BC Ministry of Forests

Structural Field Grouting, Sampling and Testing Standard

November 4, 2022

1.0 General

Structural field applied grout is a critical component to the safe performance and structural integrity of ministry bridges. When structural field grouting is required (e.g., composite concrete decks, shear connections for concrete slabs, etc.) mix and place the grout to attain the required bridge design compressive strength in accordance with the manufacturer's specifications.

Grout shall attain a minimum 35 MPa @ 28 days. Grout for block-outs shall be Target Traffic Patch with coarse aggregate or an equivalent alternative product. Grout for deck panel transverse joints shall be Target Traffic Patch with fine aggregate, or an equivalent alternative product. Alternative products must be approved by a ministry engineer.

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. When mixed properly, the grout is usually not fluid and cannot be poured; rather it is packed 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 procedures and ensure adherence to manufacturer's specifications. Utilize a minimal amount of water in order to attain the required design strength.

Other factors also influence set time, such as the ambient temperature, over which there may be limited control. Additional precautions are required for mixing and placing grout in cold or hot weather extremes. Placing grout during extreme cold or hot weather has the potential to affect both the long term strength and durability therefore procedures should be reviewed by a ministry engineer.

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

Hot weather can have a negative impact on both the plastic and hardened state of grout. 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 shall be taken in advance of grouting operations that are anticipated to be affected by cold or hot weather.

2.0 Cold Weather Grout Procedures

Where it is anticipated that the temperature will drop below 5 degrees Celsius during grouting, the contractor shall implement cold weather concreting procedures in accordance with CSA A23.1.

Prior to commencing the grouting operation, the contractor shall provide the ministry with written cold weather concreting procedures.

In cold weather conditions it is important to protect grout 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 grout may be required to ensure that the curing is not affected and the grout is kept from freezing. If the concrete deck panels or slabs are not pre-heated, they will draw heat out of the grout and will increase the possibility of the grout freezing in sub-zero 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 sub-zero temperatures particularly if the concrete deck panels or slabs are cold. If the grout freezes, it will most likely need to be extracted and re-done which is a 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 Celsius. The component 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 to use 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 covers the deck and drapes below the bridge to capture the rising heat. The dry mix grout can be placed on the deck, under the wrap and will 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 is directed away from bridge components to avoid adversely warping steel components or causing cracking of concrete;

2) Use warm water (20 degrees Celsius) in mixing the grout; and

3) Provide sufficient labour, thereby minimizing the time required to place and finish the grout, which results in decreased heat loss.

3.0 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 the ultimate strength.

Precautions may include some or all of the following:

1) Moisten precast components, steel reinforcement, and formwork prior to grout placement;

2) Keep the grout cool prior to mixing, store in a cool location. Use cold water or ice, as part of the mixing water. Ice should be in a crushed, shaved or chipped form and shall 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 labour 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 as soon as possible after the grout finishing processes have been completed, then periodically re-wetting to maintain moisture as the grout sets; and

6) In extreme conditions consider adjusting the time of grout placement to take advantage of cooler temperatures in the early morning or night time.

4.0 Grout Sampling Procedure Introduction

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 provided in this section.

The sampling procedure is to be provided to, and followed by, the individuals tasked with taking grout samples in the field for each particular bridge project. The grout sampling procedure may also be implemented for other structural grout applications as may be appropriate.

This 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 in order 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; rather it is a hybrid of standards to accommodate the ministry's particular needs.

Various standards (e.g., ASTM, CSA) specify that grout should typically be tested using 50 mm cubes. These cube moulds are costly and are not readily available for ministry needs. Alternatively, cylindrical moulds are suitable for ministry utilization and their shape allows them to be tested for compressive strength in a laboratory. Local material testing laboratories have the capability to test these samples at a reasonable cost.

The ministry's procedure is described in the following section.

5.0 Ministry Grout Sampling Procedure

This section provides procedures for making, curing and testing cylinder specimens from representative samples of fresh grout being field-placed at ministry bridge construction sites. Samples shall be taken during the field grouting processes for all ministry (including BCTS)

bridges that incorporate field grouted structural work. Example situations include, but are not limited to:

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

Procedure

1. Sampling of the grout shall occur at various times, at roughly even intervals, as the field grouting process progresses.
2. The samples shall be taken using the ministry supplied 50 mm diameter x 100 mm long plastic cylindrical moulds.
3. A minimum of 6 samples of each type of grout being used shall be taken following these procedures, or as directed by the responsible ministry engineer.
4. Where Target Traffic Patch product is used, a minimum of 6 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 pockets of precast deck panels. Fine grout is typically used in deck panel joints between precast deck panels.
5. Sampling steps:
    a. A sample of representative fully mixed grout that is ready for placing shall be taken;
    b. Fill a cylindrical mould approximately halfway with grout;
    c. Tap the sides of the mold while rotating it to initially consolidate the material into the bottom of the mold.
    d. Using a blunt non-absorbent rod, approximately 6 mm in diameter and 250 mm in length (such as a spike), uniformly, over the cross section, rod the grout to the bottom of the mould 15 times to fully consolidate the material into the mould and eliminate voids;
    e. Slightly overfill the mould with the second layer of grout, tapping the side of the mould while rotating it to consolidate the material into the mould, and rod 15 times, approximately 13 mm into the bottom layer, providing even distribution over the cross section, to fully consolidate the material into the mould and eliminate voids;
    f. Strike-off the top surface of the mould with a flat edge trowel, or other suitable straightedge, to remove excess grout and create a flat top surface;
    g. Cover the mould with a damp cloth or paper towel and set the sample aside on site in a safe, flat location where the mould 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 prior to moving the samples shall be at the discretion of the ministry engineer;
    h. Ensure that a supplied self-adhesive label is filled out and placed on each grout sample; and
    i. Grout samples shall be provided to the ministry engineer or provided to the individual

identified in contract documents or specifications.

6. 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.
7. 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.
8. 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, test samples may need to be cored from the actual bridge for testing. 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.