ultraviolet material and 14 days for ultraviolet protected and low ultraviolet susceptible polymer geotextiles.

Riprap placement shall commence at the base of the blanket area and proceed up the slope. The height of drop of riprap shall be limited to 1.0 m or less, and the riprap shall not be allowed to roll down the slope. Heavy equipment will not be permitted to operate directly on the geotextile.

300.4.14.2 Placing of Stone Riprap

300.4.14.2.1 General:

The work shall consist of constructing a protective covering of stone riprap for embankments and channels at the locations and of the type and class shown in the Design Data. Work within any watercourse shall generally be carried out in conformity with the environmental protection provisions of the agreement.

300.4.14.2.2 Slopes:

Areas to receive riprap shall be trimmed to a uniform surface and to the slope(s) indicated in the Design Data or as directed by the Engineer of Record.

Before stone placement commences, loose material shall be removed and minor pot holes and hollows filled with selected materials well tamped to the approval of the Engineer of Record and the Quality Manager.

The stone shall be handled, dumped or placed into position to conform to the specified gradation and to the cross section shown on the drawings. The finished surface shall be reasonably uniform, free from bumps or depressions, and with no excessively large cavities below or individual stones projecting above the general surface.

300.4.14.2.3 Watercourses:

In addition to slope erosion protection requirements:

- To provide a stable foundation and protection against any undercutting, the riprap shall be thickened at the toe, laid horizontally to form an apron and/or keyed into the bed of the watercourse.

300.4.14.3 Inspection of Stone Riprap

Control of gradation shall be by visual inspection. Project Co shall provide a minimum of two samples. These samples shall be proven to acceptably conform to the required gradation by direct weighing of all the individual pieces with suitable scales; the mass of each piece in the sample shall be painted on the piece. These samples, located as required by the Quality Manager at the construction site and at the source or quarry site, may be incorporated in the finished riprap when they are no longer required for reference purposes. The samples shall be used for frequent reference in judging the gradation of the riprap being loaded at the source and placed at the site. Project Co shall provide whatever facilities are required to assist the Quality Manager in auditing gradation.

If, during the delivery of the material to the site, a particular load is found to be made up of pieces predominantly one size, or to be lacking in pieces of one size, it shall be dumped in a suitable location outside the area to be protected. Additional material as required to make up the deficient sizes shall be added to this load such that the combination can then be placed to ensure uniformity.

300.4.15 Elastomeric and Pot Bearings

300.4.15.1 General

This Section 300.5.15 of Schedule 15-2 – Design and Construction is for the supply, fabrication and installation of elastomeric bearings and pot bearings. Installation shall be in accordance with Section 300.4.3 and Section 300.4.4 of Schedule 15-2 – Design and Construction.

300.4.15.2 Materials

All materials shall be new and unused, with no reclaimed material incorporated in the finished bearing.

300.4.15.2.1 Steel

The steel laminates shall be rolled mild steel with a minimum yield strength of 230 MPa. The steel for base plate, keeper bars, pintels and shims shall conform to the requirements of CSA Standard G40.21 Grade 300W. The steel for sole plate and top bearing plate shall be as per Section 200.6.7.4 of Schedule 15-2 – Design and Construction.

300.4.15.2.2 Stainless Steel

Stainless steel sheets shall conform to the requirements of the American Iron and Steel Institute (AISI) Type 304, No. 8 mirror (0.2 μm) finish. The chemical and mechanical properties conform to the requirements of ASTM Specification A240M.

300.4.15.2.3 Brass

Brass sealing rings for confined elastomer bearings shall be according to ASTM Specification B36M, halfhard.

300.4.15.2.4 Elastomer

Elastomeric compounds shall be low temperature Grade 5 and meet the physical and low temperature brittleness requirements listed in Table 1 and Section 8.8.4 of AASHTO M251-06. Elastomeric compounds shall have 60 Durometer hardness for elastomeric bearing pads and 50 ± 5 Shore A for pot bearings.

300.4.15.2.5 PTFE

PTFE used for horizontal sliding surfaces shall be unfilled, 100% virgin polymer. PTFE used for guides for lateral restraint may be one of the following:

- Unfilled PTFE, or
- PTFE filled with up to 15% by mass of glass fibres.

PTFE shall be in accordance with the Bridge Design Code.

300.4.15.2.6 Lubricant

Lubricant shall be silicone grease, effective to -40 °Celsuis, and shall comply with U.S. Department of
Defense MIL-S-8660C.

300.4.15.2.7 Adhesives

Adhesive for bonding PTFE to metal shall be an epoxy resin producing a bond with a minimum peel strength of 4 N/mm, when tested according to ASTM Specification D429, Method B. Adhesives shall not degrade in the service environment.

300.4.15.2.8 Base Plate Corrosion Protection

Bearing base plate corrosion protection shall be as per Section 300.4.3.3.7 of Schedule 15-2 – Design and Construction.

300.4.15.2.9 Connecting Bolts

For connecting bolts, the following material properties shall be used:

Bolts through girder bottom flange and into sole plate (galvanized or weathering steel)	ASTM Specification A325 Type 3.
Bolts connecting galvanized or weathering steel sole plate to top bearing plate	ASTM Specification A325 galvanized.

300.4.15.3 Submissions

The following information shall be submitted to the Ministry within ten days prior to fabrication;

- Identification of bearing supplier;
- Layout installation drawings;
- Welding procedures for all welds;
- Shop drawings;
- Mill certificates and mill test reports for all material; and
- Quality assurance test reports.

The following shall be submitted for review in accordance with Schedule 9 – Review Procedure in the event of repairs being required:

- Repair procedures for unsatisfactory weldments and accidental arc strikes; and
- Repair procedures for damage galvanizing.

The following information shall be submitted to the Ministry on request:

- Methods and materials for setting anchor bolts and constructing bearing pads; and
- Methods of forming and pouring grout.

300.4.15.4 Supply and Fabrication

300.4.15.4.1 Standards

Fabrication of plain and laminated elastomeric bearings and pot bearings shall conform to:

- The American Association of State Highway and Transport Officials (AASHTO) LRFD Bridge Construction Specifications,
- AASHTO's Standard Specifications for Transportation Materials and Methods of Sampling and Testing M251-06 Standard Specification for Plain and Laminated Elastomeric Bridge Bearings, and
- Welded Steel Construction CSA Standard W59

Where imperial/metric conversions are necessary, The CSA Standard Z234.1 shall be used as the basis of conversion.

300.4.15.4.2 Qualification

Fabrication shall be done in a shop certified by CWB to CSA Standard W47.1 in Division 1 or 2.

Only welders, welding operators and tackers approved by the Canadian Welding Bureau in the particular category shall be permitted to perform weldments. Their qualifications shall be current and submitted to the Ministry pursuant to Schedule 9, Review Procedure.

300.4.15.4.3 Engineering Data

Welding Procedures

Welding procedures including welding procedure datasheets approved by the Canadian Welding Bureau shall be submitted for each type of weld to be used.

Shop Drawings

Shop drawing requirements shall be as per Section 300.4.3.3.3 of Schedule 15-2 – Design and Construction. In addition, the following requirements shall be met:

The shop drawings shall clearly indicate all material properties, dimensions, connection attachments, fasteners and accessories, the bearing identification, and the load capacity at the serviceability and ultimate limit states as follows:

- Maximum vertical permanent and total load.
- Maximum lateral load and corresponding vertical load.
- Maximum rotational capacity about any horizontal axis and about the vertical axis at the centre of the bearing.

When bearings for more than one bridge are included, individual shop and erection drawings shall be submitted for each bridge.

300.4.15.4.4 Fabrication

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 CSA Standard W59. 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, and shall not be used. However metal core welding process utilizing low hydrogen electrodes with diffusible hydrogen designation of H4 will be allowed. The deposited weld metal shall provide strength, durability, impact toughness and corrosion resistance equivalent to base metal. Field application of metal core arc welding shall not be used.

Cleaning Prior to Welding

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

Tack and Temporary Welds

Tack and temporary welds shall not be used unless they are to be incorporated in the final weld. Tack welds, where used, 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.

Methods of Weldment Repair

Repair procedures for unsatisfactory weldments shall be submitted for review in accordance with Schedule 9 – Review Procedure by the Ministry prior to repair work commencing.

Arc Strikes

Arc strikes will not be permitted. In the event of accidental arc strikes, Project Co shall submit to the Ministry a proposed repair procedure for review in accordance with Schedule 9 – Review Procedure. The repair procedure shall include the complete grinding out of the crater produced by the arc strike. These areas shall be examined by the Engineer of Record to ensure complete removal of the metal in the affected area.

Plug and Slot Welds

Plug welds or slot welds will not be permitted.

Fabrication

Fabrication shall be performed in a fully enclosed area which is adequately heated. The temperature shall be at least 10 Celsius.

Plain Bearings

Plain bearing pads shall be moulded individually, cut from moulded strips or slabs of the required thickness, or extruded and cut to length.

Laminated Bearings

Laminated bearings shall be moulded under pressure as a single unit and heated in moulds that have a smooth surface finish.

Steel laminates shall have a uniform 3.2 mm thickness without any sharp edges. 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. For bearings with a sliding surface, an unfilled 3 mm thick PTFE sheet shall be recessed 2.5 mm into and bonded to an exposed stainless steel shim which shall be bonded to the top of the elastomeric pad. The stainless steel sliding surface shall conform to AISI 304, No. 8 finish and shall be welded to the bottom of the sole plate.

Pot Bearings

Stainless steel sheets in contact with PTFE shall be continuously welded around the perimeter to a backing plate to prevent ingress of moisture. The weld shall be clean, uniform, without overlaps, and located outside the area in contact with PTFE.

The threaded portion of the bolts shall be coated with silicone grease prior to installation. 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 prior to applying the adhesive.

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.

Machining

Machining shall be done after welding. Any metal to metal contact surfaces shall be machined.

The pots and pistons shall be machined from solid metal plate or castings. There shall be no openings or discontinuities in the metal surfaces in contact with the elastomer or PTFE.

The surface finish of metal plate in contact with any metal plate or elastomer shall be machined to a surface finish of 6.4 μm and a flatness tolerance of 0.001 x bearing dimension.

Identification

Each bearing shall be marked with the fabricator’s name, date of manufacture and unique identification number. The characters shall be not less than 10 mm in height.

Coating

Metal components described on the site specific drawings, except weathering steel (CSA Standard G40.21, 350A and 350AT) and stainless steel, shall be hot-dip galvanized after fabrication in accordance with ASTM Specification A123/A123M, *Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products* and ASTM Specification F2329, *Standard Specification for Zinc Coating Hot-Dip Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners*.

Pot, piston and sliding plate, except surfaces in contact with elastomer for pot bearings, shall be metalized as per ASTM Specification A780, Method A3. The thickness of metalizing shall not be less than 180 microns.

Repair of galvanizing shall only be done if bare areas are infrequent, small, and suitable for repair. A detailed repair procedure shall be submitted for review in accordance with Schedule 9 – Review Procedure by the Ministry prior to its use. It should be noted that repairs may require complete removal of the galvanized coating and re-galvanizing. Repair shall be in compliance with ASTM Specification A780, Method A3 Metalizing. The thickness of the metalizing shall be 180 µm, and the repair shall be tested for adhesion.

Top surface of bolted galvanized sole plate or metalized slider plate shall be coated with two coats of epoxy mastic paint when in contact with girder bottom flange (weathering steel).

Tolerances

Plain and laminated bearing tolerances shall be as per AASHTO Standard M251-06. Pot bearing tolerances shall be as follows:

- The deviation from flatness of PTFE surfaces shall not exceed:
  - ....0.2 mm, when the diameter or diagonal is equal to or less than 800 mm.
  - ....0.00025 of the diameter or diagonal, when the diameter or diagonal is greater than 800 mm.
- The deviation from flatness of stainless steel in contact with PTFE for plane surfaces and from the theoretical surface for spherical surfaces shall not exceed:
  - ....0.0003 LH mm for a rectangular PTFE element.
  - ....0.0006 RH mm for a circular PTFE element.

  where:
  - ....L = the greater plan dimension for a rectangular bearing,
  - ....R = the radius of a circular bearing, and,
  - ....H = the free height of PTFE element.
- For confined elastomer bearings, the tolerance of fit between the piston and the pot shall be + 0.75 to + 1.25 mm. 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:
  - ....0 to + 0.125 mm for diameters up to and including 500 mm.
  - ....0 to + 0.175 mm for diameters over 500 mm.
- 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:
  - ....Overall bearing plan dimension..... ± 3 mm
  - ....Overall bearing height .....± 3 mm

- ....Machined surface dimensions .....± 0.4 mm

- Elastomeric components shall meet the following tolerances:
  - ....Diameter shall be 0.0 to -1.5 mm for diameters ≤ 500 mm and 0.0 to -2.0 mm for diameters > 500 mm
  - ....Thickness shall be 0.0 to + 1.0 mm
- Brass rings shall meet the following tolerances:
  - ....Difference between internal diameter of brass ring and diameter of recess in the moulded elastomer shall be 0 to + 0.5 mm.
  - ....Difference between sum of thicknesses of brass rings and recess depth in the moulded elastomer 0 to + 0.25 mm.
- Recessed Guide Bars shall meet the requirements of the American Standard Clearance
- Locational Fit Class LC3 according to ANSI B4.1.
- Guides for lateral restraints shall have a 0.50 mm ± 0.25 mm gap between metal restraints surfaces and mating PTFE elements.
- PTFE components shall meet the following requirements:
  - ....The plan dimension of the PTFE shall be 0 to - 0.2% of diameter or diagonal.
  - ....Difference between internal diameter of brass ring and diameter of recess in the moulded elastomer shall be 0 to + 0.5 mm.
  - ....The thickness of the PTFE shall be within 0 to + 10.0% of the design thickness.
  - ....The depth of recess of the PTFE shall be within 0 to + 0.3 mm of the design depth.

300.4.15.4.5 Testing and Inspection

Project Co shall be responsible for quality control and quality assurance testing required to ensure the work meets the Design Data and the Technical Requirements, and shall engage an independent accredited testing company to perform testing of bearing materials and the finished bearings. All quality control/quality assurance testing and inspection records shall be made available to the Ministry on request.

The testing shall meet the acceptance criteria outlined in the standards. Project Co shall also submit a written affidavit from the manufacturer certifying that the materials supplied meet all technical requirements.

Elastomeric Bearings

Testing of elastomeric compounds shall be completed in accordance with AASHTO M251-06. Testing of the finished bearings shall be in accordance with AASHTO M251-06. The optional testing described in section 8.9 of AASHTO M251-06 is not required.

The increment in compressive deformation of laminated bearings shall not exceed 0.05 of the effective rubber thickness, when the bearing load is increased from an initial pressure of 1.5 MPa to a pressure of 7 MPa when tested as per the requirements of Section 9.1 of the AASHTO M251-06.

Pot Bearings

Testing of elastomeric compounds shall be completed in accordance with AASHTO M251-06. Testing of the finished bearings shall be completed in accordance with requirements of 18.3.4 of the AASHTO LRFD Bridge Construction Specifications. The long-term deterioration test described in 18.3.4.4.3 is not required. The proof load test described in 18.3.4.4.4 shall be carried out as per the long-term proof load test requirements.

300.4.15.4.6 Pot Bearings Suppliers

Pot bearing manufacturer's products shall comply with the design parameters in the Design Data and the Technical Requirements.

300.4.15.5 Warranty

Project Co shall obtain from the bearing supplier a written and signed warranty, certifying that all bearings shall remain, as installed, free from any material or performance defect, for a period of five years from the date of acceptance. Project Co shall submit a copy of the warranty to the Ministry.