4.1 Cast-in-Place Concrete - General

Concrete is a combination of a paste, or binder, and mineral aggregate filler. The paste is a mixture of cement, water and air, the water being required both to hydrate the cement and to provide a lubricating effect to make the resulting mix workable. Properly proportioned, handled and cared for while hardening (curing), concrete results in a strong and durable building material.

- The aggregates and mixing water are usually readily available resulting in a relatively economical construction material.
- Plants producing concrete are numerous and generally distributed throughout the populated part of the province.
- At bridge sites outside the range of established concrete plants, temporary batching facilities can be set up to provide concrete.
- Durable concrete requires rigid quality control.

4.2 Environmental Constraints

Be aware of the environmental constraints:

- Do not pump or unload any concrete into the water channel.
- Do not throw debris or forming residue materials into the water channel.
- The concrete truck and pump should be cleaned in a suitable area away from the stream channel.

4.3 Safety

Refer to the Alberta's Occupational Health and Safety Regulation, General Safety Requirements for specific approved safety requirements:

- Part 15 Personal Protective Equipment
- Part 20 Scaffolds and Temporary Work Platforms
- Part 30 Oil and Gas Well Servicing and Drilling
  - Section 392 Emergency means of escape

- Be aware that joints in the line of the concrete pump could burst open during difficult pumping causing a hazardous situation.

- A concrete pump is operating under high pressure and this pressure could vary causing the end of the hose to “whip” thus creating a potentially dangerous situation.

- Concrete pump should be cleaned away from the worksite.

- Be aware of the swing when concrete is being placed with a crane and bucket.

- Be aware of unsecured lumber during formwork inspections.

4.4 Bridge Inspector’s Record

On any bridge project, concrete probably plays a very important part in bridge construction. Many costly contract disputes involve the concrete item as concrete is a costly item to rectify if mistakes are made. Therefore, it is important for a Bridge Inspector to keep an accurate and detailed record in order to minimize any potential extra claims.

- All survey information such as: location measurements, elevations and cambers, etc.

- All quality control test results.

- Location of each tested batch.

- Condition of quality control facilities.

- Dates and core locations if required.

- All aggregate sieve analysis results.

4.5 Property of Concrete

Following are the principal properties of harden concrete:

- It should attain the required strength, be homogeneous, watertight and resistant to weather, wear and other destructive agents to which it may be exposed.

- In freshly mixed concrete all the granular solids including cement are temporarily suspended in water, the individual particles generally being separated by thin layers of water.

- The separation of the particles and the lubricating effect of the water layers, together with certain inter-particle forces among the finest particles, make the mix workable.

- The concrete may or may not contain one or more admixtures, which are used to modify the properties of the fresh or hardened concrete.

4.5.1 Air Content

The minute air voids entrapped in concrete serve to enhance the workability and resistance to freeze and thaw. The quantity of air entrapment in concrete can be controlled by the introduction of an air-entraining agent or admixtures. Consolidated concrete without any air-entraining agent added, usually contain less than 2% of air void by volume. This entrapped air content generally increases if the proportion of cement or other fines in the concrete mix are reduced.

- The entrained air voids in the concrete provides a more workable mixture and imparts added “body” and cohesiveness to the paste.

- Entrained air as produced by an air-entraining agent is essential for a high degree of frost resistance, which is desirable if the concrete is to be exposed to freezing temperatures while wet.

- Excess quantity of air voids is detrimental as it reduces the durability of the concrete.

Air-entrained concrete has the following benefits:

- Increases the workability and cohesiveness.

- Increases the resistance to freezing and thawing.

- Increases the resistance to sulfate attack.

- Decreases segregation and “bleeding”.

4.5.2 Settlement and Bleeding

In undisturbed newly placed concrete, the solids will slowly settle through the body of water, usually leaving a layer of clear water at the surface. This process, resulting in visible water, is known as bleeding, or water gain. As a result of settlement the solids at the bottom become more closely packed, but because settlement is stopped from the setting of the cement paste the upper part of the concrete remains less compact than the lower part.

- Settlement or bleeding is greatly influenced by friction against the forms, temperature, and by the composition and consistency of the mix. Well proportion concrete mixes will reduce settlement and bleeding.

- Settlement will produce microscopic fissures between the paste and the underside of the aggregates and these fissures will reduce the strength of the concrete and increase its permeability.

4.5.3 Composition of the Paste

Since the paste surrounds and separates the individual aggregate particles, the strength of the concrete is due almost entirely to the strength of the paste and the strength of the bond developed between the paste and aggregate.

- All stresses and water borne corrosive agents must act on or pass through the paste. It is desirable that the paste be strong and dense, especially where the concrete has prolonged contact with the corrosive agents.

- The strength and density of the paste depend primarily on the original amount of water filled space surrounding the cement grains and on the extent the cement becomes hydrated.

- The permissible amount of water filled space is specified in terms of the water-cement ratio.

4.5.4 Hardening Process

As the cement paste sets and hardens, the principal reaction product is a gel, formed from water and the dissolved constituents of the cement grains. However, if the paste is kept moist, this process continues until the supply of cement is exhausted or until all the space in the paste becomes filled with hydration products. In commonly used concrete mixes, the supply of cement is the limiting factor.

- If the paste is not kept moist, hydration of the cement may cease when the evaporable water escapes from the paste; hence the importance of moist curing.

- The time required for complete hydration of cement varies with the richness of the mix, the type of cement, the ambient temperature, and the accessibility of an external water supply.

- Under field conditions, the concrete usually becomes partially dry within a few days.

- The hydration of cement may continue for many years, although the strength may be considerably less than its potential if it had been fully hydrated.

- The gain in strength is generally due to an increase in the degree of cement hydration. Premature drying is detrimental to the development of strength.

- Increasing the ambient temperature increases the rate of hydration. However, very high temperatures will lower the ultimate strength of the concrete.

4.5.5 Curing

The period of positive curing specified is intended to assure attainment of the specified strength and to minimize formation of shrinkage cracks due to loss of water. Cement in slabs not in contact with moist earth and in beams and columns may effectively cease hydration soon after termination of controlled curing.

- To assure hydration at the maximum possible rate, the cement paste should be kept saturated. Water must be supplied not only to compensate for evaporation from surface but also to replenish the water removed from the pores by the chemical process.

- Moist curing may be attained from covering the concrete surface with wet burlap or filter fabric after the concrete surface is sufficiently cured. The burlap or filter fabric is kept in a moist condition for the duration of the specified curing period.

- When concreting in cold weather, special curing procedures such as hoarding and heating are necessary.

4.5.6 Durability

The ability of concrete to resist the disintegrating action of freezing and thawing increases if the concrete has a 4 to 6% of air entrainment introduced into the concrete mix by using an air-entraining agent. The entrained air disperses throughout the concrete in the form of minute disconnected bubbles. It provides spaces where forces that would cause disintegration can be dissipated.

- A controlled quantity of air entrainment in concrete will increase the concrete durability.

- Low water-cement ratios increase concrete durability

- Proper vibration will increase concrete durability. An excessive amount of vibration will cause segregation, thus reducing concrete durability.

- An air content in excess of 6% may reduce concrete durability.

4.5.7 Shrinkage and Swelling

When concrete is kept continuously damp, the volume remains relatively constant. However, concrete is usually not kept continuously damp and, hence, it is subject to water loss and shrinkage.

- The average concrete will shrink approximately 0.06% from a saturated to a dry state.
- The more porous the hardened paste, the greater its shrinkage.
- Higher cement content will cause greater shrinkage.
- Higher water content will also cause greater shrinkage.
- Unequal drying will cause shrinkage cracks.
- Unequal drying will cause thin slabs to warp or curl.

4.5.8 Workability

Workability is the ease with which materials can be mixed into concrete and subsequently handled, transported and placed with minimum loss of homogeneity. Good workability is required for proper placement and consolidation of concrete into the forms and around the reinforcing steel.

- A concrete mixture should be sufficiently workable for proper handling and placement, but still as “dry” as possible to obtain maximum strength and durability.
- Fluidity if the concrete mix is an important component of workability and can be measured with the slump test. For a given mix variation in slump is a good indicator of changes to the water/cement ratio.

4.5.9 Creep

When concrete is subjected to a sustained load, the deformation produced by the load may be divided into two parts: elastic deformation, which occurs immediately, and creep, which develops gradually. In most concrete structures, dead loads, which act continuously, constitute a large part of the total load; thus, both immediate strain and gradual yielding contribute to the total final deformation.

- In prestressed beam and girders, the prestressing forces may induce a net upward loading resulting in upward creep deflections.

- Under sustained load, the creep of concrete continues in the direction of loading for an indefinite time but at a steadily diminishing rate.

- Creep increases with increasing water-cement ratio and is approximately proportion to load intensity. Factors that increase the strength of the concrete will reduce the creep.

- Creep is also reduced with increasing age of concrete at the time of loading and it is therefore important to maintain a minimum length of time before stripping and removing shoring regardless of the strength gain of the concrete.

4.6 Inspection of Concrete

Concrete is one of the most important components in a bridge structure. The service life of a bridge depends largely on the concrete quality.

- All the materials necessary to produce concrete are to be supplied by the Contractor.

- The Bridge Inspector must be especially thorough and diligent in fulfilling his responsibilities in inspecting all aspects relating to this phase of the work.

- It is imperative for the Bridge Inspector to ensure that all quality control tests are properly performed by the Contractor in accordance with CSA Standards A23.1-00, Concrete Materials and Methods of Concrete Construction, and A23.2-00, Methods of Test for Concrete.

4.6.1 Formwork

Most plastic concrete will be contained and formed into the desired shape by formwork. Exceptions to this are for some footings where concrete can be cast into neatly trimmed excavations. Formwork may be built from a number of materials including steel, aluminum and fibreglass, however the most common formwork material is plywood sheathing supported by wood studs, walers, joists and stringers.

- The responsibility for the design, construction and performance of the formwork, containing and shaping the concrete, and the falsework supporting the weight of the concrete along with temporary construction loads, lies with the Contractor.

- The contract documents require the Contractor to submit certain formwork and falsework drawings designed and sealed by a Registered Professional Engineer. The formwork and falsework drawings must be reviewed and approved by the Bridge Project Engineer prior to the start of any concreting.

- The Bridge Inspector must check the dimensions of the spaces being formed to ensure that the resulting concrete will be of the required size and shape.

- The formwork must be rigid enough to prevent bulges and be adequately braced with internal form ties being tight.

- All construction debris such as sawdust, bits of wood and wire etc., shall be cleaned out, possibly by blowing with an air compressor through a cleanout hole.

- The condition of the formwork is vital to the appearance of the finished concrete.

- Plywood panels must be properly aligned to eliminate visible joints. The joints between panels must be mortar tight and the form surface should be smooth, free from splinters, gouges and damaged edges. Forms being re-used must be cleaned of all concrete mortar.

- Fillets and chamfers are required at exposed corners and must be neatly done. Blockouts, where required, must be accurately located and neatly built.

- The form surface should have a parting agent (form Oil) applied to facilitate form removal.

- Where formwork is supported by falsework resting on the ground, the Contractor must ensure that the ground is firm enough to carry the anticipated loads.

- Thawing and softening of the ground should not occur until after the falsework has been removed if mudsills for falsework are set on the ground. If pre-heating is required, care must be taken not to thaw the frozen ground.

- The Bridge Inspector must ensure that the Contractor has accommodated any required camber in the forms, and that his screed procedure for the top surface will also reflect this camber.

- In setting cambers, allowance for settlement of the forms must be made. Adjusting mechanisms must be installed in the forming system to allow for adjustments if required.

4.6.2 Reinforcing

Concrete is a material, which is strong in compression but is very weak in tension. Reinforcing steel bars are used to provide the tensile capacity.

- Reinforcing steel must be cleaned of all mud, oil, concrete, mortar and other substances, which tend to reduce or prevent the necessary bond between concrete and steel. Mud and loose concrete can be removed by wire brushing, while oils can be removed using solvents or high-pressure washing.

- When the Contractor applies form oil, he must ensure that no spray gets on the rebar. Compressed air used for cleaning the forms may contain oil, which must not get on the rebar.

4.6.3 Quality Control

Concrete plays a major role in any bridge structure and it is imperative to ensure that a rigid quality control is carried out at the site.

- The responsibility for quality control of the concrete produced for the bridge project lies with the Contractor, as it is the Contractor who “controls” the means of achieving the required quality. The Contractor must perform all necessary quality control tests to assure that the required quality is being achieved.

- The Bridge Inspector must ensure that the Contractor has certified personnel to perform tests for air content, slump and strength requirements and also to monitor that the testing is in conformance with the specified standards.

- The quality control tests are empirical and they rely on strict conformance to procedure to produce results indicative of the actual quality of the concrete being tested.

- During cold weather, the Contractor must provide a thermostatically controlled storage facility on site for concrete test cylinders. During the summer, this storage facility only needs to be shaded and ventilated and possible covered with wet burlap in order to keep the cylinders from overheating.

- All necessary equipment for concrete testing is the Contractor’s responsibility.

- Test cylinder records must be completed in full detail on the appropriate forms.

- The concrete sample must be collected by intercepting the ENTIRE discharge stream to ensure that the sample is representative.

- Concrete cylinders must be properly coded and a sketch is required to show where the sample batch is deposited.

4.6.4 Rejection

If concrete being supplied to the bridge project fails to meet the specified requirements it should be rejected, with a clear explanation of why it is being rejected. The Bridge Inspector must be confident to what aspect of the concrete does not meet the specifications. If a batch appears questionable, the Contractor should stop placing it until slump and air tests are completed to determine whether or not the concrete is acceptable.

- Low slump may be increased by the addition of water, provided the design water/cement ratio is not exceeded, or when approved, a superplasticizer may be added.

- Low air content may be corrected by adding air entrainment at the site.

- If the 7-day strength results indicate the possibility of low strength at 28 days, the Contractor should be notified immediately as he has certain recourse under the Contract.

- Coring is not permitted until approval is obtained from the Bridge Project Engineer. When approved cores must be handled, cured and tested in accordance with CSA Standards A23.2-14C, Obtaining and Testing Drilled Cores for Compressive Strength Testing, by an independent testing laboratory.

4.6.5 Mixing, Handling and Placing

All concrete shall be mixed thoroughly until it is uniform in appearance, with all ingredients uniformly distributed.

- The mixer must not be loaded above its rated capacity, and the mixer must be maintained in good working condition. The inner surface of the mixer must be kept free of harden concrete and mortar and all bent or worn down fins must be replaced.

- The mixer must not be operated at a speed above that recommended by the manufacturer.

- Diluted air entraining agents or admixtures should be introduced into the mixer after the initial water is in the mixer drum.

4.6.6 Placing

The Bridge Inspector should discuss with the Contractor, the proposed methods of handling, placing and consolidating the concrete. The Bridge Inspector shall check that the forms are rigid, clean, the reinforcing steel is adequately tied into its proper locations, and inserts are properly located.

- The concrete may be placed by discharging directly from the truck into the forms, conveyors or chutes, crane and bucket or by pumping.

- The concrete must not be allowed to segregate, or cause displacement of the reinforcement.

- If concrete is to be dropped more than 1 m it should be deposited through approved elephant trunks or by a concrete pump. The end of the discharge pipe should buried in the newly placed concrete.

- The method of placing must not be allowed to impart vibrations to any concrete, which has set but is less than 48 hours old.

- Concrete should be placed in such a way so that an entire element is completed, or in large elements, placing will occur from one pre-planned construction joint to another.

- These construction joints must be located only where shown on the plans, or in the pouring schedule, unless approved otherwise by the Bridge Project Engineer.

- If the concrete placing must be stopped, the unfinished face of the concrete is to be prepared or treated according to the standard construction joint drawings.

- Once placed in the forms, the concrete must be thoroughly compacted, usually by internal vibrators. Concrete vibrators must be held VERTICAL while vibrating concrete.

- All laitance, mud, oil and sawdust etc. must be thoroughly removed and the hardened substrate concrete must be THOROUGHLY WET prior to casting the new concrete.

4.6.7 Finishing Plastic Concrete

Finishing the unformed surfaces of concrete elements vary from simple to major. Leveling a narrow exposed width of concrete at the top of a wall is simple. Achieving smooth, dense, durable and uniform surface of a finished slab or deck, which will be driven on for many years, is major and critical effort expended.

- Finishing effort should be **the minimum required** to achieve the specified surface since overworking tends to draw fines to the surface and can result in later scaling or dusting of the surface.

- Finishing should begin immediately after placing and before any bleed water appears on the surface.

- Concrete finishing is accomplished by screeding the surface of the concrete to the required elevation.

- Screeding often produces open voids on the surface. These voids must be closed with a hand float or with a “bull float” constructed from wood or magnesium.

- Finishing with a steel trowel is generally not permitted since it results in a closed shiny surface, which can prevent the escape of bleed water.

- Overworking the concrete during finishing operations leads to produces water and fines at the surface and often results in hairline cracking of the surface.

- Cracking can also be caused by untimely finishing and by excessive drying or cooling.

- No concrete finishing operation shall be performed while there is excess moisture or bleed water on the surface.

4.6.8 Shrinkage Cracks

Plastic shrinkage cracking sometimes occurs in slabs and decks, especially on warm dry windy days. This is cracking of the surface of the concrete after placing and while it is still in a plastic condition.

- The cracks are usually discontinuous, roughly parallel to each other, up to 3 mm wide and 50 to 100 mm deep.

- At initial stages of finishing, the concrete may be reworked to close the cracks, but prevention is a better solution.

- A rapid drop in the temperature of the concrete surface may result in thermal cracking.

- The complete surface must be protected against cold air and curing water should not be substantially colder than the concrete surface.

- The following precautions by the Contractor help to minimize plastic shrinkage:

- Dampening the subgrade and formwork.

- Supplying concrete within the allowable slump range.

- Erecting windbreaks and/or sunshades to reduce evaporation rates. Alternatively, do the work during evening or night.

- Reducing time between placing and start of curing by improved placing and finishing procedures.

- If a delay between placing and finishing is unavoidable, placing white polyethylene sheets over the unfinished concrete to help keep it cool and moist.

- Lowering the temperature of the concrete mix using cold water or ice.

- Utilize a fog mist upwind of the concrete to humidify the air passing over the finished concrete. Do not allow this procedure to cause free water on the surface while still finishing.

4.6.9 Curing and Removal of Forms

Inspection does not end with the actual casting of concrete.

- Concrete should be protected from damage.

- Observation of the finished parts of the work should be continued throughout the construction period.

Curing concrete means keeping it moist and, if necessary warm so that hydration of the cement can continue.

- Proper curing significantly improves the surface condition and the quality of concrete.

- The more moisture retained within the concrete, the more the curing effectiveness.

- Decks, curbs and approach slabs must be moist cured for a minimum of 72 hours (Class SF concrete must be moist cured for a minimum of 7 days).

- Other exposed concrete surfaces may be cured with 2 coats of a curing compound. Where premature drying is expected or experienced, moist curing is to be used on these elements as well.

- A sealing or curing compound will retard evaporation of the mixing water.

- The surface to be sealed should still be moist when the coating is applied.

- If bleeding occurs under the film, it may split open in many directions and require resealing as soon as the excess water disappears.

- The preferred method of curing is by use of continuous sprays, ponded water, or continuously saturated coverings of burlap or filter fabric.
- Water should be applied on unformed surfaces soon after concrete is placed but only when the water will not wash out the cement or damage the finish.
- Wood forms, kept wet, will provide some protection against the loss of moisture.

4.6.9.1 Removal of Forms

Concrete supports should be allowed to remain undisturbed until the concrete can safely bear its own weight plus any construction live loads. Supports and forms should only be removed in conformance with the specifications.

- At normal temperatures, vertical forms can be removed 24 hours after concrete is cast.
- Forms directly supporting the weight of the concrete must be left in place for a longer period, depending on such factors as the type and size of the member, the hardening characteristics of the concrete, the mix, the temperature and the expected loads.
- Supports should be removed in such a manner as to permit the concrete to take its share of the load gradually and uniformly.
- Early removal of forms is desirable for finishing in that surface repairs and treatments bond better to the "green" concrete, and is usually desirable from the standpoint of curing.
- In warm dry weather, it is preferable to remove formwork and establish the specified curing procedure at the earliest possible time after concrete is placed.
- While forms remain in place, exposed portions of the concrete should be kept wet.
- Concrete test results from field-cured specimens will provide an indication as to when forms may be removed.
- Horizontal spanning elements such as beams and slabs should remain supported for as long as practicable in order to increase the maturity of the concrete at the time of loading. Increased maturity has one of the larger effects in reducing creep deflections.
- In cold weather, forms should not be removed while the concrete is still warm, since rapid cooling of the surface may cause checking and thermal cracks.

4.6.9.2 Finishing Harden Concrete

The type of finish required for harden concrete depends upon the exposure of the surface in the completed structure and will be clearly detailed on the drawings and in the specifications. Finishing includes removal of projections, minor surface repairs, and treatment to both improve tightness of the surface and to result in a uniform pleasing appearance.

- All fins and irregular projections are to be removed by chipping or grinding. Serious honeycomb areas should be inspected with the Bridge Project Engineer to determine whether the structural capacity has been impaired. Minor honeycomb areas may be chipped down to sound concrete and patched.

- Finishing should be done at an early stage of concrete maturity to assure bonding of applied materials to the concrete. The concrete surface must be thoroughly wetted before and after treatment to ensure sufficient moisture for complete curing.

4.7 Special Considerations

The foregoing dealt with situations, which will likely be encountered on every bridge project. The following are situations, which may arise only occasionally but are situations sufficiently common that the Bridge Inspector should be prepared for them.

4.7.1 Depositing Concrete under Water (Tremie)

Depositing concrete under water, called tremie concrete, is sometimes beneficial during construction of footings in rivers where it has not been possible to de-water the footing excavations. Approval by the Bridge Project Engineer must be obtained and the proposed procedures should be thoroughly discussed with the Contractor. Tremie concrete requires a special concrete mix design.

- Tremie concrete is deposited through a tube into a compact mass at the bottom of the footing. The upper end of the tremie terminates in a hopper into which the concrete is discharged. The lower end is equipped with a closing device or seal such as a ball bladder that will prevent the entry of water at the start of this work.

- Tremie concrete may be placed using a concrete pump, but special precautions should be taken to ensure that the discharge end is constantly embedded in the freshly placed concrete.

- **It is essential** to keep the lower end of the tremie discharge below the surface of the freshly placed concrete to ensure that a seal is maintained.

- Concrete is not vibrated while under water.

- The top surface of tremie concrete is rough with laitance, and must be thoroughly cleaned and chipped down to sound concrete.

4.7.2 Cold Weather Concrete

Construction of bridges during winter months is common. Special precautions are required when concreting in cold weather to prevent damage to the “green” concrete.

- Heating methods must be discussed with the Bridge Project Engineer and the Contractor.

- Both aggregate and water may require to be heated to produce sufficiently warm concrete.

- Heated aggregate will affect air content and slump, and requires diligent quality control.

- Heating will be required to warm forms and reinforcing steel before concrete placing begin.

- The forms and reinforcing steel must be carefully inspected to ensure that they are free of snow and ice.

- If concrete is being placed on grade, the grade must be completely thawed.

- Insulated forms are acceptable for massive (thick) sections but unacceptable for thin sections.

- Hoarding must be constructed to enable warm air circulation completely around the element.

- Heaters must not be allowed to impinge directly on any concrete, and intense local heating is prohibited.

- Moist cure is important whenever concrete is subjected to artificial heat.

- Concrete which has been cured using artificial heat should be brought to ambient temperatures at a rate not exceeding 5^{o}C per day for concrete up to 300 mm thick, and 4^{o}C per day for thicker concrete.

4.7.3 Hot Weather Concrete

Problems encountered during hot weather may include premature setting, rapid drying and insufficient moisture for curing.

- The temperature of the concrete mix should be kept at the low end of the allowable range using cold mixing water or ice.
- Placing procedures should be “streamlined” so that finishing can be accomplished quickly and efficiently.
- Concrete pours should not be allowed to commence on a hot and windy day.
- Moist curing should be started as soon as the concrete surface hardens.

4.7.4 Shear Keys on Precast Concrete Girders

Shear keys on precast beams and girders are very small in section, requiring small volume of concrete. Shear keys are an important integral part of the bridge deck and must be cast and cured with as much care and attention as deck concrete.

- The keyways should be thoroughly cleaned and wetted before concreting.
- A bonding agent should be applied immediately in advance of fresh concrete, and the fresh concrete should be carefully placed and consolidated.
- All keyways shall be moist cured.
- Concrete for shear keys should be batched in smaller loads.
- Sufficient concrete finishers must be available to ensure that proper concrete finishing keeps up with the concrete placement.

4.7.5 Protection of “Weathering” Steel Girders

Steel girders for Department bridges are almost exclusively fabricated of weathering steel. Weathering steel is low alloy steel whose corrosion rate on exposure to the atmosphere is considerably less than ordinary steel. As the steel weathers, it forms rust, which is initially lightly colored, fine grained and loose. As further oxidation occurs, a tightly-adhering stable oxide film or patina forms which is rough, dark brown in color and adheres tightly to the surface preventing further oxidation. It is essential that the uniformity of rust formation is not adversely affected by the Contractor’s work.

The Contractor must take whatever precautions are necessary to prevent mortar and concrete residue from being spilled or spattered on the weathering steel, which will slow the weathering process, resulting in a blotchy appearance.

If the face of the exterior girder is stained or marked by the Contractor, the entire exterior face of the girder is to be lightly sandblasted and “weathered” to achieve uniformity of color. “Weathering” is achieved by repeatedly fogging the exterior faces with clean water and allowing them to dry. Fogging should leave the girders wet, but not “running wet”, and should be repeated only when the girders are completely dry.

The Bridge Inspector should discuss with the Bridge Project Engineer, the necessary to require the Contractor to carry out weathering procedures.

In the event that weathering is determined necessary, the Bridge Inspector must ensure the following:

- After sandblasting all dust and grit be completely removed.

- Precautions taken to see that the grit does not settle into moving parts of bearings or expansion assemblies.

4.7.6 Protection of Substructure

For a completed bridge structure, the typically prevents precipitation from washing the steel girder surfaces. However during the period from girder erection to casting of the concrete deck, the substructure elements will be subject to staining.

The Contractor is responsible to implement measures to coat or cover the piers and abutments before erection of steel girders.

If staining occurs, the Bridge Inspector should ensure that:

- The Contractor removes all staining on the concrete prior to any concrete finishing.

- The cleaned surface is acceptable and that no stains remain.

4.8 Checklist

4.8.1 Bridge Inspector’s Responsibilities

- Understanding of the Specification and drawings requirements.

- Check aggregate gradations and mix designs that are approved by the Bridge Project Engineer.

- Inspect batching plant and mixer trucks and provisions for quality control.

- Check forms for:
  - Location and alignment
  - Provision for settlement
  - Stability
  - Tightness of ties and form joints
  - Surface preparation and form oil
  - Fillets, chamfers and blockouts
  - Cleanout holes and cleanliness
  - Cambers, etc.

- Check reinforcing per Section 5 of the Specifications for Bridge Construction.

- Check anchor bolts and inserts.

- Check cleaning and wetting of concrete contact surfaces.

- Check placing to ensure no segregation occurs.

- Check that vibration of concrete is thorough and uniform.

- Check location and preparation of construction joints.

- Ensure Contractor perform tests for air content, slump, and strength and clearly marks test cylinders in accordance with the coding system.

- Record location of each test batch.

- Ensure test cylinder storage box is adequate and in proper working order.

- Check finishing to ensure concrete surface is not overworked.

- Check curing to ensure that expose surfaces are continuously moist.

- Ensure concrete is protected from any possible damage.

- Check formwork removal meets criteria as stated in specifications.

- Check finishing of formed surfaces for:
  - Removal of fins
  - Repair of defects
  - No surface drying
  - Surface finish requirements

- Check depositing concrete under water for:
  - Approval by the Bridge Project Engineer
  - Lower end of tremie pipe or pump hose to be kept below fresh concrete surface.

- Check cold weather concreting for:
  - Forms and rebar free of ice and snow
  - Concrete placed on thawed grade
  - Heated mixing water and aggregate
  - Record temperature of each batch placed
  - Heating and hoarding
  - Protection from drying
  - Protection from too rapid cooling

- Check hot weather concreting for:
  - Concrete temperature (record temperature of each batch placed)
  - Protection from drying
  - Moist curing

- Check shear keys on precast concrete girders for:
  - Keyways cleaned and wetted
  - Bonding agent applied
  - Placing and consolidating concrete
  - Surface properly finished
  - Moist curing

- Record girder cambers

- Calculate quantities for payment.

- Calculate low strength quantities and penalties if required as discussed with the Bridge Project Engineer.

- Check that mortar and concrete residue are cleaned off steel surfaces.

- Ensure that the Contractor’s protection of the substructure from rust is adequate and effective.

- Check that sandblasting if required results in a uniform surface.

- Check that grit and dust from sandblasting is cleaned up and moving parts of bearings and expansion assemblies are free from grit.

- Check wetting of steel surface – it must be uniformly wet over the full surface.

- Decide when sufficient wetting cycles have been done. Check with the Bridge Project Engineer.

- Accept completed work and calculate quantities for payment.

4.8.2 Bridge Project Engineer’s Responsibilities

The following items must be discussed with the Contractor and the Bridge Inspector:

- The pour procedure and schedule.

- Anticipated problems and possible solutions.

- The formwork design.

- The concrete mix design.

- The quality control procedure and the facilities provided by Contractor.

- Reduced payment for substandard concrete where applicable.

- Final pay quantities

SECTION 4

CAST-IN-PLACE CONCRETE


4-1 Abutment form


4-2 Wood form between backwall and grade beam


4-3 Pier footing formwork


4-4 Pier shaft formwork


4-5 Pier footing (EFCO) form insulated with Styrofoam


4-6 Lower pier shaft (EFCO) formwork

SECTION 4

CAST-IN-PLACE CONCRETE

4-7 Upper pier shaft (EFCO) forms

4-8 Deck formwork

4-9 Deck form soffit knee braces c/w softeners at contact points between the knee brace and the steel girder

4-10 Load testing form taking into account the effect of form deflection under the actual construction loads

4-11 Deck soffit forms

4-12 Deck curb form with bridgerail post anchor bolt assemblies installed

SECTION 4

CAST-IN-PLACE CONCRETE

4-13 Placing abutment seat concrete with crane and hopper

4-14 Cold weather concreting at abutment

4-15 Placing pier footing concrete

4-16 Placing pier shaft concrete in cold weather conditions

4-17 Placing and curing deck concrete under adverse weather conditions

4-18 Placing and finishing curb concrete in alternate 3m long sections

SECTION 4

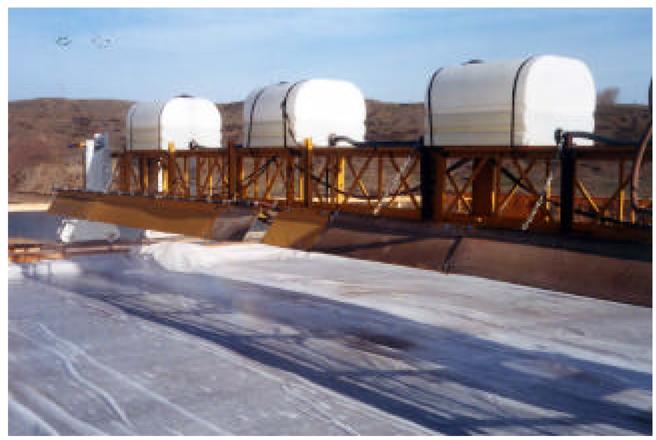
CAST-IN-PLACE CONCRETE

4-19 Sealer being applied to pier shaft after surface preparation

4-20 Deck pour at dusk when cooler temperature and no wind

4-21 Work bridges immediately behind screed machine for bull floating and application of curing compound

4-22 Wet curing for deck concrete for a minimum period of 7 days



4-23 Fog misting setup - 3-100 gallon water tanks mounted to Truss Work Bridge

4-24 Fog misting being done over finished concrete prior to applying filter fabric curing material

CAST-IN-PLACE CONCRETE

4-25 Grinding fins and irregular projections on curb face

4-26 Curb face saturated with water for a period of not less than 30 minutes prior to rubbing with cement mortar

4-27 Using a carborundum stone to produce smooth and closed surface

4-28 Applying sealer after curb concrete has been properly cured for at least 14 days

4-29 Masking tape used at bottom of reglet to debond caulking.

4-30 Curb construction joint being caulked