706.00 CONCRETE CONSTRUCTION (*SSHC Section 704)*

706.01 DESCRIPTION

A. This section of the Specifications deals with the construction of structures composed of portland cement concrete. This work includes constructing, setting and supporting the forms, and handling, placing, finishing and curing the concrete for bridges, box culverts, arch culverts, headwalls, retaining walls and steps, and the miscellaneous structures listed in the incidental construction portion of the Specifications.

706.02 MATERIAL REQUIREMENTS

A. Composition of Concrete

1. The class of concrete to be used in the work is specified in the plans or special provisions and shall be one of those described in *SSHC Subsection 1002.02*. In the event that the contractor has a choice of several classes, he/she is required to advise the Project Manager by letter of the one to be used. This information should be obtained prior to any concrete construction to allow engineering personnel to make provisions for necessary inspection and testing. The contractor may not change classes of concrete during construction without the written permission of the Project Manager.

2. *SSHC Subsection 1002.03* prescribes requirements for concrete materials. The Contractor's responsibility for material requirements may be summarized as follows:

   a. Check with Materials & Research as to the approval of cement, coarse aggregate, fine aggregate, air-entraining agent and curing compound.

   b. Submit samples of non-approved materials to the Central Testing Laboratory in sufficient time before use to allow time to receive results. The size and frequency of samples are provided in the "*Materials Sampling Guide*".

   c. Materials for which approval has not been received must not be used in the work.

3. The inspector is concerned not only with the approval of materials but also with the storage of materials. Bag cement shall be stored in a dry location. If stacked more than 8 bags high for a period of time the lower layers take on a "warehouse set" and should not be used. Cement stored over 90 days must be retested before use.

B. Admixtures

1. Admixtures are those ingredients in concrete other than portland cement, water, and aggregates, that are added to the mixture immediately before or during mixing. Admixtures typically encountered on our jobs can be classified by function as follows:

   a. Air entraining admixtures (optional)

   b. Water reducing admixtures (optional)

c. Set retarding admixtures (required)

d. Set accelerating admixtures (optional)

e. Finely divided and permeability mineral admixtures (Fly Ash & Silica Fume) (optional)

f. Coloring agents (normally not used for NDR work) (optional)

2. The amount of any admixture used in a mix should be as recommended by the manufacturer. Effectiveness of an admixture depends upon such factors as type, brand, and amount of cement; water content; aggregate shape; gradation and proportions; mixing time; slump; and temperatures of concrete and air.

3. Concrete with a low air content shall not be incorporated into work. One addition of air entraining admixture is allowed at the site according to specification.

4. Concrete with a high air content should not be incorporated into work except under extreme circumstances. If low compressive strengths result, the concrete may be required to be removed and replaced. (*SSHC Subsection 106.05*)

C. Air Entraining Admixtures

1. Air entraining admixtures are used to purposely entrain microscopic air bubbles in concrete. Air entrainment will dramatically improve the durability of concrete exposed to moisture during cycles of freezing and thawing. Entrained air greatly improves concrete's resistance to surface scaling caused by chemical deicers.

2. Rules-of-Thumb

a. As cement content increases, air agent must increase to maintain equal entrained air.

b. As cement fineness increases, the amount of air agent must increase to maintain equal entrained air.

c. As coarse aggregate size decreases, the air content increases for a given amount of air agent.

d. As fine aggregate volume increases, the air content increases for a given amount of air agent.

e. As mixing water increases, the air content increases for a given amount of air agent.

f. Air entraining admixtures should be introduced into mix at the plant, but additional may be added at the site to adjust mix for correct air content.

g. Air entraining admixtures should (usually) be added to the front of the truck at the plant. If corrosion inhibiting admixture is used, air entraining agents should be added to the back of the truck.

D. Water Reducing Admixtures (Type A) (optional)

1. Water reducing admixtures are used to reduce the quantity of mixing water required to produce concrete of a certain slump or reduce the water/cement ratio. Regular water reducers reduce water content by about 5% to 10%.

2. Adding a water reducing admixture to a mix without reducing water content can produce a mixture with a much higher slump.

a. Rules-of-Thumb

(1) Typically, water reducing admixtures do not reduce the rate of slump loss; in most cases, it is increased. Rapid slump loss results in reduced workability and less time to place concrete at the higher slump.

(2) Typically, water reducing admixtures decrease on bleed water because less water is available.

(3) Certain types of sulfate starved portland cements may cause false set with certain brands of water reducers. Typically, water reducers contain lignosulfonates and these sulfates are easily attracted by sulfate starved cements. This action may cause early false set.

(4) Despite reduction in water content, water reducing admixtures can cause a significant increase in drying shrinkage.

E. High Range Water Reducing Admixtures (Type F) (optional)

1. They are added to concrete with low-to-normal slump and water content to make high slump "flowable" concrete. Flowable concrete is a highly fluid, but workable concrete that can be placed with little or no vibration and can still be free of excessive bleeding or segregation. Flowable concrete has applications:

a. In areas of closely spaced and congested reinforcing steel.

b. In tremied concrete where "self consolidation" is desirable.

c. In pumped concrete to reduce pump pressure.

d. To produce low water/cement ratio - high strength concrete. High-range "super plasticizers" can reduce water content by about 12% to 30%.

2. Rules-of-Thumb

a. The effect of most super plasticizers in increasing workability or flowable concrete is short lived. Typically, maximum is 30 to 60 minutes followed by a very rapid loss in workability.

b. Typically, super plasticizers are added as split treatments (part at the plant part at the site). Sometimes the addition is totally at the site.

c. Setting time may be affected depending on the brand used, dosage rate, and interaction with other admixtures.

d. Excessively high slumps of 10 inches (250 mm) or more may cause segregation.

e. High-slump, low water/cement super plasticized concrete has less dry-shrinkage than does high-slump high water/cement conventional concrete.

f. Effectiveness of super plasticizer is increased with an increased amount of cement and/or increased fineness of cement.

g. Effectiveness of water reducers on concrete is a function of their chemical composition, cement composition and fineness, cement content concrete temperature, and other admixtures being used.

h. Some water reducing admixtures, such as lignosulfonates, may also entrain some air in the mix.

F. Retarding Admixtures (required)

1. Retarding admixtures (retarders) are used to delay the initial set of concrete. High temperatures of fresh concrete 85°F (30°C) and up often cause an increased rate of hardening. Since retarders do not decrease the initial temperature of concrete, other methods of counteracting the effect of temperature must be used.

2. Rules-of-Thumb

a. Retarders are sometimes used to delay initial set of concrete when difficult, long placement times, or unusual placement conditions exist.

b. Retarders offset the set acceleration effect of hot weather.

c. Retarders can be added at the site.

d. In general, some reduction in strength at early ages (one to two days) accompanies the use of retarders.

e. Use of retarders must be closely monitored, because there is probably no single admixture which has caused more field problems.

f. If too much retarder has been used in a mix:

(1) Time will usually counter the effects.

(2) Be sure to maintain the cure during the added time.

G. Accelerating Admixtures (optional)

1. Accelerating admixtures (accelerators) are used to accelerate the setting time and strength development of concrete at an early age. Strength development can also be accelerated by using:

   a. Type III "high-early" cement

   b. Lowering water/cement ratio

   c. Curing at controlled higher temperatures

2. Calcium Chloride ($CaCl_2$) is the material most commonly used in accelerating admixtures. Besides accelerating strength gain, calcium chloride also causes an increase in drying shrinkage, potential reinforcement corrosion, discoloration, and potential scaling.

   a. Rules-of-Thumb

      (1) Always add calcium chloride in solution form as part of the mixing water.

      (2) Calcium chloride is not an antifreeze agent. When used in allowable amounts, it will only reduce the freezing point of concrete by a few degrees (may cause deck cracks).

H. Finely Divided Mineral Admixtures

1. These admixtures are powdered or pulverized materials added to concrete to improve or change the properties (plastic or hardened) of concrete. Based on the mineral's chemical or physical properties, they are classified as: (1) Cementitious, (2) Pozzolans, (3) Pozzolanic and Cementitious, and (4) Nominally inert. Typical PCC mix designs use pozzolanic and cementitious minerals.

2. Pozzolanic Materials

   a. A pozzolan is a siliceous or aluminosiliceous material that in itself possesses little or no cementitious value but will, in finely divided form and in the presence of water, chemically react with the calcium hydroxide released by the hydration of portland cement to form compounds possessing cementitious properties. Pozzolans include fly ash and silica fume.

3. Fly Ash (Class C & F)

   a. Fly ash is a finely divided residue that results from the combustion of pulverized coal in electric power plants.

4. Silica Fume

   a. Silica fume, also referred to as micro-silica or condensed silica fume, is another material that is used as a pozzolanic admixture. This light to dark gray powdery product is a result of the reduction of high-purity quartz with coal in an electric arc furnace.

b. Fly ash and silica fume have a spherical shape. Silica fume has an extremely small particle size (about 100 times smaller than the average cement particle). Although silica fume is normally in powder form, because of its small size and increased ease of handling the product is commonly available in liquid form.

c. Rules-of-Thumb

(1) Mixes containing fly ash will generally require less water (about 1% to 10%) for a given slump. Silica fume concrete requires more water for a given slump.

(2) The amount of air-entraining admixture required to obtain a specified air content is normally greater when fly ash or silica fume is used. The amount of air-entraining admixture for a certain air content is a function of the fineness, carbon content and alkali content.

(3) Fly ash will generally improve the workability of concretes of equal slump. However, fly ash in low slump concrete will tend to tear and have reduced workability. Silica fume tends to reduce workability, thus high-range water reducers are usually added to maintain workability.

(4) Concrete using fly ash or silica fume generally shows less segregation and bleeding than plain concrete.

(5) Use of fly ash will reduce the amount of heat buildup in concrete. Silica fume most likely will not reduce the heat of hydration, because typically high-range water reducers are used and they increase mass temperatures.

(6) Use of fly ash will tend to generally retard the setting time of concrete. Silica fume alone will accelerate the setting time, however, high-range water reducers tend to offset this.

(7) Use of fly ash generally aids the pumpability of concrete. With adequate and correct curing, fly ash generally reduces the permeability. Silica fume is especially effective in this regard.

(8) With adequate and correct curing, fly ash generally reduces for permeability. Silica fume is especially effective in this regard.

I. Concrete Temperatures

1. Recommended Concrete Temperatures

a. Concrete should be between 45°F and 80°F (7°C and 27°C) when placed. To ensure a concrete temperature of at least 50°F (10°C) for 72 hours after placement the concrete for thin sections such as culvert walls, end posts, piling encasements, etc. should be 65°F (18°C) or higher, since the only additional heat source is the heat of hydration. Concrete for massive sections such as abutments, heavy piers, and footings should be in the 55° to 65°F (13° to 18°C) range.

b. Since only dry insulation is effective, any insulation that has a propensity to absorb water or become saturated must be protected with a waterproof membrane. The insulation system must provide complete coverage and be secured to provide maximum protection during the full curing period.

c. For typical protection applications, insulated forms must be left undisturbed for 96 hours before being removed.

2. Checking Temperature of Concrete

a. For checking compliance with minimum temperature requirements during the 48-hour period after placement thermometer wells should be cast in the concrete during the pour. The following procedure for checking temperature is suggested:

(1) Drill a 5/16 inch (8 mm) hole through the form at one or more locations where temperature checks will be made.

(2) Grease the thermometer probe and insert it through the hole about 4 inches (100 mm) into the plastic concrete.

(3) Remove probe after the concrete is set and cover hole with insulating material.

(4) Further checks can be made by inserting the thermometer through the insulation into the well developed in step 2. Leave thermometer in place if desired, but protect from damage or theft.

NOTE: The thermometer stem should be inserted about 3 inches (75 mm) into the concrete because the sensitive portion of the stem is about 1¾ inch (44 mm) below the groove.

b. Record the temperature daily for 5 days following the pour. Temperature readings below 50ºF (10°C) during the first 48 hours should be entered in the Field Book and reported to the District Construction Engineer for evaluation of possible damage or price adjustment.

c. A thermocouple - - with recorder can also be used to document temperatures during curing.

3. Deck Concrete Temperature and Curing

   a. Subsection 706.03 identifies requirements for placing and curing concrete bridge floors. Of importance for this section are:

      (1) Plastic concrete, when placed, shall not exceed 86°F (30°C).

      (2) The curing method requires "wet" burlap cure for four (4) days.

      (3) If the forecast high outside air temperature for the day is predicted to be above 80°F (26°C) the contractor should cast the deck starting at 5:00pm.

   b. The placing of concrete will require close monitoring to comply with the specifications. Obtain a weather report to determine predicted air temperature, wind velocity, and relative humidity for the pour day.

   c. The above information should be discussed by the inspector, contractor, and ready mix plant operator before a deck pour. The pour should not be attempted if concrete temperature is predicted at 86°F (30°C) or higher and predicted air temperature is above 86°F (30°C).

4. Temperature Field Documentation

   a. The temperature of concrete should be taken as soon as concrete is placed. It should be taken when the first load is placed. Additional checking is warranted if the temperature is running at or near maximum. Air temperature should also be taken about the same time as the concrete temperature.

5. Maximum Air Temperature--No continuous placement is to be attempted when temperature forecast is above 86°F (30°C).

   a. Working time of concrete varies with the temperature of concrete, and concrete temperature varies with the temperature of different materials used in the mix. In order to determine the dosage rate of retarder, an estimate of the mix temperature must be made. The following are suggested estimating methods:

      (1) The temperature of concrete from previous placements could be taken.

      (2) If a ready mix producer is placing concrete the day before a deck placement, this concrete could be checked for concrete temperature.

   b. Regardless of the method used, make the best estimate of what the concrete temperature will be during the warmest part of the day. Remember, concrete shall not be placed in new decks if the concrete temperature is above 85°F (30°C).

706.03 CONSTRUCTION METHODS

A. Prepour Meeting

1. It is very important to use the prepour meeting to discuss the specifics of placement, establish communication, and resolve potential "sticky" issues prior to placement. Generally it is recommended to discuss:

   a. Chain-of-command. Who is in charge for the contractor? Who needs to be notified if material tests do not comply with specifications? Establish prior to placement how test results are reported (i.e., does the Contractor want to be notified verbally, or in writing each time?).

   b. More cement paste will cause more cracks and less paste means fewer cracks.

   c. Material requirements and admixtures needed for the placement (Examples: Single cement source, concrete temperature and methods used to cool the mix, source and amount of any admixtures, specific mixes required for bridge decks, etc.)

   d. Vibration can make a stiff mix workable with better results than adding water.

   e. Procedures for introducing admixtures during mixing operations need to be discussed and formalized. For example: How and where will the air entraining agent be introduced? There is a growing concern that placement location of admixtures is causing significant variability in mixes. The plant monitor must watch and document how admixtures are introduced during mixing.

   f. Method and frequency of acceptance testing during any placement. Inform the Contractor what is expected if non-acceptable material is found during placement.

   g. Scheduling, truck availability, placement method, and required placement rates.

   h. Establish an acceptable source of preplacement weather forecasting. Agree on weather parameters which will be used for "go" or "no-go" decisions both "prior to" and during the placement activity.

   i. Larger limestone aggregate will reduce deck cracks. The gradation tables all have tolerances. Make sure we get as large of limestone aggregate as is available.

2. Adequate Labor Force

   a. At preplacement meetings talk about and, before starting a placement be sure the contractor has:

      (1) Proper and adequate materials to protect the placement.

(2) Adequate numbers of sufficiently skilled laborers available.

(3) Proper tools on the job.

(4) Arranged for the rate of delivery of concrete to make the placement operation efficient.

b. 25 cy (20 cubic meters) per hour should be a minimum placement rate. Any method of delivery to the deck should be checked to see that rate of placement can be such that finishing operations can proceed at a steady pace, with final finishing completed before the concrete starts its initial set.

B. Concrete Plant Inspector's Checklist

1. Specifications regarding plant inspection, equipment approval, and batching operations should be reviewed for familiarity. **In addition to proper plant calibration, the inspector should verify that each truck mixer used on the job has a current certification as required by *SSHC Section 1002*.** It is good practice to inspect a random sample of ready mix trucks that will be used on the job, verifying that the certification accurately reflects the truck's condition. Truck certification numbers should be recorded in the inspector's diary and will need to be reverified at least every 30 days.

2. Batching and mixing should be limited to the lead truck until slump and air content have been tested for conformance with specifications. **Contractors may make preliminary tests at the plant but project acceptance is based on job site tests.** It is intended that the ready mix plant supply concrete to the construction site that conforms to all applicable specifications at the point where the acceptance sample is taken.

   a. *SSHC Table 1002.02*, Concrete Proportions, lists slump and air content requirements.

   b. If concrete is being delivered which deviates much from these target values, the contractor is responsible for taking corrective action to bring the mix to within target values. Even if the current mix is within specified limits. The intent of the tolerance is to provide latitude during placement for unforeseen changes in materials, mixes, and placement methods. Placing concrete "consistently" near a tolerance limit is not desirable and warrants additional sampling.

   c. What is important, is the contractor's response to test results approaching tolerance limits. Continually having to add water and/or air agent to each load at the site will not be permitted. If such practice is occurring, the inspector shall notify the contractor (or whomever was designated as "the" responsible individual in charge of the concrete at the site.) Ultimately, it is the contractor's responsibility to initiate immediate corrective action.

3. Non-responsiveness on the contractor's part is reason to initiate sampling and testing of each truck or halt placement. The purpose for additional testing is to ensure that no noncomplying materials are incorporated into the project.

4. In some cases admixtures, such as water reducers, are required to be added in split doses or sometimes totally at the site.

5. All Structural Concrete

   a. At the start of each day's placement, no concrete is to be placed in the forms or on the deck until the first truck has been sampled, tested, and approved. Incorporation of materials from this truck will not be permitted unless desired slump and air content are within specified limits. Continuous placement shall not begin until after test results indicate the material meets specified requirements.

   b. If the first load is close to a limit value, it is recommended to sample and test the second load unless site experience indicates it is not necessary.

   c. Initial start up test results (if taken from the truck chute) must account for method of placement. For example: If placement will be through a pump, air values should be on the high side of target to account for loss during pumping. Again, site/project experience should be factored in this decision.

   d. Routine acceptance testing will be at a minimum frequency of one sample per 100 yd^3 (100 m^3). This frequency may be changed for large, continuous placement where placement rates warrant a lesser frequency. Minimum quantity placed between routine acceptance tests is 100 yd^3 (100 m^3). This rate of testing may be increased (made more frequent) if the inspector has a concern that target values are not being met.

NOTE: Only the Materials and Research Division has authority to approve decreasing (less frequent) testing frequencies from those listed in *Materials Sampling Guide*. PLAN AHEAD and obtain approval for those cases where a variance would be reasonable.

(1) For routine acceptance testing, obtain a representative sample at the last practical point before incorporation, but prior to consolidation.

NOTE: When concrete is placed by means other than directly from the back of the truck the sample shall be taken after the concrete has passed through the conveyance method being used. (This includes placement by bucket, belt, pumps, power buggies, etc.)

(2) Routine acceptance sampling and testing does not require holding a truck until results are available. However, if there are obvious deficiencies, the inspector has the authority to hold that truck until test results are available.

(3) Inspectors should be alert to obvious visual changes in consistency, with routine acceptance air and slump tests being made as noted above. Any load having questionable consistency should be checked for slump, and air content.

(4) If noncomplying test results are found during routine acceptance sampling, no more material (from that truck or others) shall be incorporated until complying test results are obtained. When test results indicate noncomplying material:

(a) The rest of that load shall be rejected and not incorporated, unless adjustments can be made to bring it back into compliance.

(i) In an attempt to bring noncomplying concrete into compliance, the supplier may make field adjustments (i.e.. add air entraining agent, or rotate the drum). Such "field" adjustments shall be an EXCEPTION and not the general rule and the 90 minute time restriction shall not be waived for any situation.

(b) For all noncomplying test results the inspector shall immediately notify the contractor or their representative in charge of the concrete. This notification shall also inform the Contractor if noncomplying materials have been incorporated into the structure.

(c) If test results indicated noncomplying materials have been incorporated, the inspector shall make a note in the diary indicating the test results, approximate volume incorporated, location the material was placed, and to whom the notification was given. The inspector should also note a noncomplying event on that particular truck's delivery ticket.

(d) When noncomplying materials are found, the inspector will: a) hold each truck, and b) initiate sampling and testing of each truck until two consecutive loads meet specifications. At this point sampling and testing may return to normal project acceptance frequency.

6. Specifications spell out requirements that materials must meet to be acceptable. Further, the *Materials Sampling Guide* identifies a frequency for sampling/testing and whether the test is an acceptance or assurance test.

a. Authority for initially rejecting noncomplying materials and poor quality work performance is given to the inspector in *SSHC Subsection 106.05*. This rejection authority is only superseded by the Project Manager. There is an old saying to the effect "*We shall not knowingly incorporate noncomplying material into a project*." This means exactly what it says and there is ample support in the specifications for this position.

7. During placements, the inspector should alternate sampling among the various trucks involved in the operation.

8. If there is a specific truck which is identified as causing a problem with consistency, that truck shall be rejected from further use.

9. Transit mixers shall be completely emptied of wash water before reloading. If the truck's top fill hopper is washed after loading, no wash water shall be allowed to enter the mixer.

10. The inspectors will need to satisfy themselves regarding compliance with the specifications for the number of drum revolutions at mixing speed.

11. If water, air entrainment or other admixtures are added at the project site, acceptance testing will not be performed until all additions have been made AND required mixing has been completed following the change.

C. Falsework

1. General: *SSHC Subsection 704.03*, paragraph 7.f. requires the contractor to submit 6 copies of falsework plans when required or when certain conditions apply. These plans shall be prepared by an Engineer registered in the State of Nebraska. The contractor shall prepare falsework plans, as called for in plans or in the special provisions, and for:

- Support of plastic concrete for concrete slab bridges with spans greater than 50 ft (15.25 m) in length.
- Cast-in-place concrete girders
- Slab bridge false work should allow for ? inch (3 mm) of deflection for each 10 feet (3 m) of span. This means that on an 80 foot simple span bridge the falsework should be I inch high at midpoint.

2. Falsework Inspection

a. Contract requirements governing falsework construction are contained in *SSHC Subsection 704.03, paragraph 7*.

b. The Project Manager should observe the falsework as it is erected to ensure that:

(1) Only sound materials are used.

(2) Quality work is used.

(3) During concrete pour, the falsework will carry the load. (More than ½" movement is bad.)

NOTE: Any inspection and/or acceptance by the Project Manager is not intended to relieve a contractor of responsibility under the contract for falsework design and construction.

c. By specification, a contractor is responsible for proper evaluation of the quality of their falsework materials. However, the Project Manager should not permit use of any material, when there is doubt as to the materials ability to safely

carry the load. If there is any question, the contractor should be required to perform a load test or furnish other evidence of structural adequacy.

d. Timely inspection is essential. Falsework deficiencies should be brought to the contractor's attention at once. Deficiencies include:

(1) Poor quality work.

(2) Use of unsound or poor quality materials.

(3) Construction which does not conform to the contractor's falsework drawings.

e. If the contractor fails to take corrective action, a noncompliance letter shall be issued. Corrective action will be required prior to placement of any additional dead or live load to the support structure.

3. Falsework Foundations

a. Falsework piling should be driven to adequate bearing unless mudsills or spread footings can be founded on rock, shale, compact gravel, coarse sand, firm clays in natural beds, or well compacted fill.

(1) Falsework Piles

(a) If requested, pile bearing values will be determined by the wave equation. Otherwise, the contractor is responsible for adequate foundation support.

(b) The pile bearing value required to support the design load must be shown on falsework drawings, and the pile driving operation must be inspected sufficiently to ensure that falsework piles attain required bearing.

b. Mudsills and Spread Footings

(1) Foundation material should be inspected before the footings are placed.

(2) To ensure uniform soil bearing, falsework pads must be set on material that provides a firm even surface, free of bumps or depressions within the pad bearing area. If necessary to obtain uniform bearing, a thin layer of sand may be used to fill in surface irregularities.

(3) Continuous pads must be analyzed differently than individual pads, and the two should not be considered equivalent. A change from one to the other requires resubmittal in the Construction Division for review by the Bridge Division.

(4) Falsework pads should be level. Benches in fill slopes should be cut into firm material, with the pad set well back from the edge of the bench.

(5) Many soils lose their supporting capacity when saturated. Adequate falsework construction must provide for drainage and protect pads from being undermined or ponded in water.

c. Soil Load Test

(1) Project Managers should require the contractor to perform a soil bearing test if there is any doubt as to the ability of foundation material to support the falsework load without appreciable settlement. One method to evaluate in-situ bearing capacity is to perform a plate bearing test as per ASTM D-1 194. (The above referenced method is not the only such test procedure, but is included to provide one method of determining in-situ capacity.)

4. Falsework Materials

a. One aspect of a falsework design and review is based on the use of undamaged, high-quality materials. Material strength values must be reduced if lower quality materials are to be used. Obviously, evaluation of the quality of materials actually furnished is an important, and essential, part of the falsework inspection procedure.

(1) Timber

(a) Inspecting falsework materials is necessary to prevent the use of materials which obviously do not meet the "undamaged high-quality" design criteria.

(b) Falsework materials delivered to the job site, should be equal to or greater than the grade, or type of material, assumed in the design review. Timber having large shakes, checks or knots, or which are warped or split should not be used at critical locations. Abused timber, although stress graded, may no longer be capable of withstanding the original allowable stress.

(c) Rough sawn timbers should be measured to determine their actual dimensions. Unlike surfaced/finished material, the dimensions of roughcut timber are not uniform from piece to piece. The variation may be appreciable, particularly in the larger sizes commonly used for falsework posts and stringers. If actual dimensions are smaller than the dimension assumed in design, the member may not be capable of carrying the imposed load without overstress. Therefore, undersized material should not be incorporated into the falsework, unless the design is reevaluated using smaller dimensions.

(2) Structural Steel

(a) Used beams, particularly beams salvaged from a previous commercial use, should be examined carefully for loss of section due to welding, rivet or bolt holes, or web openings which may adversely affect the ability of the beam to safely carry the load imposed by the falsework design.

(b) Welded splices should be inspected visually for obvious defects. Radiographic inspection or other methods of nondestructive testing will not be required as a means of determining the quality of the splices unless the Project Manager has reason to believe the welds are defective.

(3) Manufactured Products

(a) Manufacturer's ratings are based on the use of new material or used material in good condition. The determination as to whether a manufactured product is in good condition is highly subjective and requires experience and judgment.

(b) When manufactured assemblies are used in falsework, they shall be shown on the falsework plans along with their identification number. The actual assembly shall be clearly and permanently marked with the identification number.

b. Identification numbers will allow field inspectors to verify the capacity and proper application of various devices.

c. Identification by the contractor applies not only to jacks, beam hangers, overhang brackets, and similar devices, but to all vertical steel shoring systems as well.

d. Manufactured products such as tubular steel shoring and steel overhang brackets are particularly vulnerable to damage by continual reuse. Fabricated units in which individual members are bent, twisted, or broken will have a substantial reduction in load carrying capacity. Steel shoring materials should be examined carefully prior to use. Shoring components should not be used if they are heavily rusted, bent, dented, or have broken/damaged welds or other defects. Connections, in particular, should be examined for evidence of cracked or broken welds. Miscellaneous components such as screw jack extensions, clamps, and adjusting pins should be inspected as well.

e. Proprietary scaffolding must be used as intended and not subjected to additional stresses or conditions for which it was not originally designed and tested.

(1) Cable Bracing

(a) Cable bracing systems must be carefully inspected to ensure that field installation conforms to details shown on the falsework drawings. This is particularly important with respect to the location and method of cable attachment to any falsework.

(b) Prior to installation, each cable should be inspected to verify that the type, size, and condition (new or used) are consistent with design assumptions. Used cable should be inspected for strength-reducing flaws. Use of obviously worn, frayed, kinked, or corroded cable should not be permitted.

(c) Particular attention should be paid to cable clamp fasteners. Improperly installed clamps will reduce the safe working load by as much as 90 percent. Also, the omission of the thimble in a loop connection will reduce the safe working load by approximately 50 percent. After installation, clamps should be inspected periodically and tightened as necessary to ensure their effectiveness.

(d) A cable clamp has two parts - the "U-Bolt" and the "Saddle." Also a cable has two parts, the wrapped non-continuous end (dead end) and the continuous portion which supports the load (live side). Always put the cable clamp's "saddle" on the live side and the "U-bolt" over the "dead end."

5. Falsework Quality

a. High quality work, particularly in such details as wedges, fasteners, bracing, friction collars, jack extensions, etc., is critical to the proper performance of falsework. Accordingly, construction details should receive close attention from the project inspector.

(1) Timber Construction

(a) The following checklist is included as a guide to points which require special consideration:

(i) Diagonal bracing, including connections, must conform to details shown on the falsework drawings.

(ii) Diagonal bracing should be inspected after any falsework has been adjusted to grade. Connections must be securely fastened to ensure their effectiveness in resisting horizontal forces. Bolted connections may need retightening.

(iii) Timber posts may be wedged at either the top or bottom for grade adjustments, but not at both locations. Large posts may require two or more sets of wedges (side by side) to reduce compression stresses perpendicular to the grain.

(iv) Blocking and wedging should be kept to a minimum. It is poor workmanship to extend a short post by piling up blocks and wedges. This practice should not be permitted.

(v) Particular attention should be given to falsework bents where grade adjustment is provided at the bottom of the posts. Differential grade adjustment of posts within a particular bent may induce undesirable stresses in the diagonal bracing.

(vi) Splicing of wood posts will not be allowed unless shown on approved falsework plans.

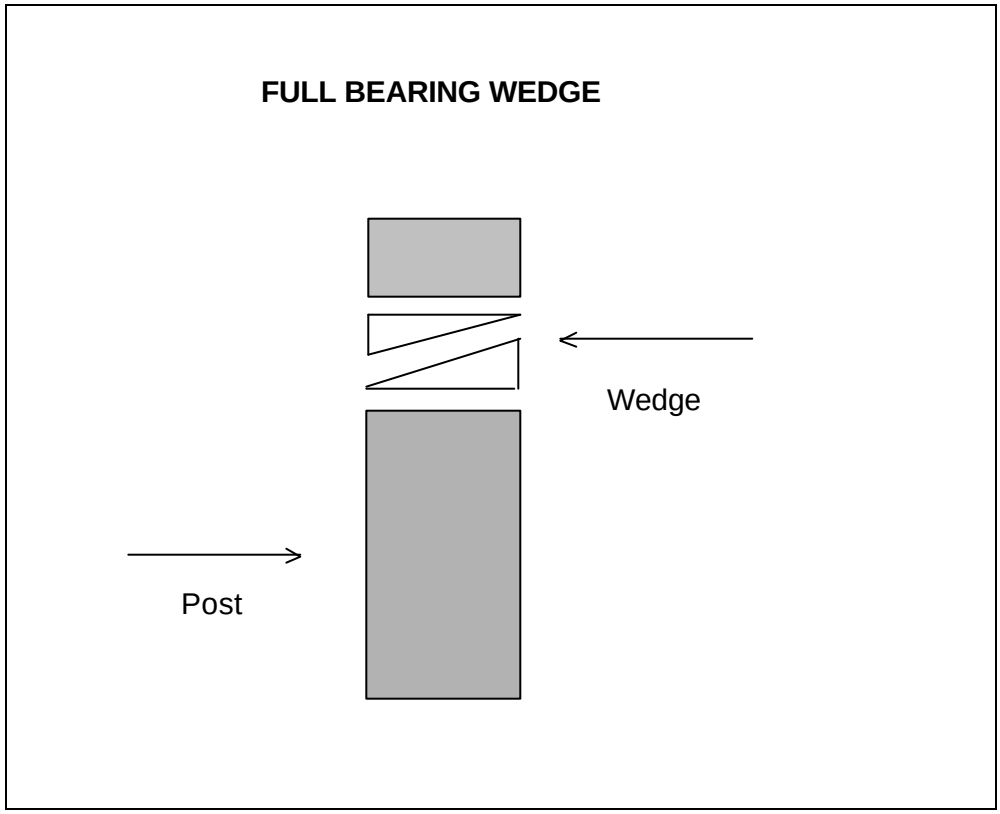
(vii) The ends of spliced posts must be cut square. The need for a post splice should have been anticipated by the contractor and the splice detail shown on falsework drawings. If this is not the case, the contractor must submit a detail for approval.

(viii) Posts must be plumb and centered over the falsework pad or corbel.

(ix) Abutting edges of soffit plywood should be set parallel to the joists and continuously supported on a common joist.

(x) A sufficient number of telltales must be installed to accurately determine the amount of joint take-up and settlement. Telltales should be attached to the joists as close as possible to the supporting post or bent.

(xi) Full bearing must be obtained between all members in contact. Deficiencies in this respect may be improved by feather wedging. If the joint requires more than a single shim or wedge, extra care should be taken to ensure that full bearing is obtained.



When using wedges, it is a good practice to use wedges inserted from both sides rather than deeply setting a single wedge. Using only one wedge increases the twisting effect on the member.

- When using wedges, it is good practice to install them parallel to and with the flat (nontapered) side against the main member. This improves contact with the main member and decreases the chance of a wedge "backing out" from vibration.

- Nail or clamp the wedge in place after installation.

(2) Steel Shoring (Scaffolding)

a. This checklist may be used as a guide by inspectors when inspecting falsework constructed of steel shoring.

(1) Shoring components should be inspected prior to erection. Any component that is heavily rusted, bent dented or rewelded, or which is otherwise defective, should be rejected. Fabricated units having individual members that are bent twisted, broken, or where welded connections are cracked or show evidence of rewelding should be rejected.

(2) A base plate, shore head, or screw jack extension device should be used at the top and bottom of all vertical components.

(3) All base plates, shore heads, and extension devices must be in firm contact with the footing at the bottom and the cap or stringer at the top.

(4) Shoring components should fit together evenly, without any gap between the upper end of one unit and the lower end of the other unit. Any component which cannot be brought into proper contact with the component it is intended to fit, should not be used.

(5) Shore heads, extension devices, and similar components must be axially loaded. Eccentric loads are not permitted on any shoring component.

(6) All locking devices on frames and braces must be in good working order, coupling pins must align the frame or panel legs, and pivoted cross-braces must have the center pivot in place.

(7) Shoring should be plumb in both directions. Maximum deviation from true vertical should not exceed 3 inches per 1000 inches (3 mm per meter).

6. Miscellaneous Falsework Items

a. This checklist covers items that may be used in either type of support system.

(1) New high strength bolts shall be used on any item that requires bolts to be torqued.

(2) Friction collar bolts and concrete anchors should be torqued initially and checked again just prior to concrete placement.

(3) Permanently deflected stringers should be placed with the crown turned upward.

(4) Jacks should be plumb and not overextended.

7. Falsework Adjacent to Traffic

a. This will be an unusual situation in Nebraska. If it occurs, the Construction Division should be notified.

8. Falsework Field Changes

a. If supplemental calculations are necessary to verify compliance with contract requirements, he change will be considered substantial. In this case, the proposed change must be submitted for review and approval in the same manner as the original drawings.

b. The following are examples of changes considered substantial and must be shown on revised falsework drawings, regardless of other considerations:

(1) A change in size or spacing of any primary load-carrying member.

(2) A change in method of providing lateral or longitudinal stability.

(3) Any change, however minor, which affects the falsework to be constructed over or adjacent to a traffic opening.

(4) A revised concrete placing sequence, if it significantly affects the stresses in load-carrying members.

(5) When revised drawings are required, they must be submitted for review in the same manner as the original falsework drawings. The Department does not approve falsework! Time shall be allowed for review of revised falsework drawings. Typically this is the same as required for the original submittal.

(6) The PM should be alert to and document any field changes to falsework plans.

9. Falsework Inspection During Concrete Placement

a. As concrete is being placed, the falsework should be inspected at frequent intervals. In particular, look for the following indications of potential failure:

(1) Excessive compression at the tops and bottoms of posts and under the ends of stringers.

(2) Pulling of nails in lateral bracing.

(3) Movement or deflection of braces.

(4) Excessive deflection of stringers.

(5) Tilting or rotating of joists or stringers.

(6) Excessive settlement of tell-tales.

(7) Posts or towers that are moving out of plumb.

(8) Sounds of falling concrete or breaking timbers.

(9) If any member deflects unduly or shows evidence of distress, such as splintering on the bottom of stringers, crushing of joints or wedges, etc., placement work in the affected area should be stopped immediately and the falsework strengthened by addition of members, installation of supplementary supports, or some other means.

(10) Settlement of the falsework should be limited to a maximum of ? inch (10 mm) deviation from the anticipated settlement. Should actual settlement exceed the anticipated settlement by more than the ? inch (10 mm) allowable, and if it appears that a serious problem is developing, concrete placing should be temporarily discontinued in affected areas until the contractor provides satisfactory corrective measures. Concrete placing should not be resumed until the Project Manager is satisfied that further settlement will not occur.

(11) If it is apparent that satisfactory corrective measures cannot be provided prior to initial setting of the concrete, the Project Manager shall stop placing of concrete and contact the Construction Division.

(12) One important and often overlooked point is the danger of curing water softening the falsework foundation. Some means should be provided to prevent curing water from reaching and soaking the foundation material beneath the falsework bearing pads.

(13) The contractor should provide the drainage for any water that accumulates in box-girder cells. Such accumulated water could easily overstress the falsework.

b. Falsework and Centering

(1) It is the contractor's responsibility to provide form work adequate to support the dead load of the fresh concrete. However, the inspector shall consult with the contractor and the Project Manager concerning any form work which he/she has reason to believe is inadequate to support the load capacity. In calculating the strength of centering, a mass of 150 lb/ft^3 (2400 kg/m^3) shall be assumed for fresh concrete.

(2) All falsework shall be rigidly braced and cross braced. Timber piling shall be free from defects with at least a 7 inch (175 mm) butt and a 5 inch (125 mm) tip, measured under the bark. The contractor shall provide jacks or suitable wedges to take up any settlement in the form work during the placing of the concrete. When setting grades for falsework or structure forms, allow 1/16 inch (1.5 mm) settlement or "take-up" for each lap in the falsework timbers.

(3) Build falsework for slab bridges with ? inch camber for each 10’ of span. Deflection after forms are removed should bring deck back to the proper elevation.

(4) Settlement caused by the concrete loads may be checked as placing of the concrete progresses by means of vertical “telltales” fastened to the bottom of the floor form. When this settlement has reached the amount allowed for “take-up” in the falsework timbers, any further settlement should be prevented by means of the wedges or jacks previously noted. Any adjustments that have to be made must be completed before the concrete has taken its initial set. If adjustments are made after the concrete has set, the concrete may be damaged

irreparably. (In general, if falsework settles more than ½ inch, the PM must investigate and determine the damage.)

10. Removal of Falsework (SSHC Table 704.02)

a. Specifications and applicable special provisions, contain specific criteria which must be met before falsework may be removed. Project Managers and inspectors should review these sections prior to falsework removal operations.

b. The Project Manager should discuss falsework removal methods and procedures at the preconstruction and/or prepour meeting. The need to provide for employee and public safety is of particular concern.

c. In general, all elements of the falsework bracing system must remain in place for the specified time period or until concrete attains the specific strength. In the case of cast-in-place, post tensioned construction, falsework elements must not be removed until stressing is completed.

D. Forms

a. The inspector shall check the lines, grades and dimensions on all structural form work before allowing the contractor to place concrete. On walls and columns this is best done as the form work progresses.

b. Forms shall be made of wood, metal or other approved materials. The forms shall be substantial, unyielding and mortar tight. All forms for exterior exposed surfaces, except those locations requiring a specific texture finish as listed in *SSHC Subsection 704.03* shall be lined with pressed wood, plywood or other approved materials used in the largest practicable panels. Forms shall be coated with a colorless oil to prevent sticking to the concrete. The forms should be oiled before placing the reinforcing steel to avoid splattering of oil on the steel. Forms for walls and columns, or wherever else required, may be constructed with the bottom board removable for cleaning out wood chips, dirt, etc., before placing the concrete. Metal tie rods or anchors within the forms shall be constructed so as to permit their removal to a depth of one inch below the surface of the finished concrete. All tie rod and tie-wire holes shall be filled with cement mortar as soon as possible to insure proper bond with the structure concrete.

c. Pier columns may be constructed using a laminated fiber form which is moisture resistant and seamless. These forms must be capable of withstanding the hydraulic pressure of fresh concrete. Any questions concerning the acceptability of a proposed fiber form should be referred to the Construction Engineer through the District Construction Engineer.

d. Removal of Forms and Falsework

(1) Specific requirements concerning the time limitations for form removal are listed in *SSHC Subsection 704.03*. Proper inspection includes both the monitoring of this time and the method of removing forms. Stresses in concrete due to its own weight must be introduced slowly and carefully during form removal operations to prevent concrete failures. For instance, the removing of falsework from under a cantilevered element, must begin at the point furthest from the support and proceed toward the support. In removing the falsework from under a structure that is continuous over its supports, removal should begin near the areas of maximum dead load positive moment and proceed in both directions towards the supports. In general, all

falsework should be removed before placing any surcharge, such as sidewalks and railings, on the superstructures.

(2) The requirements listed in the Specifications are based on sound engineering principals and the structures inspector should be thoroughly familiar with and rigidly enforce these requirements.

12. Use of Insulated Forms for Protection

a. Commercial insulation may be used for protecting concrete during cold weather, or when the contract documents require controlling the heat of hydration. This technique is the contractor's option and could be used in lieu of housing and heating. The contractor must furnish housing and heating and/or insulation of sufficient quality and thickness to maintain concrete at a temperature of not less than 50°F (10°C) for the first 72 hours after placing, and above 41°F (5ºC) for the next 48 hours.

E. Placing Concrete

1. Concrete shall be proportioned, mixed and handled in accordance with the requirements of *SSHC Section 1002*. The inspector should also refer to the Materials and Research Manual which outlines the method of proportioning, sampling and field testing the materials necessary for the production of concrete. The contractor shall organize his/her work so that the maximum interval between batches shall not exceed 30 minutes.

2. Concrete should not be placed in footings, columns, etc, until all pile driving within a radius of 50 feet has been completed. If concrete pours must be made within this area prior to the completion of pile driving, such concrete shall set at least three days before further driving is permitted within this radius. Concrete shall not be placed without special permission in steel pile shells for cast-in-place concrete piles for each bent, pier, or abutment until all the shells for that bent pier or abutment have been driven (*SSHC Section 703*).

3. When depositing concrete in the forms, segregation must be avoided. The mass of concrete should be generally free of surface cavities resulting from the trapping of air and water along the forms. Careful spading of concrete along vertical forms and tapping of the forms will usually release the air and water bubbles. Forms which are not mortar tight will leak cement paste and result in "sand streaking." Forms should be mortar tight to the maximum extent possible. Chutes shall be of metal or metal lined and of sufficient number to preclude the necessity of shifting the chutes. If necessary, the contractor shall leave holes in the forms for the entry of the chutes or pipes. Concrete must be deposited within 8 ft (2.5 m) horizontally of the place of its final location. Concrete shall not be dropped vertically more than 5 feet (1.5 m). Concrete in walls, footings, columns, etc, shall be placed in continuous horizontal layers not more than 18 inches (450 mm) thick and vibrated to a monolithic mass. Do not allow dried concrete to collect on forms or reinforcing bars where it will fall into the work.

4. See Section 1003.06 Concrete Cylinder Policy for cylinder requirement.

F. Placement Considerations

1. If there is any doubt about the concrete temperature exceeding 86°F (30°C), the contractor needs to identify measures which will be implemented to keep mix temperatures within specifications. If the contractor is not prepared to maintain a mix temperature below specifications, the pour should be postponed.

2. There are several ways concrete temperatures may be kept within specifications. They are:

   a. Scheduling placements during cooler times of the day.

   b. Wetting the aggregate stockpiles.

   c. Covering/shading the aggregate stockpiles.

   d. Maintaining a supply of portland cement on hand to preclude getting hot material from the supplier.

   e. Chilling the mixing water is one of the most effective ways to lower mix temperatures.

   f. Shaved ice can be used, however, the ready mix operator must submit a proposal for this to the Project Manager for review by the Construction Division.

NOTE:

- No payment will be made for methods taken to keep concrete temperatures within specifications.

- If pour has to be delayed because of temperature, and pouring is the controlling operation, no working days will be charged.

- Location of permissible headers should be discussed with the contractor during the pour, it appears the temperature may exceed 86°F (30°C).

- When casting deck on Phased Construction under traffic make sure potholes in the driving lanes are filled.

3. General - The wind velocity temperature relationships stated in the specifications should be enforced to avoid loss of water from the concrete surface faster than it can be replaced by normal bleeding and to avoid the resultant formation of plastic shrinkage cracks. Anemometers and thermometers must be available on site to measure wind velocity and temperature.

4. Concrete in bridge floors shall be placed uniformly on both sides of the centerline and shall be placed continuously between specified joints. The sequence of placing shall be in accordance with the pouring diagram shown in the plans. If no pouring diagram is shown in the plans, concrete shall be placed as directed by the Project Manager.

5. Wet the deck forms and approach slab grade before placing the concrete. Concrete shall be adequately vibrated to encase the lower bars of the reinforcing mat where these are near the deck form.

6. Special attention shall be given to finishing the riding surface on the bride floors. *SSHC* Subsections 706.03, 710.03, and 711.03 explain concrete bridge floor finish.

7. It has been the policy to permit the contractor to use mechanical finishing machines of an approved type whether or not they are required by the plans or special provisions.

8. Method of Finish - When the hand method is employed, the concrete surface shall be struck off with a strike board which conforms to the cross section shown in the plans. If this is pulled by hand, care shall be taken not to displace the reinforcing steel by the workmen doing the pulling. A small air winch anchored to a girder outside of the day's pour will pull the strike off at a slow, uniform rate, giving a truer surface with no displacement of the reinforcing steel. The strike board shall be operated with a combined longitudinal and transverse motion, always carrying a small roll of concrete in front of the cutting edge. The strike off shall be pulled a sufficient number of times to properly distribute the concrete. A longitudinal float generally is required and is described in *SSHC Section 704*. The longitudinal float shall be lapped 1/2 its length when moved to a new position and shall be operated across the surface a sufficient number of times to produce a uniform, smooth riding surface. Occasionally during the finishing operation, conditions may require the use of the long-handled transverse float, which require extreme care in its use to preserve the desired cross-section and a smooth riding surface.

9. Regardless of whether hand or machine finishing methods are used, the floor surface shall be tested for trueness with a straightedge 10 foot (3 m). The bridge contractor is required to furnish a 3 m master straightedge for use in trueing and checking the working straightedges.

10. A burlap drag is required and this operation should be performed as soon as the surface will support the drag. A tined surface is also required by the specifications.

11. Templates used to support the strike off should be in short sections [(10 to 14 ft) (3 m to 4 m)] so they may be removed as the finishing operation advances, allowing the final floating and surface testing to take place, and the wet burlap to be applied immediately. Decks should be cast after the afternoon high temperature is reached. (In summer, this can be as late as 7:00 p.m.) Protection of the aggregates from the sun is also helpful.

12. When mechanical self-propelled finishing machines are used, they shall be capable of obtaining a finish equal to or better than that obtained by the hand method. The screeds of the finishing machine should be set to the exact cross section shown in the plans. Elevation shots will be required for the setting of the riding rails. The usual procedure is to give a fill to grade at the locations where girder shots were taken. The contractor will then set the rail to the correct height to accommodate the machine. An "eyeball" check of the rail for smoothness should always be made. On girder bridges the rail will follow a line that should be smooth after the girders have deflected from the dead load. Correct elevations of the rail can be checked by measuring the distance from the screed to the formwork which should give the correct thickness of slab.

13. Careful attention should be given to the depth of cover over the top steel. With the extensive use of salt, the service life of the steel is reduced if the concrete cover is less than that shown in the plan. (The finishing machine must be dry run to check the minimum clearance of the reinforcing steel and to check the grade of the expansion devices.)

14. If the finishing machine is used when there is a transition between regular crown and full superelevation, a system should be worked out well in advance of pouring to insure that the screed can be changed rapidly and correctly at intermediate points of the transition. This is important in order that there are no long delays caused by screed adjustments while pouring the transition.

15. Retarders – Retarders shall be used to delay the setting time of the bridge floor concrete. If the temperature is 60°F (15°C) and rising, retarders must be used. A good goal is to be finishing at the next pier before the concrete is setting-up at the previous pier. Acceptable retarders are Pozzolith 300R and Doratard-17. Water reducing admixtures like WRDA-82, Procrete-N, and Masterpave-N are not acceptable retarders.

16. When a retarder is required the rate of placing concrete for any positive moment section will be within two-thirds of the initial setting up time of the retarded concrete after the previous negative moment section has been poured. For example, if the initial set takes place in 6 hours, the pouring of a positive moment section must be completed within 4 hours after the completion of the previous negative moment section. This same procedure should be required regardless of whether or not retarders are used.

17. Calibration of Concrete Proportioning Equipment - Calibration of this equipment should be as described in the National Ready Mixed Concrete Associations' Quality Control Manual.

G. Placement Methods (Pumping, Belting, And Crane Bucket) (*SSHC Subsection 704.03*)

1. Much concern has been expressed about the method of concrete placement because of lost entrained air. Rough handling of plastic concrete during placement has, at times, reduced entrained air to less than 2% not to mention potential segregation problems. While testing at the point of placement "should" identify such problems, varying placement conditions during the pour can affect concrete conditions significantly.

2. General conditions which must be avoided (Points to watch for), or at least severely minimized, are explained for each delivery system that follows: If one of the following cannot be avoided, at least be aware of the condition, and be sure to conduct additional testing should any of the conditions present themselves.

3. Crane and Bucket

   a. In the past it was felt the crane and bucket placement method did not adversely affect concrete. This is now in question when viewed from loss of air and potential segregation. Therefore, this method will now also require testing at the placement location, if practical.

b. Points-to-Watch For

(1) Free fall of unrestrained concrete shall not exceed 5 ft (1.5 m.) Avoid exceeding a 5-ft. free fall by removing a section of form work for intermediate placement or by use of a tremie.

(2) Discharge from the bucket must be controllable.

(3) Cross section of the drop chute should allow it to be inserted into the form work without interfering with reinforcing steel.

4. Belt Placement

a. Belt equipment is typically used to convey concrete to a: (1) lower, (2) horizontal, or (3) somewhat higher level.

b. Points-to-Watch For

(1) Keep the number and distance of drops between belts to an absolute minimum. Drops tend to encourage segregation and reduce entrained air.

(2) As belt conveyors are removed from the line (i.e., as on deck pours), recheck the "as placed" air content.

(3) Be sure all mortar is being removed at the discharge. (No mortar should be on the return belt.)

(4) Check discharge for potential segregation problems.

(5) In adverse weather (hot and/or windy conditions), long belt runs need to be covered.

H. Pump Placement

1. The modern mobile pump with hydraulic placing boom is economical to use in placing both large and small quantities of concrete. These units are used to convey concrete directly from a truck unloading point to the concrete placement area.

2. Points-to-Watch For

a. Typically, pumps are initially flushed with a thin water/cement paste mixture to coat the lines. This slurry must be wasted and the lines charged with the project mix before beginning. Observe, and be sure initial pump charge is thoroughly removed from the pipelines.

b. Always pump at a constant rate and keep pipelines full of concrete. High air loss can occur when concrete is allowed to free-fall inside pump lines.

c. Avoid, if at all possible, having steep angles in the pump pipelines. Steep angles and slow placement rates are probably the worst conditions for minimizing air loss and segregation. If this condition occurs:

(1) Attempt to relocate the pumper, thereby minimizing lift angle.

(2) If discharge is not maintaining a constant flow with the partial concrete head in the pipe, request the pump operator to place a reducer and short section of hose at the discharge end. The purpose is to avoid free falling concrete from impacting the deck or forms at high velocity.

(3) If the above condition is unavoidable, watch and test the discharge frequently for loss in air and potential segregation.

3. Rule-of-Thumb for Pumping

a. Pump concrete with pipelines as flat as possible (or at least with minimal down angle).

b. Minimize (or eliminate) free falling concrete in the pipelines. To do this, maintain some amount of concrete head in the pipelines.

c. Pump concrete through as few elbows and restrictions as possible.

d. Pump concrete at "some" constant rate.

e. Watch and test the air content frequently, when drop may exceed 5 feet.

I. Consolidation of Concrete

1. The contractor must establish a pattern for vibrating the concrete and ensure the pattern is followed across the entire deck.

2. Consolidation of concrete should be accomplished by the use of a sufficient number of vibrators of a type approved by the Project Manager. The vibrators must be of such an intensity as to visibly affect one-inch slump concrete over a radius of 18 inches (450 mm). The contractor is required to furnish a tachometer for the purpose of checking the speed of the vibrator elements.

3. Lateral movement of the concrete by means of a vibrators shall be avoided. Over vibration is harmful and is evidenced by grout appearing in the concrete around the vibrator head. Insert and withdraw the vibrator slowly. It should not come in contact with reinforcing steel which extends into previously placed concrete nor should the vibrator head be placed in concrete which is taking its initial set.

J. Reinforcement Bar Cover

1. Reinforcement bar cover has contributed to shadow effect. This occurs when reinforcing cage is not rigid or has only a minimum of cover and too much vibration was used. The remedy:

a. Increase bar cover to 2 ½ inches (65 mm) from minimum of 2 inches (50 mm).

b. Maintain uniformity of bar cover.

c. Build in rigidity to the reinforcing bar cage by placing diagonal braces as described above.

d. Reduce slump and do not over vibrate the concrete.

e. Require a dry run to check alignment and uniform spacing between the edge of the mule and rebar cage.

2. Shadowing occurs when slip forming a radius because of nonuniform form pressures inside the mule. The problem manifests as repetitious surface bumps, not depressions as one might think. This problem is inherent with slipforming a radius and is especially noticeable as the radius becomes smaller. In order to minimize shadowing effects, the contractor needs to have finishers work out the bumps by hand.

K. Use of Finishing Machine (*SSHC Subsections 710.03 and 711.03*)

1. The finishing machine shall be approved before use. Care must be taken to adjust the screeds to proper crown. Support rails must extend beyond the bridge at both ends at proper grade and sufficient distance to accommodate the machine. This permits finishing to begin promptly at the start of the run and also permits the required straightening to proceed on schedule at the end of the run.

L. Straightedging

1. Following the finishing machine, straightedging should be completed to check for longitudinal smoothness. Straightedges, 10 ft (3 m) in length, need to be operated parallel to centerline of roadway. Each pass should overlap the previous one by a half length. If bull-floating (mopping) is needed to close up the surface, it should always be followed by straightedging.

M. Tining (Transverse Grooving)

1. Tine bridge decks with a rake. No longer use a bull-float.

2. After straightedging, and as soon as practical following finishing, the entire traffic surface, except areas within approximately 2 ft (600 mm) from the curbs, shall be given a suitable tining with corrugated tining rake.

3. Tine all bridge decks where posted speed limit will be 40 mph or greater, except for county road bridges 100 feet (30 m) or less in length that have gravel approaches and no plans exist for future hard surfacing.

4. On bridge decks, stop the tining 2 ft (600 mm) from the face of the bridge curb.

5. **Do not overlap the grooving.**

N. Curing

1. The Bridge Deck Curing Special Provision defines how to cure the deck.

2. The surface must be covered with wet burlap as soon as possible. (Slight surface marring and removal of tining is acceptable.) Burlap must be wet before placing. In hot dry weather, it is better to be a little early than late with burlap cover.

3. Since shrinkage cracks are due to rapid loss of mix water before the concrete has attained adequate strength, it is imperative that curing protection be initiated before much evaporation can occur.

O. Ways to Avoid Deck Cracks

1. Verify falsework is stable.

   (a) Temporary piles need to have significant bearing – practical refusal is best.

   (b) Wood crush needs to be minimized. Avoid gaps between layers of timbers – be careful to shim the entire length of support timbers.

2. Avoid unnecessary vibrations.

   (a) Use shooflys where possible to keep traffic away from the bridge.

   (b) Do not rest falsework on active bridge during phased construction unless there is no other alternative.

   (c) However, when it comes to intentional consolidation – the contractor should be very careful to establish a fix pattern for vibration and make sure it is achieved along the entire length of the deck and approaches.

3. Check the temperature of the concrete as it arrives on site. It should not be greater than 86°F.

4. Check the slump and if the slump is less than 3.5 inches, confirm that the mix is not too dry – especially if retarders or water reducers are used. Low slump measurements are a good indicator that mix is too dry especially on hot days. Also, with a low slump, it will be hard to get the mix around and in between rebars and tining with the tining rake is much more difficult.

5. Verify camber on girders is correct.

6. Avoid skewed construction of approach sections. If there must be a skew, limit it to 20 degrees. If skew is above 20 degrees, then reinforce the area near the obtuse angles because the stress is significantly increased in this region.

7. Cover the concrete with saturated wet burlap 1 ½ hours after the concrete leaves the truck or pump chute.

8. If the outside air temperature is predicted to be above 80°F (26°C) then start casting the deck at 5:00 pm and finish before dawn.

9. Check the outside air temperature during casting. It should be less than 86°F.

10. If the evaporation rate during casting exceeds .15 lbs/sf/hr, then fogging as prescribed in the Nebraska Fogging Special Provision will replace the evaporating water, keep the deck cool, and slow the setting time.

P. Seal Bridge Deck Cracks

1. Bridge deck cracks should be sealed before de-icing salt is ever applied on or near the deck.

2. High molecular weight methacrylate is the best sealant and is squeegeed into cracks.

Q. Cold Weather Placement

1. On account of the high incidence of shrinkage cracks due to artificial heat during the protection period, no bridge floors will be constructed during cold weather except with the special written permission of the Construction Division.

R. Floor Drains

1. Check floor drain locations against floor grades to be sure deck surface will drain. Adjustments of drain height may be advantageous on every flat grade surface. Also, at this time, study the discharge area from the floor drain for potential damage to features under the structure such as shoulders, railroads, or berm slopes. Major problems foreseen should be brought to the attention of the Construction Division.

S. Flowable Fill (*SSHC Section 1003*)

1. The inspector shall make daily entries in the field book on all concrete placed for each project. Record concrete placement location, all results of sieve analysis tests, all data on test beams made and tested and all quantities placed.

2. Flowable fill can be used for the following purposes:

   a. Backfilling culverts.

   b. Backfilling culverts constructed under bridges.

   c. Filling void between culvert and culvert liner.

   d. Plugging culverts.

   e. Slope stabilization.

3. Free water in the sand pile must be considered as mix water because a mix design uses oven dried sand.

4. The plans may call for a sewer pipe to receive a gasket, otherwise, see *SSHC Section 722*.

5. If the contractor uses crushed limestone for granular backfill, it shall meet the requirements for Granular Backfill. (Refer to *SSHC Section 1033*.)

6. Remember flowable fill is a liquid until the water has dissipated. Bulkheads should be strong enough to withstand the hydraulic pressures.

7. Under normal conditions, flowable mortar should be set-up sufficiently within 24 to 48 hours for placement of the final lift of either earthfill or special backfill. If "set-up" does not occur or if it seems slow, typically the problem relates directly to drainage of the granular backfill. Often contamination or "dirty" granular backfill is the culprit. Check to be sure it is draining. If not, additional time will help.

8. Placement of 2 ft (0.6 m) of flowable mortar.

T. Installation of Joints (*SSHC Subsection 704.03*)

1. Reinforcement

a. Reinforcement must be accurately placed and rigidly fastened. If cages are not rigid and braced diagonally in both transverse and longitudinal directions, problems can occur. The remedy:

(1) Recommended Procedure:

(a) Epoxy coated smooth bar, about ¼ inch (6 mm) in diameter can be placed diagonally from the top of a leading cage to the bottom of the second trailing cage. (Description is referenced to direction of paver's travel.)

(2) Alternate Procedure:

(a) Welding of diagonal braces to provide longitudinal rigidity is possible, but material would need to be epoxy coated and repair of weld location is necessary.

2. Preformed Neoprene Joints

a. Preformed neoprene expansion joints are used on a large number of bridges.

(1) Inspection Checklist

(a) Neoprene cellular joints, if properly installed, provide a leak-proof joint capable of functioning within expansion limits of the bridge. To insure that a joint will function properly, there are a number of precautions that should be noted regarding the installation of this type of joint. Precautions:

(i) A neoprene seal can be placed in two positions, one correct and one incorrect. Make sure that the seal is not installed upside down or sideways.

(ii) Position of the ½ x ¼ inch (13 x 6 mm) keeper bars on vertical face of the expansion plate angles has to be consistent with the recommendations of the manufacturer of the neoprene seal. The depth that a seal is set varies greatly with the different manufacturers.

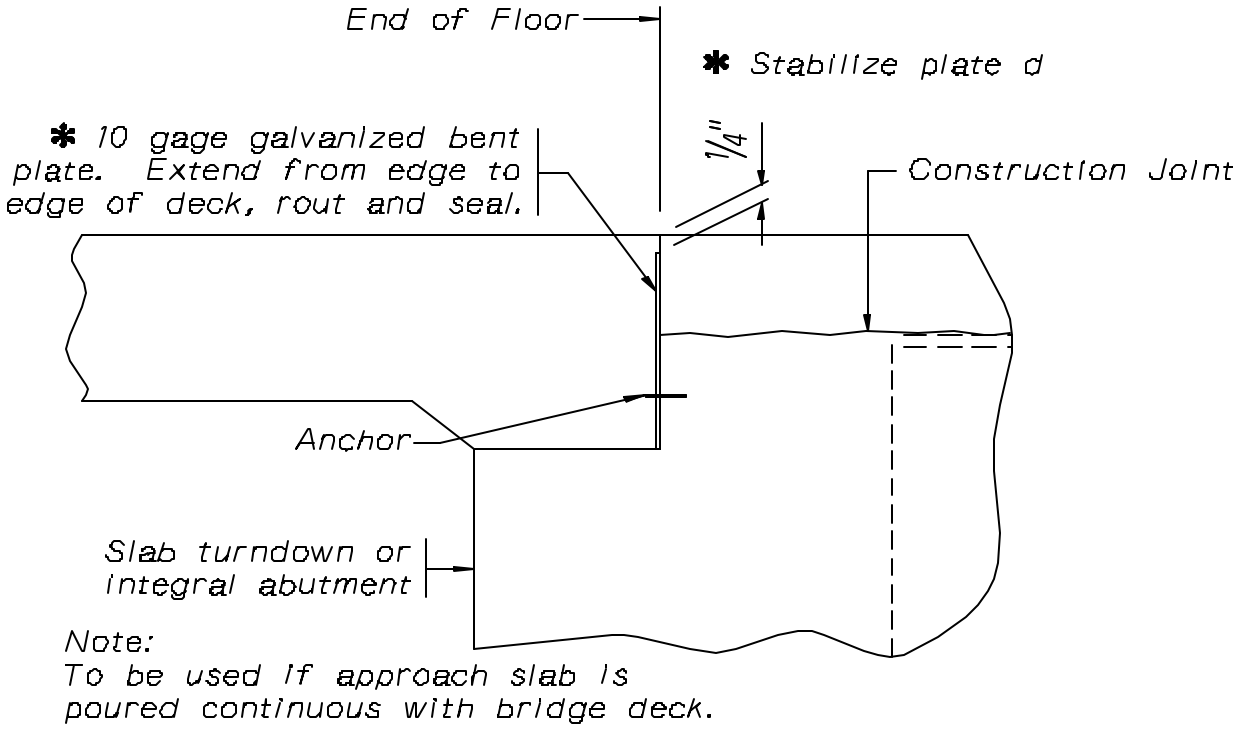
(iii) The neoprene seal has to be installed so bottom of the seal touches top of the ½ x ¼ inch (13 x 6 mm) keeper bars, but should not be forced past the keeper bars.

(iv) Make sure expansion opening between angles of the expansion device are consistent with the expansion setting shown on design plans and that the same expansion opening is maintained from gutter to gutter.

(v) The neoprene seal must project beyond the outside edge of slab as shown on the plans.

b. Summary

(1) When uncertain as to which side of the seal is top, or when the position of keeper bars is in question, the contractor must be required to submit drawings prepared by the manufacturer which indicate correct position of installation.



OPTIONAL JOINT DETAIL

U. Curing Concrete

1. The structure inspector should give careful attention to the curing, since proper curing is essential to good quality concrete.

2. When the evaporation rate exceeds 0.15 lb/sf/hr, the contractor must either fog the entire deck while placing the concrete; cover the concrete with wet burlap 1 ½ hours after the concrete leaves the truck; or take some action which will lower the evaporation rate on the entire deck below the 0.15 lb/sf/hr limit.

3. Applying wet burlap as soon as possible is essential – limited removal of tining is acceptable. The wet burlap should always be on the deck by 1½ hours after that portion is finished.

V. Concreting in Cold Weather (*SSHC Subsections 704.03 and 1002.02*)

1. As colder weather approaches each fall, the Department experiences a series of problems connected with concrete construction in cold weather. The first indication of the problem usually shows up as a low test result on a 7 day cylinder. At that stage, it is not known if the problem is an improperly fabricated cylinder.

2. A cylinder which has been exposed to colder conditions than the structure, or if the low strength actually represents the concrete in the structure. Sometimes the later cylinder tests show satisfactory results, but in other cases, low strengths are found in these tests also.

3. In some cases, definite information regarding the true condition of the concrete in the structure can only be obtained by coring the material and carrying out a series of special tests.

4. The best fogging system may be the simplest. Hand held fogging nozzles that mix compressed air and water to form a fog are some of the best fogging systems observed. (One nozzle that works very effectively is called a Hydro-Air Washer made by Power Systems Inc. of Lancaster, TX.)

W. Simultaneous Casting of Deck and Approach Slabs

1. Casting the approach slabs and the deck simultaneously creates a smoother transition and ride. However, to avoid maintenance and to preserve the integrity of the deck and the approach slabs, a metal bond breaker should be placed over the abutment across the entire width and depth of the deck. This will ensure that a random crack does not occur before the joint can be cut. At the grade beam, the joint is usually blocked out with styrofoam.

2. The rail that the finishing machine rides on must be uniformly rigid. Unfortunately, where the rail passes over the grade beam and abutment, the rail is frequently more rigid than either side of these substructures. This can cause a dip either side of the abutment and the grade beam, which can result in a “bump” over the abutment, and grade beam.

3. Another problem can result when the deck overhangs the outside girder. Typically, the deck forms are supported by outrigger jacks braced against the outside girder. The weight of the concrete and the finishing machine can momentarily bend the outside girder as the placing operation progresses. Temporary construction braces (usually wood blocks) between all girders can prevent girder movement.

X. Surface Checking (Not in Spec)

1. A 10 ft (3 m) straightedge surface check shall be conducted on all bridges and deck overlays not covered by the Smoothness Specification. Surface areas inaccessible to profilometer shall also be checked.

2. On some projects only one wheel path may be included in the placement width. For price adjustment or incentive pay, only the portion within the traveled lane shall apply. Variable width sections for on and off ramps, which are outside the through traveled lane, will be checked with the surface checker.

Y. Test Procedure for Smoothness

1. A Special Provision entitled “Bridge Deck and Approach Slab Smoothness” will usually be included in the contract proposal. This Provision deals with the method of testing for smoothness and the method for correcting surfaces outside of the smoothness limits. The contractor is responsible for scheduling the testing, which will be performed by Materials and Research Division personnel. The contractor must give the Project Manager seven days notice prior to the date he requests that testing be done. The Project Manager shall contact the Materials and Research Division and arrange for testing on the requested date. Evaluation

2. Materials and Research Division will furnish a profile index to the contractor within 72 hours of the completion of the tests.

Z. Smoothness of Bridge Decks

1. Checklist - The following items should be checked and procedures followed prior to, during, and after the overlay is placed to insure a smooth riding deck surface:

a. Guide rails are used to support and guide the finishing machine. Check for rail deflection during passage of finish machine. Any vertical or horizontal movement could compromise smoothness and rideability. Request that the contractor readjust anchor legs and/or tie-downs.

b. Check that all propulsion and control equipment are fully operational prior to placing concrete. The contractor shall traverse the finishing machine over the entire length of section to be placed. This not only serves to verify that equipment and control systems are functioning properly, but also provides a check to assure that screeds are adjusted for proper crown and height above existing surface.

c. Sufficient materials (water, cement aggregate, and admixtures) are available on site to complete the intended placement in a continuous operation.

d. The contractor may have to limit size of placement or provide additional mixers (HD-LS only).

(1) If a mobile mixer is not large enough to provide adequate volume for the placement, or

(2) If there is no provision for recharging.

e. Ensure that adequate number of vehicles are available at the work site to transport mix from mixer to the placement area at a volume necessary to provide a uniform rate of forward progress. Any equipment working on the deck should be checked for oil and hydraulic fluid leaks.

f. Contractor must provide sufficient, trained personnel to carry out the various phases of deck placement. Timeliness is of utmost importance during placement operations. Be sure specialized crafts, such as finishers, are

adequately represented and preferably have only one task during the placement.

g. Check concrete for smoothness with the 10 ft (3 m) straightedge. The straightedge should be placed on the surface from a vertical position, not pushed over the surface. Irregularities can be detected by comparing deck surface with a straightedge. Irregularities noted at this time should be corrected.

2. Surface Correction

a. Corrective work shall be done in the presence of the Engineer with a diamond bladed grinder at least one meter wide. Grinding residue must be controlled. After the deck is ground, a second test will be made to determine if the deck now meets the smoothness requirements. This second test will also be performed by Materials and Research personnel and it is anticipated they will be on-site at the time of grinding, in order that they may perform the retest while the grinding equipment is on-site.

3. Acceptance

a. Materials and Research personnel will notify the Project Manager whether or not the corrective work has resulted in an acceptable deck surface. If grinding cannot correct the surface profile, the Specification requires removal and an overlay with high-density low slump concrete.

b. Troubles and expense of this sort could virtually be eliminated by careful and detailed inspection by project personnel during construction and proper handling of test cylinders.

4**.** Missed Texturing

a. There will be times, due to various reasons, when texturing will have to be omitted from a pour. One such event could be when inclement weather catches a pour and covering prevents texturing. Obviously this condition is **NOT** desirable.

b. After full cure time has expired, grind in the required texture.

AA. Approach Sections--Bridge Approach Tapers

1. On deck overlay construction, normally some treatment of the approach is necessary and will be indicated on the plans. Watch the contract documents for bid items for ACC material. For projects where asphalt tapers are proposed and no quantity for ACC is given, an extra work order will be required.

a. Shoulder Maintenance - When temporary concrete barrier rails are used on deck repair and overlay jobs, traffic is constricted into a narrower lane. This in turn could cause a rapid deterioration of shoulders at bridge approaches and require the following corrective measures:

(1) Ruts developing in earth and granular shoulders should be repaired as necessary with a granular surfacing material. This is extra work order and a change order will be issued for this work.

(2) Ruts and loss of asphaltic cement concrete surfacing on Interstate shoulders should be repaired using an asphalt cement concrete pre-mix, hot mix, or some similar treatment to minimize the development of holes or ruts. A change order may be needed for this work unless there is an ACC contract item for shoulder maintenance and even then it may have to be extended.

(3) When shoulder strengthening was not included as a bid item, but is needed for the project, the change order must consider:

(a) Present shoulder construction and experience with shoulder stability in the immediate area.

(b) Traffic volumes, percent of trucks, and duration of potential problem.

BB. Setting Beams

1. The following should be used as a guide in conjunction with *SSHC Section 704*:

a. On diaphragm piers, beams may be set as soon as doing so will not mar or chip the concrete. It is recommended that 24 hours be considered a minimum cure time. (In cooler weather, ambient temperatures below 40°F (5°C), the minimum time indicated should be increased to 48 hours.)

b. No beams may be set on piers until the cap concrete is at least 7 days old and has its design compressive strength.

c. On stub abutments, steel beams and girders may be set as under A above. Concrete beams on stub abutments, same as A above. On full abutments (solid and continuous from spread footing), same as A above.

706.04 METHOD OF MEASUREMENT

A. The cubic yards of concrete for structures of varying sizes are computed from dimensions shown in the plans and placed in tables in the plans. All structures using the same type of concrete are lumped together.