4.12 Bridge & Major Culvert Materials Quality & Fabrication

Modern permanent structures have design lives that exceed 40 years. To achieve this longevity, ensure that the components are fabricated to detailed standards. Many important details (e.g., rebar placement, concrete design, and welds) can only be inspected during the fabrication process.

Ensure that bridge and major culvert materials and fabrication meet minimum requirements, by requiring materials and fabrication standards be met, including those of Canadian Standards Association (CSA) and the American Society for Testing and Materials (ASTM). This provides a means of ensuring the quality and consistency of materials, and provides equitable parameters for competition for supply, fabrication, and erection. The requirements, as defined in the standards, provide for a suitable blend of cost-effective and durable products. Ensure that the standards for bridge and major culvert materials and fabrication are adhered to. In exceptional circumstances, there may be a reason to vary from the standards, but consult with a Ministry Engineer and Engineering Branch beforehand.

Ensure that all materials used for constructing bridges are new and conform to applicable CSA or ASTM material standards in the Forest Service Bridge Design and Construction Manual. In particular:

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Concrete

Ensure that concrete is designed, mixed, transported, cast, and cured according to CSA Standard A23.1 – Concrete Materials and Methods of Concrete Construction and tested to CSA Standard A23.2 – Methods of Test for Concrete.

Precast concrete bridge elements conform to CSA Standard A23.4 – Concrete Materials and Construction, which means fabrication by a CSA-certified precast concrete plant.

Unless otherwise required by the designer, precast concrete blocks are exempt and may be supplied by non-CSA-certified precast plants provided they meet the following specifications:

- minimum 20 MPa concrete strength unless otherwise specified by a professional engineer;
- single pour (**must** not have any cold joints); and
- a finish free of honeycombing.

For higher risk structures, those that consist of multiple levels of interlocking concrete blocks, or those with significant bearing pressures, ensure that quality requirements of precast concrete blocks are more rigorous and are specified by the engineer taking responsibility for the design.

Structural steel

Structural steel for permanent and portable bridges comply with CSA Standard CAN3-G40.21-M – Structural Quality Steels. Primary tension members of welded structures are of type AT, grade 350 or better.

Weathering steel, type 350 AT, are not to be used for permanent bridges in marine or coastal areas or in areas where there is potential for road de-icing salts to come in contact with the bridge. Alternatively, specify galvanized or painted steel.

Steel fabrication is carried out by firms certified by the Canadian Welding Bureau (CWB) to Div 1 or 2. A list of CWD companies can be found on the Canadian Welding Bureau (CWB) website.

Timber

Timber used for bridge construction is graded in accordance with the standard grading rules of the Canadian Lumber Standards Administrative Board. Timber is grade-stamped, with the exception of unfinished or rough timber (in which case grading certificate may be requested), or local log stringers.

Structural timbers are Douglas-fir/larch #2 grade or better, except timber curbs may be any species #2 grade or better. Note that the structure strength and other characteristics, such as durability, make Douglas-fir/larch a superior product to other species.

Corrugated steel & hardware

Ensure that corrugated steel culverts are manufactured in accordance with CAN/CSA 3-G401 standard, Corrugated Steel Pipe Products. Steel culverts fabricated from steel sheets need to meet all requirements of ASTM A444, “Standard Specifications for Zinc Coated (Galvanized) Iron and Steel Sheets for Culverts and Underdrains.” Ensure that all hardware conforms to applicable standards (that is, rivets are galvanized, and bolts and nuts are Grade C, galvanized, meeting the requirements of ASTM standard A563.

4.12.1 In-Plant Inspection of Bridge Materials & Fabrication

For any FS bridge project (including those bridges built under Road Permit (BCTS) and designated in that permit to be an FS bridge to be used for harvesting after completion of the Timber Sale License), bridge components assembled or manufactured off the construction site (such as treated timber, steel girders, and precast concrete footings, girders, footings or deck panels) must be inspected during fabrication to provide quality assurance that all materials and procedures meet the materials specifications as well as the applicable codes and standards. The costs associated with inspection are more than balanced off in terms of off- setting future problems with the fabricated components. The ministry engages a contractor to provide the in-plant inspection services at the various fabrication plants around the province. The in-plant quality assurance inspection contract is coordinated by the Engineering Branch.

Ensure that the fabricator producing the bridge materials provides copies of detailed shop drawings to the in-plant inspector. The inspector confirms that the strength of materials and details of fabrication are consistent with the shop drawings and applicable specifications, as accepted for the project, standards, and codes. Where discrepancies occur, the inspector notifies the appropriate Ministry Engineer for input on acceptability or required modifications.

For more detailed information regarding material and fabrication requirements, refer to the Forest Service Bridge Design and Construction Manual.

The inspector completes an in-plant inspection report for each bridge and submits it to the Ministry Engineer.

Obtain and keep on file all relevant material documentation, such as mill test certificates, in-plant test results, field test results, and all reports or comments made by field or in-plant inspectors.

4.12.2 Structural Field Welding

Welding is a specialized field and the ministry requires minimum qualifications for companies and personnel involved in bridge construction.

Typically there are two types of structural welding on resource road bridges:

(a) shop fabrication of primary steel load bearing members and structural components, and

(b) field fabrication welding required for erection, assembly, and installation of bridge components (e.g. connection of bearings to pipes and girders, steel braces and diaphragms, and welded shear connectors for precast members).

Both types of structural welds are critical to the long term performance and integrity of the structure. Structural welding on ministry bridge structures is required to conform to Canadian Standards Association (CSA) Standard W59, **Welded Steel Construction (Metal Arc Welding)**. Firms carrying out welding on ministry structures are required to conform to CSA Standard W47.1, **Certification of Companies for Fusion Welding of Steel Structures**.

The Canadian Welding Bureau (CWB) is accredited by the Standards Council of Canada as a Certification Body for the administration of CSA Standards including W47.1, for :

- Certification of companies involved in welding
- Certification of Welding Inspection Companies
- Certification of Welding Inspectors
- Certification of Welding Electrodes

The CWB qualifies welders, welding procedures. The activity of the CWB contributes to the high level of competence enjoyed by industries employing welding and joining and the consistent progress in welding technology, and the reliability of welded products.

All CWB certified companies are required to have certified welders and written welding procedures for each specific type of weld produced (Weld Data Sheets). A list of CWB certified companies is found on the Canadian Welding Bureau website.

The minimum welding certification requirements, for ministry bridge work, is CWB Certification Division 2 for shop fabrication and Div 3 for field welding. A Ministry Engineer or designer may elect to specify a higher certification requirement for complex welding. Note that provincial welding qualification is not adequate as it is different and not equivalent to CWB certification. CWB certification of the firms employing the welders, as well as conformance to CWB procedures and standards, is required for all ministry bridge projects involving structural welding.

4.12.3 Structural Field Grouting

Structural field grout is a critical component to the safe performance and structural integrity of ministry bridges. Where structural field grouting is required, such as for composite concrete decks or shear connections for concrete slabs, mix and place the grout to attain the required bridge design compressive strength, and in accordance with manufacturer’s specifications. The age of the grout should also be checked. Ideally grout should not be more than 6 months since manufacturer and absolutely not older than 12 months.

Manufacturer’s specifications provide for varying amounts of water which will significantly affect the attainment of the design compressive strength within a specified time frame. Do not exceed manufacture's maximum amount of water. It is recommended to have a vessel to measure the water. When mixed properly, is usually somewhat fluid and is difficult to pour. Mixed grout should be packed and can be vibrated into place. Where excessive water is used in mixing grout, the cure time, strength and durability of the grout are compromised. This is a serious problem where the grout is intended to be a structural connection, which is almost always the case for ministry bridge projects. Monitor grout mixing and placement procedures and ensure adherence to manufacturer’s specifications. Utilize minimal amount of water in order to attain the required design strengths.

It is also noted that other factors influence set time such as the ambient temperature over which there is limited ability to control. Additional precautions are required for mixing and placing concrete or grout in cold or hot weather extremes. Placing of concrete products during extreme cold or hot weather has the potential to affect both the long term strength and durability and procedures should be reviewed by a Ministry Engineer.

Low temperatures during the placement and curing of grout can affect the ultimate strength and durability of gout both temporarily and permanently. Grout cures slower in cold temperatures and develops ultimate strengths over longer periods of time. Exposure of fresh concrete to temperatures below freezing may actually stop the curing (hydration) process.

Hot weather can have a negative impact on both plastic and hardened state of concrete. Hot weather affects all of the major components of grout including water, cement and aggregates. Hot weather also has an impact on batching, mixing and placing of grout.

Precautions ***must*** be taken in advance of grouting operations that are anticipated to be effected by cold or hot weather.

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Cold weather grout procedures

In “cold weather” conditions it is important to protect the concrete from freezing and to maintain curing conditions to ensure sufficient strength and durability to satisfy intended service requirements. When temperatures drop or will potentially drop below 5 degrees Celsius, cold weather procedures should be implemented. Cold weather procedures may extend beyond heating the water used to mix the grout and will need to address forecast temperature conditions. Preheating and continued heating for the initial set period for the concrete or grout may be required to ensure that the curing of concrete or grout is not affected by cold temperatures and kept from freezing. If the concrete deck panels or slabs are not pre-heated, they will draw the heat out of the grout and will increase the possibility of the grout freezing in subzero temperatures. If the grout is not preheated, it will dramatically reduce the temperature of the heated water when mixed. The heat of hydration of the grout is not sufficient to keep the grout from freezing in subzero temperatures particularly if the concrete deck panels or slabs are cold. If the grout freezes, it will most likely need to be extracted and redone which is a highly labour intensive and laborious process to be avoided.

Precautions may include some or all of the following:

1. Pre-warm the dry mix grout and components being grouted to above 10 degrees Celsius. The temperature during the initial 24 hours of cure time should be maintained above 10 degrees centigrade. The components’ temperature should be kept above freezing for a minimum of 72 hours subsequent to grout placement. Ensure compliance with the manufacturer’s specifications in order to meet the specified compressive

strength within the required time frame.

Practices that have been typically implemented consist of wrapping the structure in tarps and heating from beneath the structure using suitable heaters. Various types of tarps and covers have been used including: plastic sheeting, construction tarps, lumber wrap and even non-woven geotextile. The basic concept is using the wrapping to contain the heat from a heat source such as a tiger torch or propane heater and to warm the components that are being grouted. The wrapping would cover the deck and drape below the bridge to capture the rising heat. The dry mix grout can be placed on the deck, under the wrap and be heated with the deck or slabs. For steel girder bridges, it may be sufficient to have a heat source between the girders to keep the deck sufficiently warm through the grouting placement and initial setting. Exercise caution to ensure that any heat source be directed away from any bridge components to avoid adversely warping steel components or cause cracking of concrete.

1. Use warm water (20 degrees centigrade) in mixing the grout.
2. Provide sufficient labor to minimize the time required to place and finish the grouting process, to minimize the handling time of the grout and resulting heat loss.

Hot weather grout procedures

Higher temperatures cause water to evaporate from the surface of grout at a much faster rate and cement hydration occurs more quickly, causing the grout to stiffen earlier, lessening workability, increasing the chances of plastic cracking and reducing ultimate strength.

Precautions may include some or all of the following:

1. Moisten precast components, steel reinforcement, and form work prior to grout placement.
2. Keep the grout cool prior to mixing, store in a cool location. Use cold water or ice, as a part of the mixing water. Ice should be crushed, shaved or chipped form and ***must*** be considered as part of the mix design. Mixing should continue until all of the ice is completely melted.
3. Use a grout consistency that allows rapid placement and consolidation within acceptable tolerances to achieve the required design strength.
4. Provide sufficient labor to minimize the time required to place and finish the grouting process, as hot weather conditions substantially shorten the times to initial and final set.
5. Maintain moisture for the curing process by covering with damp burlap, and periodically rewetting, to maintain moisture as the grout sets, as soon as possible after the grout finishing processes have been completed.
6. In extreme conditions consider adjusting the time of concrete placement to take advantage of cooler temperatures, such as early morning or night time placement.

Grout field sampling during field placement

Acquiring samples to allow for compressive testing of field placed structural grout is standard practice for Ministry bridges. The Ministry procedure for grout sampling of in-situ placed structural grout, used for composite precast concrete decks on steel girders and precast concrete slab bridges with grouted shear connections, is in Appendix 4.5. The sampling procedure is to be provided to and followed by the individuals tasked with taking the grout samples in the field for each particular bridge project placing structural grout in the field during construction. The grout sampling procedure may also be implemented for other structural grout applications as may be appropriate.

This Ministry procedure provides instructions on how to take representative samples of the grout that has been placed in the field. The cured grout samples will provide the ability to later test for compressive strength attained at appropriate times to assess the adequacy of the grout. This sampling and testing procedure is not fully consistent with various published Canadian or American standards for grout testing, but rather it is a hybrid of standards to accommodate Ministry ’s particular needs. Various standards (e.g., ASTM, CSA) specify that grout would typically be tested using 50mm cubes. However, the cube molds are costly and would not be readily distributed where required for our needs. The cylindrical molds are applicable to our utilization and their shape allows them to be tested for compressive strength in a laboratory. Local material testing laboratories will have the capability to test the samples and the testing costs range from $20 – $30 per sample.

Taking grout samples

The initial set time for the sampled grout is a critical factor. Allowing the samples to cure in-situ, at minimum, overnight, will provide an approximate representation of the field conditions. These samples are not precise replicas of the grout in the field but should provide a very good indication of quality and strength. Increasing the minimum number of required samples or specifying longer field curing times shall be at the discretion of the Ministry Engineer.

Distributing grout sample molds

Suggested approach for distributing the cylinders – provide an envelope with an adequate number of cylinders, labels and one page instruction sheet included, to the party responsible for obtaining the samples. Would suggest discussing the procedure with the individual, identifying how the sample should be handled and placed subsequent to casting and who the sample should be provided to subsequent to initial set.

Testing grout samples

Testing of the grout samples is a recommended procedure as there should be some objective basis from which to gauge when the grout has attained sufficient strength to place the related structure in-service. The number of samples to be tested is at the discretion of the Ministry Engineer. For example, if the first sample attains or exceeds the required design strength, it may not be necessary to test additional samples.

In the event that tested grout samples are found to be deficient in compressive strength, further investigation would be required. Depending on the nature of the test results, coupled with observations in the field, it may be required that test samples would need to be cored for testing from the actual bridge. Where grout sample test results are deficient, the Ministry Engineer will specify the necessary steps to assess the problem in order to establish the safe use of the structure of concern.

Ministry bridge field grouting sampling procedure

This section provides procedures for making and curing cylinder specimens from representative samples of fresh grout being placed on Ministry of Forests, Lands and Natural Resource Operations bridges in the field.

Samples shall be taken during the field grouting processes for all ministry (including BCTS) bridges incorporating field grouted structural connections. These include:

- precast concrete deck panels on steel or concrete girders, and
- precast concrete slab girders with grouted shear key details.

Requirements:

Sampling of the grout shall occur at various times through the field grouting process, at roughly even intervals as the field grouting process progresses.

The samples shall be taken using the Ministry supplied 50mm diameter X 100mm long plastic cylindrical molds.

A minimum of 3 samples of each type of grout being used shall be taken using these procedures or as directed by the responsible Ministry Engineer.

Where Target Traffic Patch is used, a minimum of 3 samples of each of the coarse and fine grout shall be taken. Typically, coarse grout is used in the shear connections on slab bridges and for stud grout pockets and fine grout is used in deck panel joints for precast deck panel and girder composite action structures.

Grout samples shall be provided to the Ministry Engineer or provided to the individual identified in contract documents or specifications.

Procedure:

1. A sample of representative fully mixed grout that is ready for placing shall be taken.
2. Fill a cylindrical mold approximately halfway with grout.
3. Using a blunt non absorbent rod, approximately 10mm in diameter and 250mm in length (such as a spike head), uniformly over the cross section, rod the grout to the bottom of the mold 15 times.
4. Slightly overfill the mold with the second layer of grout and rod 15 times, evenly distributing over the cross section, and approximately 13mm into the bottom layer.
5. Strike off the top surface of the mold with a flat edge trowel, or other suitable straightedge, to remove excess grout and create a flat top surface.
6. Cover the mold with a damp cloth or paper towel and set the sample aside on site in a safe, flat location where the mold will not be disturbed for a minimum of 12 hours or overnight. The location should be representative of the conditions of the placed grout such as on the deck of the grouted surface or on the inside flange of a steel girder. Longer field curing times shall be at the discretion of the Ministry Engineer.
7. Ensure that a supplied, self adhesive, label is completed and placed on each grout sample.