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100 Structures General

101 Scope

This portion of the construction handbook pertains to bridge structures. Its purpose is to clarify or emphasize certain portions of the specifications and to describe desirable procedures in those areas where experience has indicated a need. Infrequently used items and portions of the specifications involving common practice have not been included.

The intent of the information presented is to assist project personnel in obtaining finished work conforming to the plans and specifications. It is not intended to supersede specification requirements and in case of apparent conflict, the plans and specifications govern.

New methods of equipment that the Contractor proposes to use which are not specified, but can be expected to produce a satisfactory or superior product, may be permitted. In case doubt exists concerning the quality of expected results, the particulars should be reviewed with higher authority

102 Personnel

The handbook is intended to serve as a guide to the Engineer and inspectors during the construction of bridge structures. Sufficient qualified personnel are to be assigned to control the work properly. District personnel should be readily available for review of problems of whatever nature arising on the project which cannot be resolved by the Engineer or when assistance is desired.

103 Engineering

When the survey work is performed by the Contractor, the Engineer shall, by observation of the work and review of notes, assure himself that accuracy is obtained. A state survey crew shall be available for checking any part where this assurance is not obtained. The Contractor's surveyor should cooperate with the Engineer by providing the notes on critical work such as bridge seat elevations, profiles of beams or girders and grade for finishing the deck for review and concurrence. Information that indicates the elevation of bridge seats and deck grades have been properly set shall be recorded in the project file.

Relations between the Engineer and surveyor should be in the spirit of cooperation toward achieving the common goal of bridges constructed of specified quality in plan location and on proper grade which will benefit both the state and the Contractor.

104 Construction Plans

Plans for temporary structures, sheeting and bracing, erection of prestressed box beams, welding either temporary or permanent attachments to the structural steel, and falsework shall be submitted at least 30 days before construction is scheduled to begin.

Sheeting and bracing plans for work adjacent to railroads, temporary bridge plans over a railroad, and demolition procedures for structures over a railroad should be submitted at least 50 days ahead of scheduled construction or sooner, depending on past experience with the railroad involved. Plans for an erection procedure for structural steel shall be submitted at least 30 days before erection is scheduled to begin. Erection plans which involve a railroad shall be submitted at least 50 days before work is scheduled to begin.

105 Safety Provisions

When traffic is maintained while work is performed overhead, platforms, nets or other devices shall be provided to safeguard the traveling public from falling objects.



200 Temporary Structure

This item consists of the construction, maintenance and subsequent removal of a temporary bridge or culvert for maintaining traffic.

201 Plans

The design of a temporary bridge shall be in accordance with SOP PH-C-205 (Directive No. DH-20C). The waterway opening generally should be not less than 75 percent of the effective waterway of the proposed structure based on the 5-year water level. The deck of a bridge shall have at least a 7.0 m (23-foot) clear roadway and, if pedestrian facilities existed at least a 1.2 m (4-foot) wide sidewalk shall be provided.

The proposed plan should be reviewed in the District for accuracy of existing features not shown on the project plans. If the proposed waterway is less than 75 percent, comments regarding local knowledge of stream fluctuations will be helpful. In lieu of a bridge, a pipe culvert or multiple pipe culverts with required waterway may meet the requirements for a bridge and will be considered when submitted.

Plans shall be submitted at least 30 days before construction is scheduled to begin and must bear the signature or seal of the registered professional engineer designer. When a temporary structure is to be built over a railroad, the plans should be submitted at least 50 days before construction is scheduled to begin.

202 Materials

A careful examination of all stress-carrying materials to be used in any temporary structure shall be made since used materials generally are employed and may not possess the physical properties considered in the design. Timber elements shall be examined for specified size and soundness. Steel members shall be examined for holes and alterations that would reduce their section modules. Welded splices in members are not cause for rejection providing the welds have been made properly and are proven to be free from defects. Welded butt splices shall be subject to radiographic inspection. Hardware and miscellaneous materials must be as specified on the approved plan.

203 Construction

203.1 Piling

Piles shall be driven in accordance with 507. The bearing capacity of each pile shall be as specified on the approved plan but in no case less than 107 kn (12 tons). If actual driving requires lengths greater than anticipated and feasible to provide, capped piles with

a post bent or specifically designed splices will be considered when submitted for approval.

203.2 Conformance to Plan

Construction of the temporary structure must be according to details and notes shown on the approved plan. Proposed substitution of the elements of equal or greater strength may be made. All other proposed substitutions or changes in design shall be submitted for approval.

204 Use of Existing Substructure

When the plans permit the use of an existing structure as part of a temporary run-around, the bridge shall be relocated in such a manner that there will be no reduction in load carrying capacity. The plans for temporary substructure units shall be submitted for approval.

205 Maintenance

The Contractor is required to maintain the temporary structure in good condition with respect to safety, ride quality and waterway opening for the duration of the run-around. Periodic inspection of the structure shall be made and any questionable members or connections that are damaged or over stressed shall be corrected immediately.



300 Excavation for Structures

301 Cofferdams, Cribs and Sheeting

The Contractor may elect to use whatever materials or methods he considers necessary to accomplish this item unless specific details are required by the plans. Many times stream beds into which sheeting is installed, consist of sand or gravel. Sand and gravel are pervious materials and will allow water to flow through them. If this condition exists, water can flow under the sheets and come up through the bottom of the cofferdam. This can loosen the soil in the bottom of the cofferdam and cause it to be very soft and unstable. It can also result in water coming up through any freshly placed concrete. If this situation exists, the contractor should take measures to prevent the flow of water up through the bottom of the cofferdam. These measures can consist of driving the sheet piling deep enough to cut off the flow of water or placing a concrete seal in the bottom of the cofferdam prior to pumping out the water. If additional measures are required, they are considered to be part of the cofferdams, cribs and sheeting item and no additional compensation should be allowed for these items.

In order to qualify as Cofferdams Cribs and Sheeting for a particular substructure unit, it is necessary for the contractor to perform work to protect and maintain the excavation at that particular substructure unit. This work can include pumping out water, installing cribs or sheeting, or building an earthen cofferdam.

302 Unclassified Excavation

This item may include bedrock and requires the removal of all materials necessary for construction of structures according to plan. It also includes subsequent backfill and disposal of excavated material.

302.1 Protection

Sides of excavation should be protected from caving. If side failure occurs, the disturbed soil should be removed and replaced with properly compacted soil. The sides must not be laid back to the extent where the slope will endanger the stability of adjacent foundations.

302.2 Undercut

302.2.1 Spread Footings.

When footings are not on piling, any material undercut or disturbed below plan or authorized elevation shall be replaced with concrete at the Contractor's expense. If the

excavation is allowed to remain exposed for a considerable period of time and the material becomes unsuitable, it shall be removed and replaced with concrete at the Contractor's expense. The additional concrete may be placed with the footing concrete, however, the footing reinforcing steel shall be located at the elevation indicated on the plans.

302.2.2 Pile Foundations.

When footings are supported on piling, any material undercut or disturbed shall be replaced with properly compacted material. If the bottom of the excavation becomes muddy, the Contractor may wait for it to dry out to provide stability by removal and replacement with suitable granular material.

302.3 Drainage

When the Cofferdam, Cribs and Sheeting item is not provided, drainage outside the forms and pumping necessary to keep the surface suitable for placement of concrete are considerable as included in the excavation item.

303 Rock Excavation

This item includes removal and disposal of material which, in the opinion of the Engineer, is rock or hard shale. Shale that is removed by the same methods and comparative effort as soil should be classed as soft shale.

303.1 Methods

Rock or hard shale may be removed by whatever methods the Contractor elects. These usually are blasting, jack hammering or ripping. It is desirable to have rock excavation below the tops of footings as near to the sides of the footings as practical.

303.2 Qualifications for Payment

To qualify for payment as rock excavation, the material must be considered rock or hard shale by the Engineer and all of the rock excavation below top of footing must be filled with concrete. Rock excavation performed above the top of footing may be to any width, however, payment above as well as below the top of footing is to the plan dimensions of the footing only.

303.3 Elevation Changes

In the event bedrock is encountered over 0.3 m (1 foot) higher than indicated by the borings or bedrock is not encountered at plan elevation, the findings should be reported to the District Construction Engineer for consideration of a change in elevation of the footing. A plan note usually will be provided when raising the footing can be permitted. When bedrock is not encountered at footing elevation, an investigation of the soil should be made as deep as practical. Hand augers or probes are recommended for initial investigation.

Generally, when bedrock is found less than 0.3 m (1 foot) lower than plan elevation, the additional height of pier or abutment can be provided by additional footing concrete; however, reinforcement should be placed at plan elevation.

When bedrock is found 0.3 m (1 foot) or more below plan elevation, consideration should

be given to lengthening the pier or abutment above the footing. Relative costs should be investigated in either case and, if the cost difference is significant, should be reported to the District Construction Engineer for review.

304 Approval of Foundations

When the foundations for a bridge are spread footings, they are designed to be supported on soil or bedrock as indicated by the soil borings and drive rods. The soil or bedrock encountered at plan elevation must be examined by the Engineer for agreement with soil boring data and to assure that it will provide the intended bearing capacity. This bearing capacity will be listed in tonnes per sq. meter (tons per square foot) in the plan notes.

304.1 Bearing Capacities

Listed below are bearing capacities that various materials generally will provide, and may be used as a guide in evaluating materials encountered.

| Normal Bearing Capacity Tonnes per Sq. Meters Material | (Tons per Sq. Ft.) |
|---|---------------------------|
| Clay, Silt, or Clay and Silt..... | 5 to 39 (½ to 4) |
| Sand or Gravel..... | 0 to 39 (1 to 4) |
| Cemented Sand and Gravel..... | 0 to 98 (5 to 10) |
| Soft Shale..... | 9 to 49 (3 to 5) |
| Hard Shale | 9 to 117 (5 to 12) |
| Solid Rock..... | 9 to 293 (5 to 30) |

304.2 Questionable Support

Whenever there is doubt that the material encountered at plan elevation will provide the necessary bearing capacity, the District Construction Engineer should be consulted. Whenever the material encountered is different and of lesser quality than indicated by the borings, an investigation similar to that described in 3.3.3 should be made, and the findings reported to the District Construction Engineer for review.

305 Cold Weather Excavation

Footings placed on pile foundations which were exposed to temperatures below freezing sometimes settle during the setting of the concrete and result in unsatisfactory footings. It is therefore, imperative that the soil in such cases be free from frost and, if disturbed by freezing, compacted to proper density.

305.1 Protection

When excavation for footings is performed and freezing temperatures are expected during the time it is exposed, insulation such as an adequate thickness of straw is recommended for protection from frost.

305.2 Examination

When the excavated area has become frozen and the area is heated in an enclosure, the effect of the supplied heat on the frozen soil is slight, and a thorough examination for complete removal of frost is required. Satisfactory temperatures found in spot checks of soil over the entire area to as deep as frost may have penetrated is an indication of frost

removal.

When frozen soil is thawed out, the density is lessened by frost heaving and the soil requires recompaction. If reinforcing steel has been placed in a footing area at the time the soil was frozen, it will be necessary for the contractor to first remove the reinforcing prior to recompacting the soil.

306 Measurement

306.1 Excavation Prior to Altering the Original Ground Line

When the plans do not require the original ground line to be altered by removal of the embankment and when structural excavation is performed prior to building an embankment, elevations or measurements that establish the elevation of the original ground must be made. Measurements made and recorded from the Contractor's footing grade stakes can be used to establish the elevation of the original ground.

306.2 Excavation Made After Altering the Original Ground Line

When the original ground will be altered by removal or construction of an embankment prior to excavation, the plan line of the excavation or embankment items is to be used for top boundary of excavation.

306.3 Verification of Footing Elevation

The bottom elevation of the footing is to be as shown in the plans. This elevation is to be verified by subtracting the total verified height of the substructure unit below the beam seat, from the beam seat elevation which has been verified as provided in 103.



400 Piling

Piling is an arrangement of beams installed in the ground that provide a foundation for substructure units. These beams for the most part consist of either steel H beams (H-piling) or hollow steel tubes which are filled with concrete and sometimes reinforcing steel (Cast-in-place piles). When piles are used, they are designed to carry the entire load of the substructure unit under which they are placed.

401 Mobilization

This item provided for reimbursing the contractor for moving his pile driving equipment to and from the site as well as all other fixed costs.

402 Layout

A layout should be prepared showing piles in each substructure unit with a numbering system which identifies each pile. Dimensions that locate the piles, batter, required bearing and any other pertinent information should be shown on the layout.

403 Bearing Piles

Bearing piles or service piles are piles that are driven to the required bearing capacity to serve as support for substructures.

404 Driving Equipment

404.1 Hammers.

In Appendix 1 are listed all power driven hammers which have been assigned a State energy rating which is to be used in the driving formula. In addition to power driven hammers, a drop hammer may be used having a ram weight of 1360.8 kg (3,000 pounds) and a distance of fall not exceeding 2.1 m (7 feet).

Power driven hammers are powered by either compressed air or igniting diesel fuel. These hammers are classified as either single-acting hammers or double-acting hammers.

404.1.1 Single Acting Hammers

Single acting hammers are those which have their rams lifted by either compressed air or igniting diesel fuel. When the ram reaches the top of its stroke, it is allowed to fall back to its original position. Hammers which are powered by igniting diesel fuel, are opened on the top which allows the ram to become exposed during driving.

404.1.2 Double-Acting Hammers

Double-acting hammers are those which not only have the ram lifted by either compressed air or igniting diesel fuel, but in addition to gravity, compressed air also imparts a downward force on the ram.

Double-acting hammers for which the power source is diesel fuel, are closed at the top. The space between the top of the ram and the top of the hammer casing is called the bounce chamber. As the ram rises in the hammer, the volume of the bounce chamber decreases which increases the pressure of the air inside the bounce chamber. This increased air pressure imparts a downward force on the ram.

404.1.3 Hammer Size

If the plans specify a minimum size of hammer, one having a State energy rating at least the size specified must be used. Otherwise, the choice of size is the Contractor's option. However, the hammer selected such that the required blow count to achieve the required ultimate load for the pile, as determined by formula 507.05, must not be less than 100 blows per meter (30 blows per foot) or greater than 240 blows per meter (75 blows per foot).

The use of a hammer which is too big, i.e. the required blow count is less than 100 blows per meter (30 blows per foot), will result in a pile which does not have the required capacity. This is due to the fact that the hammer will not be operating at full capacity at these lower blow counts and its energy will be less than that used in the formula used to determine the blow count.

The use of a hammer which is too small, i.e. the required blow count is greater than 240 blows per meter (75 blows per foot), will result in a pile which does not have the required capacity. This is due to the fact that the hammer is operating at or near its full capacity and additional blows will not result in additional capacity as determined by the formula in 507.05.

A driving cap that centers the pile under the hammer and uniformly transmits the blow must be used.

404.2 Driving Leads.

Driving leads guide the travel of the hammer and cap during driving and must be capable of keeping the hammer in line with the axis of the pile. The leads should be equipped with a yoke at the base to center the pile and project beyond for anchorage.

405 Driving Piles

Piles must be driven to the bearing specified on the plans or as instructed in case penetration exceeds the limits described in 403.1. Occasionally the design bearing also is listed on the plans, however, this should not be mistaken for the bearing to which piles are to be driven. Abutment piling must be driven through embankments to bearing in the existing soil. Sometimes pre-bored holes are provided in the plans to assure this. If not, it is the Contractor's responsibility to pre-bore holes or use other means to drive the piles through the embankment and into the underlying soil.

Occasionally when bearing is achieved prior to the pile being driven 80 percent of the estimated penetration, project personnel require the contractor to continue driving the pile to achieve a penetration of 80 percent of the estimated penetration. The 80 percent of the estimated penetration is only a guide to aid the project personnel. The contractor should not be required to overdrive the pile to obtain the 80 percent without first consulting with the Director.

In the event a pile reaches 150 percent or more of the estimated length or less than 80 percent, about two more piles should be driven in scattered locations to verify this trend. If these piles also exceed the above limits, the Director should be contacted for advise. Complete information regarding equipment and driving log along with any unusual driving experiences should be made available for review. During this review, the contractor may be permitted to continue his driving operation. However, the contractor should not be required to attempt to drive the piles to 80 percent of the estimated penetration. He should also not cut the piling off until after the review.

406 Operation of the Hammer

The operation of the hammer should be observed during the driving of piles to insure that the hammer is working properly. The speed or stroke of the hammer should be as shown in Appendix 1 or as required by the manufacturer of the pile hammer. Hammers which are not operating properly will result in an indicated bearing which is higher than the actual bearing.

406.1 Double Acting Hammer

After significant bearing is obtained, double-acting hammers should operate at one of the speeds or a greater speed for which an energy is assigned. If that speed is not obtained, the hammer is not working properly, and driving should discontinue until corrections are made. If the hammer is operated too fast, it will jump off the pile and the ram will strike before it has settled back down. Maximum energy is obtained at a throttle setting just under this point.

Some double-acting diesel hammers may be equipped with a gage placed on the ground and connected to the bounce chamber by a hose. The gage shows the pressure developed for each stroke of the ram. A graph, included with the gage, can be used to convert the pressure to the energy developed by the hammer for each blow. The hose connecting the gage to the bounce chamber comes in different lengths which can affect the reading on the gauge. Therefore, it is important to insure that the graph corresponds with the length of hose used.

406.2 Single Acting Hammer

After significant bearing is obtained, the speed or stroke at which the single acting hammers is operating should be noted. If the speed or stroke is different then that used to determine the energy of the hammer, a new energy should be assigned to the hammer. If the speed is too fast, or the stroke is too short, the hammer is not working properly, this will result in an indicated bearing which is higher than the actual bearing.

The pile should not rebound significantly between blows of the hammer. Appreciable

rebound results in an indicated bearing higher than that actually obtained.

407 Driving Formula.

The formula for driving with a drop hammer is:

$$R = 3276DWH/(S+7.62) \text{ or } S = (3276DWH - 7.62R)/R$$

$$[R = 4DWH/(S+ 0.3) \text{ or } S = (4DWH-0.3R)/R]$$

$$B = 1000/((3276DWH/R)-7.62)$$

$$[B = 12/((4DWH/R)-0.3)]$$

and with a compressed air or diesel hammer it is:

$$R = 334DF/(S=2.54) \quad S = (334DF-2.54R)/R$$

$$B = 1000/((334DF/R-2.54)$$

$$[R = 4DF/(S+0.1) \text{ or } S = (4DF-0.1R)/R]$$

$$[B = 12/((4DF/R)-0 .1)]$$

R = Ultimate bearing value in newtons (pounds)

B = Blows per meter (foot)

$$D = (1-UG)/\sqrt{(1 + G^2)} \quad (\text{For battered piles only, } D=1 \text{ for vertical piles})$$

W = Weight of the ram, in kilograms (pounds)

H = Height of fall of ram, in meters (feet)

F = State's approved energy rating for compressed air or diesel hammers, in joules (ft. - lbs.), see Appendix 1.

S = Penetration, in millimeters (inches) per blow

U = Coefficient of friction, which is 0.2 for drop hammers, 0.1 single acting hammers and 0.05 for double acting hammers

G = Rate of batter (1/3. 1/4. etc.)

3276 (4) = Coefficient to be used unless modified by test loading as described in 416 or by special instructions from the Director.

408 H-piles.

When H-piles are specified, the plans usually require that they be driven to bedrock. In special cases when they are not intended to be driven to bedrock, a zone of boulders or extremely dense granular strata is expected to be encountered.

Although a design load is given to H-piles to be driven to bedrock, usually a plan note will specify driving criterion which will assure bearing on bedrock. The note requires that the piles be driven to refusal, or to 20 blows per 25 mm (1 inch).

When the bedrock is hard and unweathered, refusal can be considered as obtained after the piles contact bedrock and have been struck at least 20 more times, not necessarily for penetration of 25 mm (1 inch), to insure that firm contact has been established. Care should be used to avoid damaging the piles.

When the bedrock is soft or weathered and after the piles have contacted the bedrock, the piles shall be driven to a minimum resistance of 20 blows per 25 mm (1 inch) for a short distance (several inches). This amount of penetration may be difficult to obtain when the energy rating of the hammer is 20,325 joules (15,000 foot pounds) or less.

Mill test reports are required for steel H-piles and should be reviewed by the Engineer for conformance to 711.01.

409 Cast-in-place Piles

A cast-in-place reinforced concrete pile consists of a metal shell or casting which is filled with concrete. The gage of metal shell elected generally is heavy enough that additional reinforcement is not necessary.

The shells may be tapered or of uniform section. The tapered piles generally used are monotubes, and shells of uniform section are called pipe piles. Tapered monotube point sections come equipped with a bullet-nosed tip. Pipe piles usually have a plate welded on the point which shall not extend more than 6 mm (1/4 inch) beyond the surface of the pile at any point. The metal of the shells is not specified and mill test reports are not required.

The shells shall be inspected and necessary measurements made. Due to the possibility of lateral earth pressure causing adjacent shells to collapse, this inspection and measurement should be made after all the adjacent shells are driven. After the shells are driven the tops are to be covered until they are filled with concrete. Before filling with concrete, water and debris shall be removed. Concrete required for filling the shell is Class C containing a superplasticizer admixture. After the superplasticizer has been added, the slump should range from 150 mm to 200 mm (6 to 8 inches). The concrete should be deposited in a steady small stream so complete filling and consolidation is obtained. If there is reinforcing steel in piles, the concrete could become segregated from coming into contact with the reinforcing steel while it is dropping in place. To eliminate this problems, drop chutes should be used. No driving shall be performed within 4.6 m (15 feet) of filled piles until the concrete has cured at least seven days.

410 Alignment in Leads.

For the full effect of the energy of the hammer to be transmitted to penetration of the pile, the axis of the hammer must be in line with the axis of the pile.

411 Defective Piles

A pile is considered defective if damaged to the extent that the strength of its section is reduced over 20 percent. This can occur as a collapse of the shell where less than 80 percent of the cross-sectional area remains open or where the shell is ruptured to the extent that the pile will have over 20 percent less strength.

A pile is also considered to be defective if the location of the pile at the ground surface differs from the specified location by more than 0.3 m (1 foot) for piles which will be entirely underground or by more than 75 mm (3 inches) for piles which project above the ground. No attempt should be made to draw these piles to the specified location.

411.1 Replacement Piles

If it is practical to withdraw a pile, the replacement can be driven in the specified location. If the defective pile is not withdrawn, it shall be filled completely with concrete. If it is under a footing, it shall be cut off slightly above the bottom of the footing where it will provide some support, but will not be paid for. A replacement pile will need to be driven beside it. The replacement should be located on the same line parallel to the side of the footing and battered slightly if necessary to avoid contacting the defective pile or adjacent piles.

When a replacement pile is driven alongside, rearrangement of reinforcing steel will be necessary. If sufficient space is not available to avoid crowding of bars, it may be necessary to cut the bars at the pile and provide bars on either side lengthened for bond. In lieu of this, the pile may be cut off below the reinforcement and the footing deepened approximately 0.3 m (1 foot) around the pile and below cutoff.

The replacement pile only shall be included for payment. Any additional material or work required to make it a satisfactory pile will be at the Contractor's expense.

412 Deviation from Normal

The Director should be consulted in case of deviation in length of driven pile as described in 403.1, and also whenever uncertainty exists as to efficiency of the hammer, defective piles, driving characteristics or replacements.

413 Documentation

The following data should be included in the project records:

1. Source documents of complete or final meter (foot) logs indicating the required bearing for all piles.
2. Record of measurement establishing pay length of each pile. This may be determined from the driving length marks or the total pile length minus cutoff, whichever is sufficiently accurate and most practical. For cast-in-place piles a statement that the inside measurement checked the pay length determined as

above is to be made.

3. A layout drawing which shows the location of all piles in a structure and assigns a numbering system by which the pile logs and pay lengths can be identified.
4. A complete piling report including the source documents should be retained in the project records.

The complete report should include the information called for on the back of the Pile Driving Log, Form BR-2. One copy of the report should be submitted to the Office of Structural Engineering. This is a complete copy which includes Form BR-2 for piles requiring complete logs, and the Piling Record, Form BR-5, along with a copy of the pile layout.

414 Splicing

Splicing may be necessary to provide the required length to achieve bearing. Numerous splices using small lengths in the same pile should be avoided, particularly in an area exposed to view. Splices should be made at least three feet above the ground in order that the weld may be observed while subject to the driving forces. If bearing is obtained prior to splicing a pile, the pile should still be driven a minimum of 150 blows after the splice is made in order that the weld may be observed. When splicing structural shapes (H-piles), welding shall be performed in accordance with section 513.17 of the Construction and Material Specifications, which, among other things require the use of a prequalified welder. See Figure 414 for method of making the required welded butt splice.

415 Method of Measurement

The three main pay items associated with the pile driving operation are piles furnished, piles driven, and pile splices.

415.1 Piles Furnished

The quantity of piles accepted for payment as piles furnished shall be based on the total order length specified in the plans and required by the Engineer. The order length is the length of pile which the designer is estimating is necessary to use in the structure. If the designer determines that it will require an extremely long pile be driven to achieve the required bearing, he may specify an order length that will result in the utilization of a splice. The contractor may elect to use piles longer or shorter than the order length as he determines necessary to meet his needs. However, the contractor is responsible for any additional cost resulting from his choice to utilize length other than the order length.

During the driving, it is necessary for the Engineer to monitor the length of piling necessary to obtain bearing. If the order length given in the plans is not sufficient to achieve bearing, the Engineer should inform the contractor of the necessary additional order length. The Engineer should inform the contractor as soon as possible to allow him to order the piles in a timely fashion and avoid additional costs due to down time expenses.

415.2 Piles Driven

The pay quantity for piles driven shall be the sum of the length of all nondefective piles

measured along the axis of each pile from the bottom of each pile to the elevation of cutoff. This quantity will be paid in addition to the quantity of piles furnished, and may not necessarily correspond with the quantity of piles furnished.

415.3 Piles Spliced

The pay quantity for pile splices shall be based only on those splices made necessary when the length of pile driven is greater than the length of pile ordered. The contractor should not be paid for splices which are not made. The contractor should also not be paid for splices which are required if he furnishes pile lengths shorter than the order lengths.

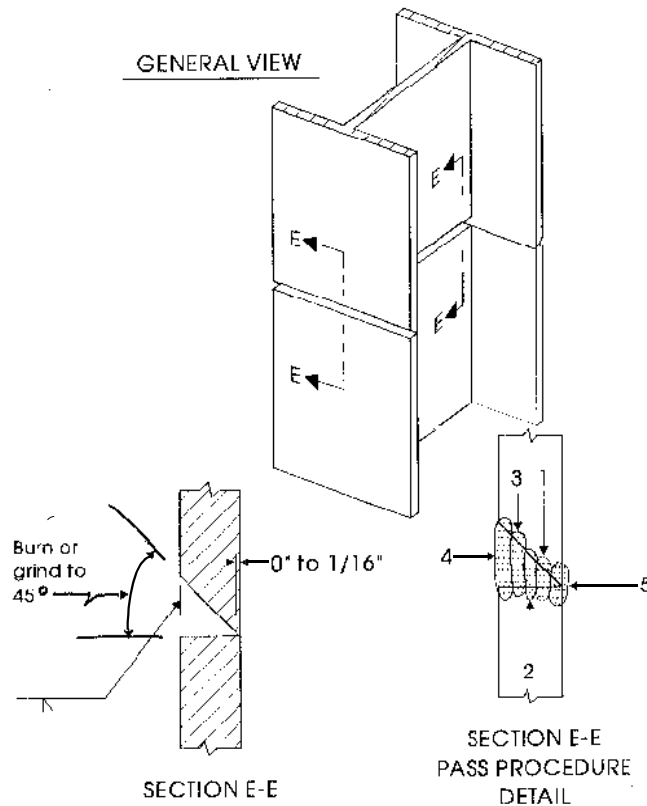


Figure 414 Joint Preparation for Groove-Welded H Pile

NOTES: In case a different number of passes is required than shown, a similar sequence must be followed with the finishing pass on reverse side. Back gouge root pass prior to making the finishing pass.

416 Pile Test Load

Pile test loads are used to determine the accuracy of the driving formula. They are provided by the plans usually for one or more of the following reasons:

1. When the predicted resistance to be encountered during driving is questionable or may not be indicative of the bearing capacity the piling will attain after it has been driven for a period of time.
2. When the amount of piling is 3,000 linear meters (10,000 linear feet) or more and a modification of the pile driving formula could shorten the length of piling which could result in an appreciable savings.
3. When the required bearing per pile is 80 tonnes (90 tons) or higher, and assurance is desired that the design bearing is being obtained.

416.1 Determination of Need

The Director shall be consulted to determine if a subsequent pile test load or dynamic pile tests should be performed.

416.2 Test Loaded Pile

The pile to be test loaded is to be selected by the Engineer. Consideration should be given to a location that permits the Contractor to use service piles as anchor piles.

416.3 Bearing

Unless instructed otherwise, the pile to be test loaded is to be driven as nearly to the required bearing as possible. Over-driving may result in misleading data.

416.4 Anchor Piles

The number of piles to be used as anchor piles and penetration obtained, is to be determined by the Contractor. They are not to be closer than 2.1 m (7 feet) center to center to the pile to be loaded and are to be parallel to it. If the anchor piles later are to serve as service piles and are overdriven, the length driven is the pay length. If underdriven, they will need to be redriven to the required bearing as indicated by the formula, and modified if required by test load results.

416.5 Application of Load

Unless a longer wait is required by the plans, the test load shall not be applied to the pile being tested nor any of the anchor piles until at least 72 hours have elapsed since they were driven. No other service piles for the structure are to be driven until after the results of the loading have been interpreted, except by permission of the Director.

The pile to be tested, should be cut off as near to the ground as practical and the jack placed in the axis of the pile with full bearing on the required load cell and bearing plate.

416.6 Instruments

The Contractor shall furnish the Engineer with a set of gages or devices capable of accurately determining settlement of the pile to 0.03 mm (0.001 inch) and a calibrated load cell for determining the load applied.

The gages or devices used to measure the settlement of the pile should be placed opposite each other and should be placed at the sides of the pile. They should be supported from posts or fixed objects. The post or fixed objects are to be independent of

the test load set up and not closer than 1.22 m (4 feet) from the pile to be loaded. However, the gages or devices should be placed as close to the pile to be test loaded as possible. Dial gages generally are furnished and they should have sufficient travel or gage blocks capable of measuring over 25 mm (1 inch).

The load cell used to determine the load applied does not rely on hydraulic pressure within the pump to determine the load. If the hydraulic pressure within the pump was used to determine the load, and for some reason the pump should bind-up, the hydraulic pressure within the pump would increase while the load transmitted to the pile would not necessarily increase.

416.7 Loading

The load is to be applied in increments consisting of a first increment of 1/5 the required capacity of the pile (R) and 1/10 R for each increment thereafter. Measurements indicating settlement of the pile are to be observed and recorded just prior to the application of each increment and immediately after each increment is applied; then every 20 minutes as long as the reading indicates a settlement of 0.3 mm (0.01 inch) or more. Whenever a reading is less than 0.3 mm (0.01 inch) an additional increment shall be applied after one hour. Readings do not need to be made during the one hour wait. At the end of the waiting period, a reading is made and the next increment applied, then repeated as described above.

416.8 Completion of Load

The yield point is reached when the pile experiences plunging failure. Plunging failure is defined as when the settlement exceeds 0.8 mm per tonne (0.03 inch per ton) for the increment applied. Whenever plunging failure is reached before the total load exceeds 1.5R, an additional increment is to be applied to determine if the pile again experiences plunging failure. If plunging failure is not repeated, additional increments are to be applied until plunging failure is reached or the total load reaches 2R. If plunging failure is repeated, the yield point is considered to be confirmed.

If the yield point has not been reached and a total load of 2R has been applied, the loading is complete and no additional increments are required.

416.9 Unloading

After loading is complete and all measurements have been recorded, the pile may be unloaded. The net settlement is to be recorded 3 hours after unloading.

If it is necessary to remove and reapply the load it shall be reapplied utilizing the same procedure used to apply the initial loads except that the load increment shall be applied 15 minutes after all measurable settlement has ceased.

416.10 Interpretation of Results

416.10.1 Yield Point Reached

When the yield point is reached, the maximum load which the pile is able to support is Q or the test load ultimate bearing value. To determine the value of Q it will be necessary to

plot the settlement versus the load on the pile. It will then be necessary to draw a straight line parallel to the plotted line. This straight line should be drawn from the zero point and extend through the .2R load value. The straight line should then be offset by the amount derived by the formula $3.8 + .008D$ ($.15 + .008D$). D is the diameter of the pile in mm (inches). Where the offset line crosses the plotted line, the corresponding load at this point is the

ultimate bearing value Q. See FIG. 416.

416.10.2 Yield Point Not Reached

If 2R is applied and the yield point is not reached, the test load ultimate bearing value Q shall be considered as 50 percent of 2R.

416.10.3 Application of Results

Before commencing to drive service piles based on the results of the test load, the Director should be consulted for review and recommendations. The complete test load data and the driving log of the loaded pile should be available for this review.

The results of a test load will apply to the same type and size of piling driven with the same type of hammer to approximately the same depth with similar driving characteristics as the test loaded pile.

The hammer used for driving the test loaded pile shall be used for driving all piles represented by the load test pile. If the Contractor subsequently finds it necessary to use a different size and type of hammer, the Office of Structural Engineering will determine if an additional test load is required; any such additional test load shall be completed at no additional cost to the State.

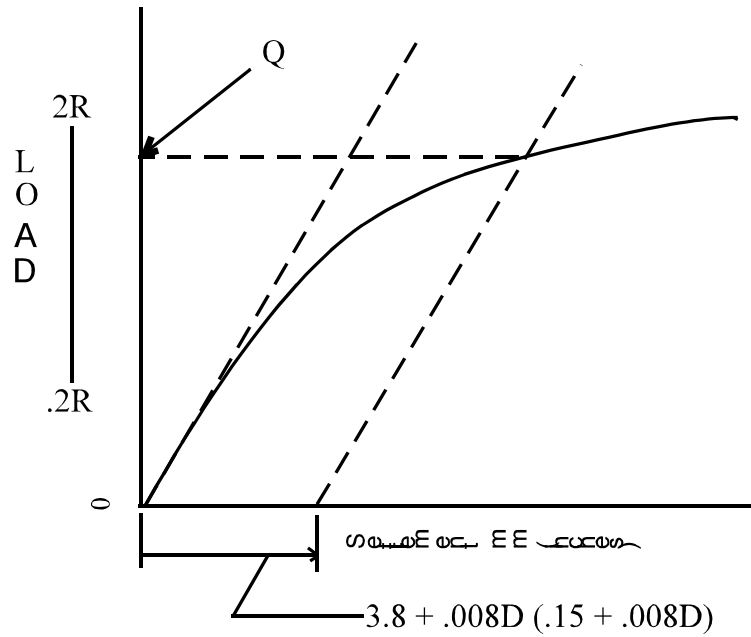


FIG. 416

416.11 Records

Documentation shall consist of the driving log of the test-loaded pile identified by the pile numbering system on a piling layout and the test load report.



500 Drilled Shafts

Drilled shafts are reinforced concrete columns which, for the most part, are built below the surface of the ground. They are designed to provide a foundation for structures and carry the entire load of the structure.

501 Contractor's Installation Plan

Prior to installing drilled shafts the contractor is required to submit to the Engineer a written installation plan. This plan should be closely reviewed for conformance with the specifications. Among other things, the plan should describe how the contractor is proposing to excavate the hole and place the concrete.

If a permanent casing is specified, the casing should be installed to the prescribed depth before excavation begins. In some cases the contractor may not have the required equipment to completely install the casing prior to excavation. If the contractor is not able to completely install the casing prior to excavation, he is allowed to either excavate the material within the casing or excavate a pilot hole ahead of the casing. If the contractor proposes to excavate the material within the casing to aid in the installation of the casing, it is important that it is made clear that the excavation does not proceed beyond the casing. If the contractor is proposing to either pump or tremie the concrete under water while utilizing a temporary casing, his plan should describe how he proposes to remove the casing while not disconnecting or breaking apart the tremie or pump hose.

502 Types of Drilled Shafts

There are basically two types of drilled shafts. The two different types are end bearing and friction types.

End bearing drilled shafts derive most of their capacity through point bearing on a hard substrate such as bed rock.

Friction type drilled shafts derive most of their capacity through a combination skin friction with the soil along the perimeter of the drilled shaft, and point bearing on the substrate immediately below the drilled shaft. In order to obtain the required skin friction, it is important that the integrity of the soil be maintained during the drilling operation and prior to placing the concrete.

503 Methods of Excavation

There are several different methods used to stabilize the sides of the excavation during the construction of the drilled shaft. Factors which impact the method chosen are types of soil,

the elevation of the ground water, types of drilled shafts, plan requirements and equipment utilized by the contractor.

503.1 Dry Construction Method

The dry construction method can be accomplished by excavating the hole without the use of steel casing. The sides and bottom of the excavation should remain stable and should not experience any caving, sloughing, or swelling. It should be possible to visually inspect the excavation prior to the placement of concrete.

The excavation should be done in a relative dry condition with very little ground water present. The flow rate of any water which might enter the excavation should be such that the elevation does not change by more than 300 mm (12 inches) per hour. At the time of concrete placement, there should be no more than 75 mm (3 inches) of water in the bottom of the excavation.

503.2 Wet Construction Method

The wet construction method should be used at sites with or without casing and where dry excavation cannot be maintained. This method consists of using either water or slurry to contain or prevent the seepage of ground water into the drilled shaft. With the use of slurry, this method may be used in lieu of a temporary casing to maintain the stability of the hole perimeter while advancing the hole to its final elevation.

If this method is used to excavate a hole for a friction type drilled shaft, it is important to not compromise the integrity of the soil along the perimeter of the drilled shaft through the seepage of ground water. It is not only important to prevent the seepage of ground water into the excavation after it is completed, but it is also important to prevent ground water from seeping into the excavation during the drilling process. To prevent this, it will be necessary to continually pump either water or slurry into the hole during the drilling operation to maintain an elevation slightly higher than the elevation of the static water table.

When the wet construction method is used, the concrete should be placed by either a tremie or a concrete pump.

Unless waived by the Engineer, it is required for the contractor to utilize a temporary surface casing to prevent soil at the top of the casing from sloughing and falling into the excavation. The temporary casing also aids in the proper alignment and positioning of the drilled shaft.

503.3 Temporary Casing Construction Method

Temporary casing may be used at sites where the dry excavation cannot be maintained and the contractor elects not to use slurry.

It is important that the contractor begins removal of the temporary casing while the concrete remains workable. Failure to remove the casing could result in a drilled shaft which is not capable of supporting the design load

When the casing is being withdrawn, there is the possibility that fluid which might be

trapped behind the casing will contaminate the concrete. To prevent this, it is important to maintain a head of concrete at least 1.5 meter (5 foot) in the casing. This minimum head may need to be increased to counteract any ground head which might be in the casing at the time it is withdrawn.

504 Friction Type Drilled Shafts

Friction type drilled shafts derive much of their capacity through the adhesion of the concrete with the surrounding soil. If the contractor elects to use a temporary steel casing and fails to remove it or he fails to protect the integrity of the soil adjacent to the drilled shaft, much of the capacity of the drilled shaft could be lost.

When drilled shafts extend below the top of the water table it is important that the water or slurry fluid inside the shaft excavation at all times be maintained higher than the top elevation of the water table. To accomplish this, it is not only important for the contractor to add water or slurry fluid after the excavation is completed, but it is also important for him to add water or slurry fluid during the drilling operation. If this is not accomplished, the surrounding ground water will begin entering the excavation and eroding the soil. This will result in the capacity of the drilled shaft being reduced.

The dry construction method can be used in construction of friction type drilled shafts. It should be used when the bottom of the drilled shaft is above the water table and the excavation can be made without the sides or bottom of the excavation experiencing any caving, sloughing or swelling. If the dry construction method results in the sidewall becoming softened or swelling, the contractor shall overream the sidewall to sound material.

If the contractor elects to use slurry, a delay in placing the concrete could result in the sidewalls degrading due to slurry cake buildup. Any slurry cake buildup shall be corrected by reaming the sidewalls to sound material.

If a temporary casing is not used, and concrete is not placed the same day that the excavation is completed, the excavation shall be re-drilled 150 mm (6 inches) larger in diameter immediately prior to the placement of the concrete.

If a casing is used, it should be smooth and free of concrete dried concrete and other foreign materials which might contaminate the fresh concrete. While the strength and thickness of the steel casing is not specified, it should be strong enough to withstand handling and driving stresses and also the pressures exerted on it by the fresh concrete and the surrounding earth.

The outside diameter of the casing should be at least equal to the plan diameter of the drilled shaft. Many times the contractor will elect to use a casing larger than the specified casing. Oversized casings are acceptable, however, all additional costs associated with the oversized casings should be born by the contractor.

Many times the diameter of the bedrock socket will be less than the diameter of the remainder of the drilled shaft. When the diameter of the bedrock socket is the same as the remainder of the drilled shaft, the diameter of the drilled shaft may need to be

increased to permit the excavation of the bedrock socket. Again, increasing the diameter of the drilled shaft should be done at no additional cost to the State.

506 Slurry

One potential method of excavating a hole through unstable or caving soils is through the use of a slurry. The slurry should be added to the excavation during the drilling process and replaces the material which is being removed. This is accomplished by mixing the slurry with the material to be removed. The combination of slurry and soil is then pumped from the hole while clean slurry is added. The slurry which was pumped from the hole is then cleaned of foreign material and then replaced back into the hole. This process is continued until the original soil has been removed.

There are two different types of materials used to produce slurries. One type of material produces a mineral slurry and the other type of material produces a polymer slurry.

If the contractor elects to use a polymer slurry it will first be necessary for him to demonstrate the slurry's ability to prevent caving of the hole. If the slurry is not capable stabilizing the perimeter of the hole while the hole is being excavated it should not be allowed. This should be accomplished by the use of a separate trial hole. This trial hole should not be one of the production shafts and no separate payment should be made for the trial hole. The trial hole should be the same size and diameter as the largest production drilled shaft except the depth of the hole need not be more than 12 meters (40 feet). The slurry used in the trial hole should be the same as that used in the production shafts.

507 Concrete

The concrete used in the drilled shaft is a modified Class S. In order to aid the consolidation of the concrete without vibration it is necessary to increase the water to cement ratio to 0.50 and the slump has been increased to 150 mm (6 inches) plus or minus 25 mm (1 inch). If the concrete is placed using a tremie, the slump should be increased to 200 mm (8 inches) plus or minus 25 mm (1 inch).

If the contractor is using the wet method or placing concrete under water or slurry, the concrete should be placed by either a tremie or a concrete pump. In order to prevent air voids in the concrete when a tremie or pump is used, the concrete should be placed in one continuous operation. If the contractor is allowed to break apart the tremie tube or pump hose to facilitate the removal of temporary casing, the tremie tube or pump hose will get air voids in them which will be forced down into the drilled shaft concrete.

If a temporary casing is used, it should be removed slowly and carefully. As the casing is removed concrete which has been previously placed will fill the void left by the casing causing the top level of the concrete in the excavation to lower. As the level of the concrete drops, the concrete will tend to pull down on the reinforcing steel. If the casing is removed too quickly, the downward force of the concrete on the reinforcing steel will cause the reinforcing steel to be displaced.

508 Tremie

A tremie may be used to place concrete in a wet hole. If concrete is placed in a wet hole

it is important that the concrete not be placed into moving water. If concrete is placed into moving water, the water will have a tendency to wash the cement off of the sand and aggregate. To prevent moving water in the excavation the level of water or slurry in the excavation shall be equal to or higher than the level of the ground water.

The tremie shall not contain aluminum parts which will come into contact with the concrete. In order that the concrete can pass freely through the tremie the minimum diameter of the tremie shall be at least 250 mm (10 inches). It is also important that the tremie be clean, smooth and free of built up concrete and other foreign material.

Prior to placing the tremie tube into the water, it is important to plug the end of the tremie to prevent the intrusion of water into the tremie. After the plug is in place the tremie can be placed into the excavation. After the tremie is filled with concrete, it should be raised up no more than one diameter of the tube. This allows for the plug to be displaced and the concrete can begin flowing into the excavation. If the tremie is not plugged the tube will fill with water. When the concrete is dropped through the tube it would drop through the water which would tend to separate the cement from the sand and gravel.

During the placement of the concrete, the end of the tremie should always be at least 3 meters (10 feet) below the surface of the concrete to prevent the water from contaminating the fresh concrete. Since the concrete will be under water and not visible, it is important to devise a method to be able to determine elevation of the top of the concrete and the bottom of the tremie. This method should be determined and agreed upon with the contractor prior to the delivery of the concrete to the project.

In order to prevent air voids in the concrete when a tremie is used, the concrete should be placed in one continuous operation. If the contractor is allowed break apart the tremie tube to facilitate the removal of temporary casing, the tremie tube will get air voids in them which will be forced down into the drilled shaft concrete.

If the end of the tremie is pulled out of the concrete prior to completely placing all the concrete the drilled shaft will contain concrete which will be contaminated by water. As a result the drilled shaft may not have the required strength and should be considered defective.

After the concrete placement has been completed, there will be a layer of concrete at the top of the drilled shaft which has been contaminated with water. This concrete should be removed either by overfilling the drilled shaft and causing the contaminated concrete to flow out of the drilled shaft or by shoveling off the concrete. If the contaminated concrete is shoveled off, it will be necessary for the contractor to place additional concrete to replace the concrete which was shoveled off.

509 Pumped Concrete

A pump may be used to place concrete in a wet hole. If concrete is placed in a wet hole it is important that the concrete not be placed into moving water. If concrete is placed into moving water, the water will have a tendency to wash the cement off of the sand and aggregate. To prevent moving water in the excavation the level of water or slurry in the

excavation shall be equal to or higher than the level of the ground water.

Due to the adverse reaction of concrete with aluminum, the pump shall not contain aluminum parts which will come into contact with the concrete.

In order that the concrete can pass freely through the pump the minimum diameter of the pump pipe shall be at least 100 mm (4 inches).

During the pumping operation the pipe used to convey the concrete to the bottom of the drilled shaft shall be anchored to the steel casing or other suitable stationary object to prevent the pipe from undulating. If this is not accomplished, the tendency of the pipe to undulate could cause it to pull out of the concrete which was previously placed.

In order to lubricate the pump equipment, grout should be first pumped through the hose prior to pumping the concrete. The grout should not be placed in the drilled shaft. This process does not need to be repeated as long as the process is continuous.

Prior to placing the pump pipe into the water, it is important to plug the end of the pipe to prevent the intrusion of water into the pipe. After the plug is in place, the pipe can be placed into the excavation. When the pipe is filled with concrete, the pressure of the concrete will dislodge the plug. If the pipe is not plugged and the concrete drops through the water, the water would separate the cement from the sand and aggregate.

During the placement of the concrete, the end of the pump pipe should always be at least 3 meters (10 feet) below the surface of the concrete to prevent the water from contaminating the fresh concrete. Since the concrete will be under water and not visible, it is important to devise a method to be able to determine elevation of the top of the concrete and the bottom of the pipe. This method should be determined and agreed upon with the contractor prior to the delivery of the concrete to the project.

In order to prevent air voids in the concrete when a pump is used, the concrete should be placed in one continuous operation. If the contractor is allowed break apart the pump pipe to facilitate the removal of temporary casing, the pipe will get air voids in it which will be forced down into the drilled shaft concrete.

If the end of the pipe is pulled out of the concrete prior to completely placing all the concrete, the drilled shaft will contain concrete which will be contaminated by water. As a result the drilled shaft may not have the required strength and should be considered defective.

After the concrete placement has been completed, there will be a layer of concrete at the top of the drilled shaft which has been contaminated with water. This concrete should be removed either by overfilling the drilled shaft and causing the contaminated concrete to flow out of the drilled shaft or by shoveling off the concrete. If the contaminated concrete is shoveled off, it will be necessary for the contractor to place additional concrete to replace the concrete which was removed.

510 Inspection Records

It is the contractor's responsibility to provide the Engineer with all the necessary labor and equipment to obtain measurements of the drilled shaft. Since it would not be possible to obtain these measurements after the concrete is placed, it will be necessary to obtain these measurements prior to placing concrete.

Due to the risks involved, at no time should the Engineer ever go down into a drilled shaft for inspection or any other purpose..

A copy of form BR112 should be filled out and submitted to the Office of Structural Engineering in Central Office.

511 Method of Measurement

The pay length of the drilled shaft is the required accepted length which is measured along the axis of the shaft. It should be measured from the required bottom of the shaft to the proposed top plan elevation. Any over excavation below the required bottom of the shaft should not be measured for payment.

Drilled shafts which extend into bedrock should be divided into two sections. The lower section is the length of the drilled shaft which extend into the bedrock or the bedrock socket. The upper section is the length drilled shaft above the bedrock . If the top elevation of the bedrock is lower than indicated on the plans, the additional upper section or length of drilled shaft above bedrock, should be measurement for payment. The contractor should not be paid for any over excavation of the bedrock unless he is ordered to do so by the Engineer.



600 Falsework

Falsework is the system of temporary support of formwork for concrete members. The falsework is to remain in place until the concrete members have attained required strength and are self-supporting. This includes the system of supporting formwork for deck slabs and pier caps.

601 Plans

For slab bridges over 6 m (20-foot) span, the contractor must submit a falsework plan for approval. No superstructure concrete shall be placed until an approved plan is received and the falsework conforms to the approved plans. The contractor may substitute elements of equal or greater strength, if it does not involve a change in depth which effects elevations. Any other deviations from the approved plan that the contractor desires or which become necessary due to unforeseen conditions must be covered by approval of a revised plan.

601.1 District Review

Before forwarding the falsework plan, a review should be made at the project to ascertain that the plan is complete and existing conditions shown are representative of those found in the field.

601.2 Camber

The maximum deflection that is permitted in the falsework of a slab bridge is specified in 508.01. Camber equal to this deflection must be built into the falsework to compensate for falsework deflection. In addition, camber equal to 1/800th of the span must be built into the falsework to compensate for deflection of the slab after falsework is released. Also camber to conform to the vertical curvature of the profile grade must be provided.

If unusual requirements for span of an existing road or channel or restrictions due to vertical clearance exist, a falsework plan may be approved which exceeds the maximum deflection requirements providing it can be expected to perform properly.

602 Materials

Falsework members must be of the section and length shown on the approved plans. Members having a greater section modulus may be used; but, if this involved a change in depth and affects elevations, details of modifications should be submitted for approval.

Steel members such as stringers shall be in good condition. They shall not show loss of section through rusting, excessive weldments or holes that would affect their strength.

Timber shall be sound and of the required size. Used timber which shows deterioration and stress cracks may not perform its functions and must not be used.

603 Construction

603.1 Piling and Posts

Piling must be driven to the bearing called for on the approved plans. A check should be made of the required blow count to obtain this bearing. Sufficient driving should be observed to assure that the required bearing is being obtained.

Posts that extend to rock are anchored with pins and provided with a mortar pad for proper seating.

603.2 Consolidation of Wood

Allowance for consolidation of wood wedges and blocking must be provided. Using rough cut timber, an allowance of 2 mm (1/16 inch) for each contact surface generally will be necessary.

603.3 Independent Support

Where adjacent concrete decks are separated by open joint, forms for the cantilevered edges of each slab must be supported independently from each structure. This is necessary to avoid warping of the forms due to differential deflections during placing of the decks.

603.4 Superimposed Concrete

Prior to placing sidewalks, safety curbs or other superimposed concrete on the deck of a slab bridge, the falsework must be removed or released, and allowed to deflect.

604 Removal of Falsework

Falsework may be removed when the conditions tabulated in the table of section 511.14 have been met. Any piling not removed is cut off at least to the slope line or riprap line of bed of stream.

605 Documentation

The approved plan and statements that the falsework was constructed in conformance with the plan are required.



700 Concrete and Reinforcing for Structures

701 General

Concrete mix design, mixing equipment and control is as set forth in the Manual of Procedures for Concrete. Inspectors whose assignments involve concrete, forms and reinforcing as applied to structures are to follow the procedures described herein, and should familiarize themselves with these instructions.

702 Forms

702.1 Location

Prior to the erection of the forms for each substructure unit, the inspector should satisfy himself that the contractor is placing the forms in the correct location. This should be accomplished by available methods which do not require the use of instruments.

702.2 Types and Use

Footing concrete may be placed against rock, hard shale or sheeting. All other concrete must be placed in substantial forms which are designed and constructed so that finished concrete will conform to plan lines and dimensions and will have a satisfactory surface. Forms for exposed surfaces are to be made of acceptable materials that will produce a smooth surface with a minimum number of joints. Acceptable materials include sheet plywood, fabricated metal forms, fabricated metal frames with plywood inserts or dressed lumber of uniform thickness with a form liner of plywood, masonite or sheet metal.

Form lumber which has had many uses and bent metal forms which will not produce an acceptable surface on concrete when stripped, regardless of finish specified, are to be rejected. Care should be exercised to obtain as flush a fit as possible at panel joints. When rustication grooves are required, panel joints should, if possible, be made to coincide.

The underside of a deck that cantilevers out from the fascia beam is considered an exposed surface and requires forms with smooth surfaces. The underside of pier caps is considered an exposed surface and forms with smooth surfaces should be used and cut to fit neatly around columns or piles.

The inside of all forms are to be coated with a bond-breaker. If the forms are not so coated and oiling is necessary, it should be done before placing the reinforcing steel or preferably before assembly of the forms.

702.3 Design

Forms must be braced adequately and provided with walers and form ties that are properly designed to maintain the proper dimension and alignment for the proposed height and rate of concrete placement. Some suppliers of form ties specify the height of concrete in meters (feet) per hour that can be placed for their design. All form ties and anchor bolts used for form support are to be designed for removal of 25 mm (one inch) in from the exposed surfaces of concrete.

702.4 Incidental Work

Moldings for the 19 mm (3/4-inch) beveled edges and rustification grooves must be surfaced on all sides and be of uniform section. The bevel strip should be nailed at sufficient intervals to completely fill a corner or contact the form for the full length. Rustification strips are fastened to the forms in such a manner that the molding will remain in contact with the concrete when the forms are stripped and not removed until the concrete has set sufficiently to avoid damage.

Weep holes through abutments and retaining walls are formed in such a manner as to obtain a smooth circular opening. To form the hole, metal such as downspouts or sonotube may be used and later removed, or noncorrodible rigid plastic pipe may be used and left in place, provided the gradient and inside diameter are in accordance with 508.02.

All scrap wood, dirt and other foreign material, including ponded water, must be removed from within the forms prior to placing concrete. If the forms are too deep or narrow to permit easy removal of foreign material from the top, a temporary opening should be left at the bottom through which this material can be removed. An opening also must be provided when necessary for inspection. Temporary openings are to be made mortar tight after the forms have been cleaned and inspected.

An inspection should be made of the forms for proper fit and holes where leakage of cement paste may occur. Openings must be corrected in such a manner as to close the hole and provide a smooth form surface. Filler strips, plugs and tin commonly are used to plug such openings. Forms should be watched closely during the placing of the concrete and any leaks must be corrected immediately.

702.5 Verification of Dimensions

Before any concrete is placed, dimensions of the forms should be measured for compliance with the plan requirements and approved change orders. Measurements that will result in concrete equal to or greater than plan dimensions are considered verified plan dimensions. The measurements must be checked for compliance with the plan dimensions and then recorded and filed in the project records. A statement that the dimensions have been checked and are in compliance with plan requirements is not acceptable verification. The recording may consist of any of the three following methods:

1. A tabulation of all the verified plan dimensions for simple shapes.
2. A sketch on an appropriate form showing all of the verified plan dimensions.
3. The plan sheet for the structure unit with the verified dimensions checked thereon.

Whichever method is used, the Inspector should date and sign the sheet. If checks are

made on different days, dates should indicate on which day each check was made. If different inspectors check parts of the measurements, each should initial those checks which he has made.

If measurement are not in compliance, correction shall be made and the dimensions rechecked before the concrete may be placed.

703 Reinforcing Steel

703.1 Storage

All reinforcing steel received on the project must be stored off the ground and kept free from dirt, oil, grease and avoidable rust. It must not be stored in a place where it will be damaged or bent by equipment or be located in the path of drainage.

703.2 Cleaning

Varying degrees of rust or scale do not adversely affect the bond characteristics of deformed bars. Thick rust or heavy scaling which has developed after prolonged exposure may cause a reduction in the effective cross section and height of deformations, and should be checked if, in the opinion of the Engineer, the condition warrants it. Light rusting which is powdery or tight needs no cleaning. Normal handling prior to installation may be sufficient to remove heavy rust, or it may be removed by tapping. Wire brushing or rubbing is not necessary. Oil or grease on the steel will affect bond seriously and must be removed with a solvent. If steel requires cleaning and this condition exists before placing, it should be done outside the forms where it will not cause an accumulation in the forms which will have to be removed before placing concrete.

703.3 Placing

Notice of approval from the Office of Material Management must be received before any reinforcing steel is encased in concrete. Conformance of the bars to plan length must be checked. This can be done during placing by comparison to fit in measured forms. All steel required in any structure unit must be included in that unit. Advance separation of the steel by structure units from prepared lists can preclude omissions. An accurate check of the total number of bars of each bar mark placed should be made and spacing spot checked. An example is the bars that make up the mats in a deck. The total number of bars is more important than extreme accuracy in the space between adjacent bars.

703.4 Clearances

For reinforced concrete to have the strength for which it was designed, the reinforcing steel must be located at the specified distance from the surface.

Reinforcement shall be placed in the position shown on the plans and kept in that position while the concrete is being placed. To attempt to position a reinforcing bar cage during or after depositing of the concrete is not permitted. Bolsters or chair should be used or the cage should be assembled and wired so that the proper clearances are obtained before encasement.

When placing reinforcing dowels extending out of a footing, they shall be located

accurately so that they will lap properly with the reinforcement in adjoining concrete. This applies particularly to dowels for pier columns where the location of vertical column bars is specified.

The most critical clearance is that between the top mat of the reinforcing steel and the deck surface, which is 57 to 64 mm (2 1/4 to 2 1/2 inches). The clearance between the bottom steel and the bottom of the slab on a beam bridge is 38 mm (1 1/2 inch). To maintain this clearance bolsters or chairs will be required to be spaced no more than 1.2 m (4 feet) apart both transversely and longitudinally on the forms between beams. The bottom steel must be spaced from the forms, never from the beams. The bolsters have a tendency to indent the forms and cause less than the 25 mm (1 inch) clearance. A tolerance of 3 mm (1/8 inch) plus or minus in bottom steel clearance is permitted.

A piece of wood approximately 51 mm (2 inches) long with accurate side dimensions of 35 mm (1 3/8 inch) and 41 mm (1 5/8 inch) is recommended for use in checking clearances from the forms for the bottom reinforcing steel.

Transverse reinforcing bars may be fabricated slightly longer than plan and result in less than the plan clearance to the fascia form. Where the transverse line of steel is made up of more than one bar, any overrun can be taken up in the lapped splices. For narrower decks where the line is a single bar, removal of any extra length that will not provide a 25 mm (1-inch) minimum clearance is required.

Reinforcing steel must be tied together sufficiently so that each bar will retain its proper position after encasement. When workers will be on the steel, additional tying is necessary to meet this requirement. Bars in the superstructure shall be tied at all intersections except where spacing is less than 0.3 m (1 foot) in each direction in which case alternate intersections shall be tied.

703.5 Supports

Reinforcement may be spaced by metal supports or precast mortar blocks of the same class of concrete as that to be placed. Metal supports should be checked and measured as soon as possible to determine that they will provide the proper clearance. Precast mortar blocks must have a wire or other device cast into each block for attaching them securely to the reinforcing steel. Broken pieces of precast mortar are not permitted.

703.6 Welding and Splicing

Welding on reinforcing steel is prohibited.

Number 45 M and 55 M (14 and 18) bars shall be spliced with approved mechanical connectors. They shall provide 125 percent of the yield strength of the bar and installed according to the manufacturer's instructions. If Cadweld's are used all splices shall be inspected for complete filling of the void between the sleeve and the bar as evidenced by metal deposited to the ends of the sleeve and projecting at the filler opening. To further insure this, the splice kits should be examined prior to installation for the proper kit number and its components.

Splices in spiral reinforcement shall be made by lapping the bar for a length equal to one and one-half turns.

703.7 Epoxy Coated Reinforcing Steel

When epoxy coated reinforcing steel is specified, plastic coated or epoxy coated bar supports and tie wires are required.

Bars shall be carefully handled and installed so that patching at the job site will be kept to a minimum. It is not expected that the coated bars, when in final position ready for concrete placement, will be completely free of damaged areas. However, numerous nicks and scrapes which expose the steel will not be allowed, regardless of the stage when they occur subsequent to coating in the plant. All damage defined as significant damage shall be patched. At the discretion of the Engineer, numerous areas of damage not defined as significant damage shall also be patched.

Significant damage is defined as any opening in the coating which exposes the steel and which exceeds the following sizes:

An area of 6 mm (1/4 inch) square or 6 mm (1/4 inch) diameter.

An area approximately 3 mm (1/8 inch) square or 3 mm (1/8 inch) diameter if the opening is within 6 mm (1/4 inch) of another opening of the same or larger size, a length of 152 mm (6 inches) in length, regardless of area.

All areas to be patched shall first be cleaned to a near white metal, i.e. free of absolutely all rust and foreign material.

No concrete should be placed against the patch until it has adequately cured. Prior to placing concrete the patches should be checked to insure that the patch has cured and is hard.

703.8 Verification

Reinforcing steel and any specified mechanical connectors are to be in place and approved by the Engineer before any concrete is placed. Record of this approval should be recorded in the daily diary. The reinforcing steel and mechanical connectors in each structure unit is verified by a check-off inspection. This verification may consist of a separately prepared list of all bars and mechanical connectors in each unit listing the number of bars by bar mark or checked off the record plan sheets with the checks identified and validated. With the exception of the mechanical connectors, all the lists and record plan sheets are summarized on the plan steel list which is verified by reference to them.

704 Placing and Finishing Concrete

704.1 Mix Design

Concrete for structure will be Class C, S, or as specified in the plans or proposal. The mix design and control are as outlined in the Manual of Procedures for Concrete except as

modified for specific uses as hereinafter described.

704.1.1 Materials.

Specifications require all concrete above the ground line in a given substructure unit or all concrete for any given superstructure be made of aggregate of the same kind and color, except upon permission of the Engineer.

All superstructure concrete (deck concrete including safety curbs, sidewalks and parapets) is to be made with natural sand, crushed stone, crushed air-cooled blast-furnace slag, or gravel. The kind and color of aggregate are considered to be the same from any one source. However, materials from the same producer but from different plants are not considered the same and require permission.

When a Contractor desires high-early-strength concrete he may use high-early-strength cement, additional cement, approved water-reducing, set-retarding admixture or a combination of these. If the Contractor desires to obtain high-early-strength using additional cement and/or admixtures as a continuing practice, his method should be submitted to the Engineer for review.

704.1.2 Control

All concrete used in structures must contain $6 \pm$ percent of entrained air unless otherwise specified. An air determination should be made for each part of the structure. This determination should be made as early as possible on the first load of concrete. For substructure concrete, as many additional air tests as necessary should be made to assure required air content. For superstructure concrete, an air test should be made for each load of concrete used. Concrete containing less than the specified amount of air may have the air content increased by addition of an air entrained agent providing additional minimum of 30 revolutions, at mixing speed, is accomplished and the time limitation for discharge is not exceeded. Concrete which is pumped can lose air as the concrete passes through the pump. Therefore, it is important that air tests be made after the concrete passes through the pump.

The slump of concrete for all units of a structure shall be maintained within the range specified in 499.03. An occasional load exceeding the nominal slump but within the maximum may be used provided immediate steps are taken to adjust the slump of succeeding loads. Before concrete exceeding the nominal slump range may be used, the Contractor or supplier must take positive action to reduce the slump of following loads. Successive loads of concrete exceeding the nominal slump should not be used even though it is within the maximum slump.

Approved chemical admixtures may be incorporated into concrete to improve workability and extend the setting time. Chemical admixtures shall meet the requirements of 705.12 which specifies that they meet the requirements of ASTM C 494 chemical admixtures. These admixtures are as follows:

- TYPE A - Water reducing
- TYPE B - Retarding
- TYPE C - Accelerating

- TYPE D - Water reducing and retarding
- TYPE E - Water reducing and accelerating
- TYPE F - Water reducing, high range
- TYPE G - Water reducing high range and retarding

The type of admixture is optional with the contractor. However, a type B or D admixture is required when the air temperature is 16°C (60°F) or higher at the time of placement superstructure concrete and the span is over 6.1 m (20 feet).

704.1.3 Records

The results of the air tests together with yield tests are shown on the back of Form TE-45. The Ready Mixed Concrete Plant Ticket (TE-57) must show the number of revolutions at mixing speed. Mixers are rated at RPM for mixing speed and agitation speed which will be listed with the operating data on the mixer. The mixers must be checked to see that they are operating at the rated speeds. Somewhere on each ticket, the structure unit in which that load of concrete is placed, should be noted.

704.2 Advance Notice of Placing Concrete

The contractor must notify the Engineer at least 24 hours in advance of placing concrete. This provision of the specifications should be reviewed with the contractor near the start of work on a structure. This should be accomplished to permit a clear understanding to be reached regarding the stage of completion of work necessary to permit inspection before approval to proceed. The need for all or part of the 24 hours will depend on the amount of additional inspection required to insure that the reinforcing steel has been properly placed, and the forms are in the correct location.

704.3 Placing Concrete for Substructures

Several methods may be used to convey the concrete to the forms. Any method that will assure placement of concrete of the proper consistency without segregation will be satisfactory. Usually ready mix trucks with open chutes, buckets, drop chutes, and concrete pumps are used in placing substructure concrete. Open chutes must be sloped sufficiently to allow concrete of the proper consistency to flow readily. Drop chutes may be maneuvered to distribute the concrete but the delivery end shall be kept vertical. Concrete is deposited as near as possible to its final position with as short of a vertical drops as practical, but not over 1.5 m (5 feet).

Consolidation of concrete by the vibration method is required for structures. Spud vibrators generally are used and should have a workman assigned exclusively to the use of each vibrator. The vibrator should be pushed into and pulled out of the freshly deposited concrete slowly and as nearly vertical as possible. For narrow sections, the vibrator may be applied to the sides of the forms or a form vibrator may be used. A pattern of placing and vibrating should be established that will provide practically horizontal surfaces and uniform vibrator coverage. Generally a vibrator can consolidate the concrete in approximately an 457 mm (18-inch) radius. Therefore, a uniform coverage pattern must be used to assure uniform consolidation.

704.3.1 Footings

Where concrete will be placed to bedrock, the rock should be free of mud and cleared of

all loose rock or other accumulations. Soil serving as the bottom of footer should be sufficiently dry and stable that it will not be interspersed in the concrete.

Occasionally, concrete may be placed in, or under water. In such cases, the placement of concrete should begin in one corner of the forms and continue placing concrete into that previously deposited until full height of footing is attained. Full height should be carried forward displacing the water ahead and out a small opening in the opposite corner of the forms. Vibration of the concrete should be kept well back of the water. Concrete never is to be deposited in running water since it will cause separation of cement from the mixture. Pumping may be used to keep the water level just below concrete level if running water exists. Immediately after the concreting is complete, pumping may be halted or reduced so that the water rises slowly and inundates the footing to provide the cure.

When the plans require a concrete seal or it becomes necessary for the Contractor to use a seal to stop upward flow of water, the concrete must be deposited under water to minimize separation of the cement. A concrete seal is deposited in a compact mass with a minimum of disturbance with the water which it displaces. When a tremie is used, it must be filled with concrete prior to lowering and kept filled during placement. Failure to keep the tremie filled with concrete during placement, could result in water entering into the tremie tube through which the concrete is passing. This will result in the cement being washed from the aggregate. The Contractor's plans for the mix and placement should be reviewed prior to the pour. Where the Contractor elects to use a seal, it is his responsibility to choose a thickness and methods which produce satisfactory results.

704.3.2 Piers and Abutments

Concrete for backwalls shall not be placed until the abutments have been backfilled to within 305 mm (1 foot) of the bridge seat elevation unless otherwise approved by the Director.

The tops of backwalls which become roadway surface requires special methods for setting the grade. Although the recommended methods have been used to set the end dams, the elevations can be slightly off grade. Therefore, the tops of the endams should not be used alone to project the grade for the backwall. The preferred method of obtaining the correct grade is to place a 3.05 m (10-foot) straightedge as a screed supported on the superstructure concrete and the end dam. The backwall can be struck to the proper grade. Grade strips tacked to the backwall form which have their elevations established in a manner described above may be used to establish the grade. In the event that the grade for the surface of concrete is not flush with the end dam edge bar, it should be finished to the grade established above and edged to a radius equal to the offset where it abuts the edge bar.

After the forms have been stripped from backwalls and before the approach slabs are placed, the top surface of concrete is subject to damage by spalling of the sharp edge on the approach slab side. Protection should be provided by covering the surface with plank or any other method that will afford equal protection.

Concrete never should be deposited through closely spaced reinforcing steel where it may

accumulate and take a set prior to encasement or cause segregation of aggregate. The bars, such as the top main bars in a pier cap, should be moved out of the path of the concrete or hopper temporarily until the concrete level has reached the vicinity of the bars, then reset. If the plans require bearings for which anchor bolt holes will be drilled later, the bars must be reset accurately and checked with a templet.

704.3.2.1 Bearing Seats

Bearing areas on abutments and piers must be finished accurately to the plan elevations in order that the deck may be placed on profile grade. The elevations should be checked accurately at the time of finishing to correct for settlement of the forms containing the original marks and possible errors. As soon as possible after completion of the substructure units, elevations should be taken and recorded for future reference.

Bearing seats that are high or uneven are to be leveled to the proper elevation by bush hammering or grinding, and then smoothed with a thin film of portland cement paste to fill the pitted surface. Bearing seats that are over 3 mm (1/8 inch) low are leveled as described above, if necessary, and raised to the proper elevation by steel shims placed under the masonry plates. If elastomeric bearings are specified, steel shims should not be placed under the bearing. In this case, the contractor's proposed method of correcting the bearing seat should be approved by the Director.

Where it is necessary to cut down the bearing area, the lowering is extended approximately 25 mm (1 inch) around the area of the masonry plate and carried full width to the face of the abutment or pier cap for drainage.

704.4 Construction Joints

The surface of construction joints should be even and have coarse texture such as produced by a wood float on fresh concrete. Vibrated concrete with a closed level surface is satisfactory. Where the construction joint terminates at an offset in the concrete surface, such as between the fascias of the deck slab and the sidewalk, the joint should be finished neatly at the corner with a wood float.

Transverse joints as permitted in 511.09 or longitudinal construction joints placed in deck slabs of steel beam or girder bridges are constructed with keys located between the reinforcing mats and having a depth of 19 mm (3/4 inch). If a longitudinal construction joint, not provided by the plans or specifications, is desired by the Contractor due to an excessive slab width, the request must be submitted to the Director for review.

704.5 Placing Concrete for Superstructures

704.5.1 Pre-Pour Conference

Prior to the day scheduled for placing a deck, preferably the day before, a conference should be held on the project to review the plans and preparations for the pour. The Contractor's superintendent and key personnel, together with the Engineer and available inspectors who will be involved should attend. At this time the superintendent should state fully his plan of operation and agreement should be reached with the Engineer on all of the following:

1. Provision for adequate delivery of concrete in order that placing operations will be continuous and provide sufficient length of workable concrete to permit proper straight edging. This includes the number of trucks assigned and an access route where ingress and egress will be maintained at all times.
2. Spacing of the trucks, especially at the start and end, so that no load will be delayed unduly in discharging or will placing be delayed for lack of concrete.
3. A communication system with the concrete plant available which will permit ready adjustments in the mix or delivery.
4. Proper tools and equipment on hand that have been checked for good working order. Tools must include 3.05 m (10-foot) straightedges of sufficient numbers and type for the size of deck and the Contractor's operations. A finishing bridge must be used when the deck cannot be reached for proper finishing.
5. A competent and experienced bridge superintendent in charge and at least two experienced finishers.
6. Factors which might determine the need for chemical admixtures explained.
7. Protection on hand in case of rain or low temperatures.
8. For decks with hinges, and where it is planned to terminate a pour at the expansion joint over the hinge, concrete placement should proceed in the direction which will load the longer part of the hinged span first in order to minimize the effects of unequal span loading, unless otherwise specified in the plans.
9. Properly curing the concrete and placing the wet burlap in a timely manner.
10. The proper use of evaporation retardard and the fact that it should not be used by the finishers to help them finish the deck.

704.5.2 Setting the Grade for Finishing the Deck

The need for setting the grade correctly for finishing a deck should be recognized as paramount for placing a deck on profile grade. Tables of deck elevations are shown on the plans. These include the dead load deflection due to the weight of the concrete.

Many times new structures will be constructed part width at a time to maintain traffic on a portion of the existing structure. Also, at times, an existing structure will be widened by adding at least two beam lines. To account for the differential deflection which will occur between the portion of the deck which has already been placed and that yet to be placed, a closure pour will be used. A closure pour involves a strip of concrete a meter (several feet) or more wide which is not placed until after the deck concrete in both phases is placed. It is placed the entire length of the deck between the two portions of deck.

When a closure pour is specified, the designer assumes that the finished elevation of the

existing deck is correct. However, due to either conditions beyond his control or conditions he has overlooked, the finished elevation of the deck may not be as he assumed. If this condition exists, it should be detected prior to placing the widened or second portion of the deck. Therefore, prior to placing the widened or second portion of the deck, the Engineer should check the finished elevation of the existing portion of the deck to assure that it is correct. If it is determined that it is not correct, the Office of Structural Engineering should be contacted for additional instructions.

704.5.3 Evaporation Rate

In an effort to reduce or eliminate some drying shrinkage cracks in the superstructure concrete, the concrete should not be placed when the evaporation rate of water from the freshly placed concrete is high. The evaporation rate should be checked by utilizing the graph in section 511.08.

The contractor should check the evaporation rate immediately before the placement of superstructure concrete begins. The evaporation rate should also be checked if there is a change in temperature, humidity, or wind speed during the placement of superstructure concrete. The wind speed can have the greatest affect on the evaporation rate, therefore, changes in the wind speed should be more closely monitored. Many times, during the summer months, it will be necessary to place superstructure concrete at night in order to comply with the evaporation rate.

In addition to the evaporation rate, superstructure concrete is also not allowed to be placed when the ambient air temperature is 30°C (85°F) or higher or is predicted to go above 30°C (85°F) during placement. The temperature of the concrete is also not allowed to exceed 32°C (90°F) during the mixing and placement. Many times it is necessary for the contractor to reduce the temperature of the mixing water in order to control the temperature of the concrete.

704.5.4 Screeding the Deck

704.5.4.1 Machine Finishing

A machine finish is required except for small bridges, where the requirement may be waived by the Engineer. Details of the method of supporting the machine on the deck and the complete procedure for placing the slab are required to be submitted to the Engineer for approval. Supports for the riding rails need to be adequate for the weight of the machine to avoid failure or excessive deflection. The concrete handling, placing and finishing procedure should be planned so that the concrete will be placed and struck off with a minimum of manipulation and at a sufficient rate to provide workable concrete in an area adequate for proper final hand finishing. Success of the contractor's procedure on previous decks should be considered.

For transverse machines, the screed should be assembled or adjusted to the required crown established from a taut line while suspended in the same manner as it will be in operation.

Prior to ordering concrete, preferably the day before, and after the finishing machine has

been made ready for use, a dry run is to be made over the entire deck. Checks of slab thickness and reinforcing steel cover shall be made along with crown conformance to both end dams and expansion joints. If the rate of crown varies and the machine can be adjusted during operation, the required crown should be determined at regular intervals not exceeding 7.62 m (25 feet), the required increment of adjustment established and the location referenced on the side of the bridge.

Plan dimensions for deck thickness and reinforcing steel cover verified during the dry run and the witnessing of the adjustments of the screed to the required crown shall be recorded in the project records. A last minute check that form dimensions and reinforcement have been verified and documented should be made at this time on the inspectors Daily Report.

Although proper measurements made during the dry run should assure plan dimensions, check measurements after the concrete is struck to grade must be made to verify that the machine is still in adjustment and reinforcing steel remains in place. Slab thickness measurements can readily be obtained by probing with a 6 mm (1/4 inch) ± straight wire and the cover over re-steel with a 90° bent wire of the same size. These measurements should be made soon after the start of the finishing operation and periodically thereafter or when an area appears questionable. Wide flat sections such as superelevated slopes are questionable and need checking. The probing should be performed in plastic concrete where the void will be more easily closed.

Some cover checks are required, however, they need not be as numerous as the depth checks which also reflect cover. It is recommended that as many depth checks be made as available time permits. A statement that check measurements have been made and conform to plan dimensions should be entered in the project records.

During operation, a uniform head of concrete should be maintained along the full length of the screed. Screeds should be lifted from the surface when not in use. During operation, only the operator is to be permitted on the machine. The machine should be in operation as continually as practical and the concrete placing procedure should not exceed the speed of the machine.

Tracking in the screeded surface is not tolerated.

704.5.5 Final Finishing

The construction joint surface under the sidewalk or the safety curb should not be used as a place for finishers to stand or as a passageway for workers. Planks may be placed on the sidewalk reinforcement providing sufficient additional ties and braces are used if necessary to obtain a rigid framework which will not disturb the bond of the stirrups.

Immediately after the final passage of the screed, any porosity that will not be closed by straight edging should be closed with long handled floats. Use of floats at this stage should be held to a minimum. Straight edging should follow the screeding as early as possible and cover the entire deck. A variety of types of 3.05 m (10 foot) straightedges can be used. Scraping or working straightedges that can correct irregularities left by the screeding

operation are required. Checking straightedges are light weight and are used for checking the finished surface. Each pass of scraping straightedge or application of a checking straightedge should lap the preceding pass by approximately 1.52 m (5 feet). When scraping straightedges are used over the entire surface, checks should be made with a checking straightedge at the start of operations and thereafter as often as considered necessary by the Engineer. The operation involving a checking straightedge, shall be performed by the contractor.

When the screeding operation leaves a smooth surface and is not followed up by working straightedges, the entire surface of the deck must be checked with a checking straightedge. The checking operation should be performed as early as possible in order that corrections can be made while the concrete still is plastic.

Minor surface irregularities left after screeding and straight edging can be corrected with long handled floats. This operation should be held to a minimum and any major irregularities encountered should be corrected by restraightedging. Use of water, or evaporation retardant on the surface of the concrete to facilitate finishing is not permitted.

In order that the concrete may be properly finished, the contractor's operation should be controlled which results in an elapsed time of no more than 10 minutes between the time the concrete is deposited and the final finishing is completed.

704.5.6 Texturing

The deck surface shall be textured to provide a surface satisfactory to the Engineer. The surface shall be textured by use of a broom or artificial turf drag. The broom or turf drag shall produce a uniform gritty texture in either the longitudinal or transverse direction. The broom or turf drag shall be immediately followed by an approved device that will produce a random pattern of grooves in the transverse direction. The grooves shall be spaced at 10 to 45 mm (3/8 to 1 3/4 inch) with 50 percent of spacing being less than 25 mm (1 inch) and shall be approximately 4 mm (0.15 inch) deep and 3 mm (0.10 inch) wide.

The grooving may be accomplished by the use of any hand or machine operated device that will impart the desired configuration. Various types of devices incorporating wire tines have been used successfully to obtain the desired end result. Timing of the application is critical for obtaining desired dimensions. However, the timing will vary with each method used and, therefore, requires close supervision to assure proper results.

704.5.7 Emergencies

During the placing of a deck, some unexpected difficulty may occur which halts further placing. This may be a sudden shower, a breakdown in the concrete plant or the finishing machine, or other unforeseen interruption.

When a shower occurs, no manipulation of concrete should be performed other than channeling that which was last deposited so that water will not pond on the concrete and run back on the finished or partially finished surface. The surface that has been textured, should be covered with the curing material as rapidly as possible and that which has not, should be covered with polyethylene sheeting. After the shower, all ponded water should

be removed from the concrete and out through the forms before resuming placing and finishing operations. The last surface covered with the curing material should be inspected and if it has been marred, the texture should be restored.

When a breakdown occurs, the delay should be investigated immediately and if indications are that it will not allow resumption of concrete placing in sufficient time, a bulkhead must be placed and work on it should be started without delay. If practical, the location should not be over a pier. The emergency bulkhead may consist of a wood strip laid across the top of the longitudinal reinforcing bars. This strip should be as deep as the plan cover which usually is 64 mm (2 1/2 inches). Kickers can be used to secure the strip or shims inserted between the bars to obtain proper crown and grade. The concrete below the wood strip should be compacted to about a 45 degree slope and all excess removed as far from the joint as possible and disposed of before it hardens. After the concrete has set but still fractures easily, the bottom edge should be broken to provide a vertical face below the bottom reinforcing steel. This may be accomplished with a pry bar prying up from the forms, but care should be exercised to see that the surface of the forms is not damaged. See Figure 704.

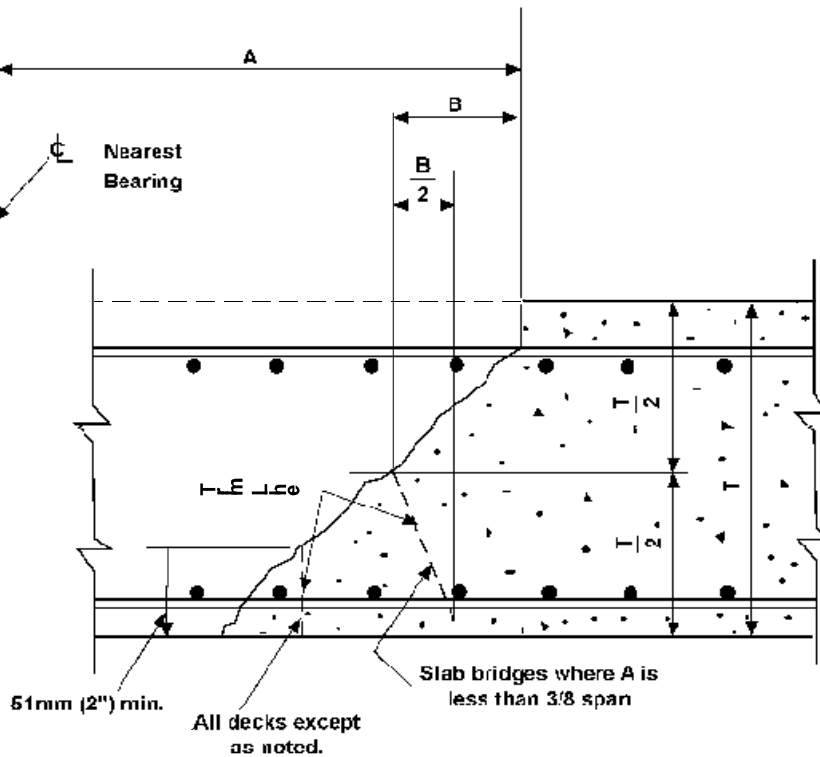


Figure 705 Emergency Bulkhead

704.6 Curbs and Parapets

Forms for curbs and parapets should be observed carefully for condition of surface, flush

fit of panel joints, proper installation of bevel strips and visual and measured alignment and elevation. Adequate form supports should be provided that will insure proper position of concrete during and after placement. That the surfaces will be rubbed does not justify use of inferior forms or lack of adequate supports.

Where expansion of bridge deck is provided for by expansion devices, slightly more open space for expansion must be provided in the curb and parapet than is required for expansion devices. Where conduits cross this opening, special attention shall be given to clearance for expansion fittings to assure free movement of the deck.

Transverse joints may be placed in the sidewalk or curb section near the center of any span.

The sponge rubber joint material in the parapet joints must appear straight and vertical after removal of forms. The recommended method of obtaining this proper location is by placing alternate sections. After the first sections have set, the joint material can be fastened in place and concrete of the adjacent section placed against it. Rubber cement performs well for fastening the joint material to the set concrete. If the Contractor proposes some other method of installation, it may be used in the first length placed, but if it does not produce a satisfactory joint, the recommended method should be required.

704.6.1 Slipforming Parapets

In lieu of conventional forming, the contractor may be permitted to slipform the parapets. This is accomplished with concrete which has a slump of around $1\pm$ inch.

Prior to placing the concrete, additional measures must be taken by the contractor to tie the reinforcing steel to prevent it from being dislocated during the slipforming operation. If after the contractor has tied the reinforcing steel, it can be moved slightly back and forth, the contractor should further tie the reinforcing steel.

Due to the low slump, many times the contractor will add water to the mix as it comes down the chute from the concrete truck and enters into the hopper of the slipforming machine. This is not allowed since it will result in concrete of inferior quality

During the slipforming operation, small amounts of concrete will drop from the edge of the deck and onto the surface below the bridge. If the slipforming operation takes place directly over a traveled roadway, the contractor should furnish all necessary platforms to protect the traffic against falling debris. These platforms will also allow access to complete the finishing operation and facilitate inspector access.

The contractor should take steps to insure that the finished concrete meets the specified tolerances. These steps should include items such as adequately tying the reinforcing steel, determining the proper slump, and properly setting up the slipforming machine. Failure to meet the specified tolerances could result in the rejection of the parapet.

Any defects such as cracking, tearing, or honeycombing should be repaired immediately. Occasionally when repairing defects, the contractor will not completely fill the defect with

concrete but will only place the concrete on the surface of the parapet thereby bridging over the defect. This is not acceptable, the contractor should take steps to insure that the defect is completely filled with concrete.

After the concrete has been formed there normally is a small amount of hand finishing required. Due to the low slump of the concrete, hand finishing can be difficult. To facilitate finishing the concrete, many times the contractor will sprinkle water, or evaporation retardant onto the surface of the concrete. The use of these substances to aid in hand finishing is not allowed since it will only result in a surface which is subject to scaling in the future.

After the concrete has taken its initial set, it is important to saw the control joints to the plan depth into the parapet as soon as possible. Any delay in performing this operation will result in additional shrinkage cracks in the parapet.

705 Curing

Curing is governed by 511.14 which permits either Method (a) Water Curing or Method (b) Membrane Curing. Curing time is seven days. No curing is required for surfaces covered by forms for the duration of the curing period. Concrete which is to be overlaid with concrete or sealed, and all superstructure concrete shall be cured in accordance with Method (a) Water Curing.

The curing material must be applied after all free surface water has disappeared from the surface, and then as soon as possible without marring the surface. Application should never be delayed until the concrete surface has dried to the extent where it begins to whiten. The criterion for the time of application is not when the concrete has set sufficiently to walk on without leaving an imprint; this is invariably too late.

When the Contractor is unable to place the curing material on time, the surface should be wet down with a fog spray and kept wet in this manner until the curing material can be placed. Fogging equipment shall have a water pressure system rated at 16.5 Mpa (2400 psi) or greater and discharge approximately 9 to 14 L (2 to 3 gallons) per minute. Wide angle and sharp angle nozzles shall be used for low wind and windy conditions, respectively.

When it is necessary to work on concrete during the curing period, such as placing deck concrete adjacent to a construction joint, only that area immediately adjacent to the joint should be exposed and the remaining area protected from damage by the workers. Plywood sheets may be used for protection. The exposed area should be kept moistened until adjacent work is completed, after which the cover should be restored and normal cure resumed.

Floor forms provide the cure for the underside of the slab and are not to be removed before the end of the curing period, unless another method is used.

705.1 Method (a) Water Curing

When two thicknesses of burlap, jute felt cotton mats or cotton mats is used to water cure

the concrete, it should be kept wet by the continuous application of water from soaker hoses or other sprinkling devices during the required period. In lieu of continual sprinkling devices, white polyethylene sheeting or wet plastic-coated blankets may be used to cover the concrete. Before any curing materials are placed, they should be soaked thoroughly. On bridge decks, plastic blankets should be placed transversely. The edges should be lapped and held securely to maintain a moisture seal. The curb area may be covered with a longitudinal strip which is held securely to the fascia form and laps the transverse strips. A continuous batten may be used to seal the blanket to the form and reinforcing bars laid on the laps to make the seal. Areas suspected of having the seal broken during subsequent work or weather disturbances should be checked and if found to be drying out, the concrete and blanket should be soaked and resealed.

Plastic-coated blankets are to be inspected prior to use to assure that they are sound and will retain the moisture required to cure the concrete. All holes and tears are to be repaired so that they are watertight. If defects are numerous and repairs are questionable or if the plastic coating has cracked from aging, the material should be rejected.

705.2 Method (b) Membrane Curing

The concrete curing membrane is white pigmented material meeting specifications 705.07. The material may be either Type 1 (clear or translucent without dye) or Type-D (clear or translucent with fugitive dye).

The membrane should be applied in one or more separate coats by spraying as a fine mist, at a uniform application rate of one liter per 70.3 square meters (one gallon per 200 square feet) of surface. The rate of application is controlled by laying out in advance, on the surface to be cured, an area that will be properly covered by the number of gallons of compound in the spray container. The procedure will insure that the membrane is applied at not less than the required rate.

706 Cold Weather Concreting

Heated concrete and protection shall be provided whenever concrete is placed at an atmospheric temperature of 0°C (32°F) or lower, or whenever weather forecasts predict temperature below 0°C (32°F) within the curing period. Concrete shall not be placed in contact with material having a temperature of less than 0°C (32°F).

706.1 Weather Forecasts

The official U.S. Weather Bureau forecast for any curing period generally can be obtained from the District Office. This information also can be obtained from some local airports and radio stations.

706.2 Forecast Variations

When the five-day weather forecast does not predict 0°C (32°F) or lower temperatures, the Contractor should not be required to erect enclosures or use insulated forms. However, during the fall, winter and spring, adequate material and equipment should be on hand to provide for unpredicted temperatures below 0°C (32°F).

706.3 Desirable Concrete Temperatures

To assure freedom from freezing until protection can be established, the temperature of concrete as placed should not be less than the minimum of 10°C (50°F) specified, but should not exceed 21°C (70°F) maximum. Concrete placed at low temperatures above freezing develops higher ultimate strength and greater durability than concrete placed at higher temperatures. Higher temperatures require more mixing water, cause slump loss, possible quick setting and increase thermal shrinkage. Rapid moisture loss from hot exposed concrete surfaces may cause plastic shrinkage cracks. It is recommended, therefore, that the temperatures of fresh concrete, as placed, be kept as close to the 10°C (50°F) minimum temperatures as practicable. When the air temperature is 0°C (32°F) or lower, it is necessary to raise the temperature of the concrete by heating the mixing water or aggregate, or both. The concrete shall be protected from freezing and specified temperatures for curing shall be maintained by a heated enclosure or by insulated forms or by either of these in combination with flooding.

Decks slabs less than 254 mm (10 inches) thick shall be protected from freezing and specified temperature maintained for the curing period by a heated enclosure.

706.4 Protection

Arrangements for covering and insulating newly placed concrete must be made in advance of placement and should be adequate to maintain in all parts of the concrete the temperature required by the specifications.

During the first few days requiring protection, most of the heat of hydration of the hardening cement is developed. As a result, outside heat generally is not required to maintain concrete at the correct temperature if heat generated in the concrete is adequately conserved. This heat may be conserved by use of insulating blankets on unformed surfaces and by insulated forms where repeated reuse of forms makes this practical. Outside temperatures, at which concrete walls, piers, abutments or slabs above ground may be protected with insulation under various conditions, are shown in the charts which follow. On work where protection by insulation is permitted, project personnel should check the protection proposed by the Contractor and be reasonably sure that the proposed insulation is adequate for the expected exposure before concreting is permitted to begin.

The application of insulation should be as follows

1. Blanket insulation is applied tightly against wood forms with nailing flanges extending out from the blankets so they can be stapled or battened to the sides of the framing. The ends of the blankets should be sealed by removing a portion of the mat and stapled or battened down to headers so as to exclude air and moisture. Corners and angles are most vulnerable. Extreme care must be taken to insure they are well insulated and the insulation held firmly in place.
2. In case of steel forms, the insulation should be applied tightly against the form and held securely with the ends sealed to exclude air and moisture.
3. Where practicable, the insulation or insulated form should overlay any cold concrete

previously placed by at least one foot.

- 4 Any tears in the liner are to be repaired immediately with approved waterproof material.
- 5 Where tie rods extend through an insulated form, a plywood washer (approximately 19 x 150 x 150 mm (3/4 x 6 x 6 inches)) should be placed on top of the insulation blanket and secured in a satisfactory manner.
6. The tops of all pours are to be covered with insulating blankets, except for areas around protruding reinforcing bars which may be insulated with straw or wrapped with insulation blankets. Waterproof covers should be used to cover the top of such pours as required by specifications.
7. Protective enclosures may be constructed of canvas, plywood, polyethylene, plastic, etc. in such a manner that will maintain uniform temperatures and allow free circulation to the warmed air.

**Minimum Air Temperatures Allowed for
Specified Thickness of Insulation for Concrete
Walls, Piers, Abutments and Slabs Above Ground**

| Minimum Allowable Air Temperatures | | |
|---|--|---|
| Slab Thickness in mm (feet) | For 25 mm (1") Insulation Blanket in Degrees C(F) | For 51 mm (2") Insulation Blanket in Degrees C (F) |
| 152 (0.5) | 0 (32) | -14 (6) |
| 305 (1.0) | -13 (8) | -41 (-41) |
| 457 (1.5) | -25 (-14) | |
| 610 (2.0) | -30 (-22) | |
| 914 (3.0) | -37 (-34) | |
| 1219 (4.0) | -39 (-38) | |

The above table is calculated for the stated thickness of blanket type insulation with a thermal conductivity of 0.75 watt/m² (0.25 BTU per hour per ft.²) for a thermal gradient of -17°C (1°F) per 25 mm (inch). Thermal resistance of the forms was not included; therefore temperatures apply more accurately to concrete in steel forms. Use of wood forms would permit somewhat lower temperatures.

For the underside of deck slabs, 19 mm (3/4 inch) plywood forms have an equivalent thickness of 16 mm (0.6 inch) and will provide protection of 0C (32F) minimum air temperature. The values given are for still air conditions and will not be realized where air filtration due to wind occurs.

Insulation Equivalents

| Insulating Materials | Equivalent | Thickness, mm (in.) |
|---|------------|---------------------|
| 25 mm (one inch) of commercial blanket or bat insulation | | 25 mm (1.000) |
| 25 mm (one inch) of loose fill insulation of fibrous type | | 25 mm (1.000) |
| 25 mm (one inch) of insulation board | | 19 mm (0.758) |
| 25 mm (one inch) of sawdust | | 15 mm (0.610) |
| 25 mm (one inch) (nominal) of lumber | | 8 mm (0.333) |
| 25 mm (one inch) of dead air space (vertical) | | 6 mm (0.234) |

Close packed straw under canvas may be considered a loose fill type if wind is kept out of the straw. The insulating value of a dead air space greater than about 13 mm (one-half inch) thick, does not change greatly with increasing thickness.

706.5 Heated Enclosures

When heat is supplied by salamanders or other heaters, local drying burning of the forms may result, and necessitate moving or adjustment of the setup. Regular observance of the forms and burlap should be made to insure that the concrete is kept wet for the duration of the curing period, as required in 511.12. Combustion type heating units shall be vented from the enclosure to preclude damaging fresh concrete. The enclosure should surround the top; sides and bottom of the concrete to be placed during cold weather.

706.6 Temperature Control

Thermometers for use in enclosures should be the high-low recording type and be furnished by the Contractor. If the enclosure is long or high, more than one thermometer may be required. The reading in the morning and the reading in the afternoon normally will represent the low and high temperature respectively and careful selection of the time should be made when the high-low recording thermometers are not used.

When insulated forms are used the thermometer shall be furnished and installed by the Contractor. They shall be of such a type and so located that they will indicate surface temperature of the concrete. In case of a tall section such as pier shafts or retaining walls, more than one thermometer will be required because of the temperature gradient. For minimum air temperatures for various thickness of slab and insulating materials see charts in 706.4. Temperatures should be read twice daily for high and low readings. When insulated forms are used, temperature of concrete will cause a lag in the change of temperature of the surrounding air. Time of observance need not be as selective for representing the high and low, but is used to indicate a trend which may require venting of the forms or erecting an enclosure. When venting of a vertical form is necessary it should be raised slightly at the bottom to create a chimney effect.

The temperature record must include the required temperature readings for the entire curing period. Outside air temperatures may be local reported temperatures.

Temperature and control methods used and temperature readings are to be recorded on the Inspector's Daily Report.

706.7 Curing Time

To fulfill the curing requirements for concrete placed in cold weather, the surface temperature must be maintained as specified in 511.12 or be exposed to ambient air temperatures not less than 10°C (50°F) for 5 days.

In case any day's temperature readings fall below the minimum specified, the duration of heating must be extended to provide the required number of days. In case of loss or breakage of thermometers, replacements or other provisions must be made to provide a complete record.

706.8 Falsework and Form Removal

Falsework shall not be removed until after the time-temperature requirements of 511.14 have been met or satisfactory beam tests have been attained. During cold weather, forms are to be removed after the curing period in such a manner that the temperature of the concrete does not drop more than 7°C (20°F) in any 24 hour period.

707 Surface Finishes

707.1 Patching

As soon as possible after the removal of forms, all cavities produced by form ties and all other holes, honeycomb spots, broken corners or edges and other defects, except air bubble holes which will be filled by grout cleaning, shall be cleaned and after having been saturated with water shall be completely filled, pointed and trued with a mortar of the same proportions as used in the concrete being finished.

On all exposed surfaces, all fins and irregular projections are to be removed with a stone or power grinder, care being taken to avoid contrasting surface textures. Sufficient white cement is to be substituted for the regular cement in the filling of holes and other corrective work to produce a finished surface of the same color as the surrounding concrete.

Exposed surfaces having an appearance which is not satisfactory to the Engineer shall be grout cleaned or rubbed in a manner satisfactory to the Engineer. The Contractor should be advised that it will be necessary to use good formwork to obtain satisfactory surfaces.

707.2 Rubbed Finish

When specified on the plans or required by the Engineer, rubbing shall be performed as outlined in 511.15.

Forms should be removed the day after the concrete is placed. Exceptions can be the slab fascia form on which other fascia forms are set and wall forms that overlap a joint. If parapets are placed in cold weather, provisions should be made to remove forms and begin surface finishing on the day following placing, while maintaining a minimum temperature of 10°C (50°F), or postpone the placing of parapets until weather conditions are suitable for proper performance.

707.3 Grout Cleaning

Grout cleaning shall be performed as outlined in 511.15.

707.4 Float Finish

Concrete for sidewalks, safety curbs and tops of substructure unit is struck off with a template and finished with a float to produce a sandy texture.

708 Loading

708.1 General

No traffic is to be permitted on a structure until concrete has attained the age specified in 511.14. For all spans this is 14 days without a beam test for 7 days with satisfactory beam test.

708.2 Loading of Completed Structure Units

No load is to be applied or work conducted that will damage new concrete. This applied to loading or work on any part of the structure that will in the opinion of the Engineer cause damage. Usually this criterion will permit work on a footing after 36 hours of normal curing where bending stresses will not occur. Equipment may be permitted to operate on a deck after three days of normal curing providing the total weight does not exceed 1134 kg (2,500 pounds) and provisions are made to protect the curing material.

709 Pay Quantity for Structure Concrete

The quantity of concrete for every reference number will be as determined from the plan dimensions, in place, complete and accepted with adjustments made for necessary changes or errors. Plan dimensions shall be verified and recorded.

The final quantity for structure concrete is rounded off to the unit for which the item is listed in the proposal. Where plan dimensions are in mm (inches), these should be converted to m (feet) and carried to a decimal place that will not affect the accuracy of the final unit. Calculations made for necessary changes or plan errors are to be identified properly with the structure unit and reference number, and be validated by the signature or initials of the person who made the calculations and the date on which they were made.



800 Structural Steel

801 Field Inspection

When the steel arrives on the site and prior to erection it should be inspected for damage and quality of fabrication as thoroughly as time and conditions permit. Any pieces noted for field inspection of fabrication on the shop inspection report shall be held for that purpose before erection.

801.1 Damage

Any damage which may have occurred because of loading, transit or unloading should be noted as to nature and extent and reported to the Director along with the identifying piece mark or member. If corrective work is obvious, the Contractor should be advised immediately in order that the responsible party will be notified and correction can be performed in the most advantageous location.

801.2 Storage

Structural steel stored on the site shall be supported off the ground on blocking and stored in an upright position where it will not be affected by drainage.

801.3 Sweep

The specified tolerance for sweep or horizontal curvature of a beam or girder is 3 mm (1/8 inch) in 3.05 m (10 feet). This can be applied to any 3.05 m (10 feet) length of the member or multiple of 3.05 m (10 feet) lengths up to the total length of the fabricated section. Thus, a beam 30.5 m (100 feet) long, checked for its entire length, must not deviate more than ten 178 mm (one-eighth inches) for a total of 32 mm (1-1/4) from a taut line stretched between its ends.

801.4 Shop Coatings

Any members for which coating thickness measurements were not made in the shop and any members where thickness appears questionable from a visual examination shall be checked in the field preferably prior to erection.

802 Required Documents

802.1 Material and Shop Work

Verification that the structural steel is approved material and fabrication has been properly performed shall be evidenced by the following documents in the project file:

1. A Structural Engineering memorandum that mill tests are approved or notice of same listed on the shop inspection report or a contractor's certification of material approval.
2. A report by the shop inspector that the fabricated steel was inspected and approved for shipment. A diary entry listing the findings of a field inspection of fabrication of members not covered in the shop inspector's memo.

802.2 Field Work

For field erection, records shall be on file for by the following items when called for the plans or specifications:

1. Approval of certification of electrodes.
2. Approval of bolts, nuts and washers.
3. Approval of welders or welding supervisor for the welding method to be used.
4. Approval of each kind of paint for field coats.
5. An approved erection procedure when required by the specifications.
6. The fabricator's approved or contractor certified shop drawings .

803 Check of Bearing Seats

A final check shall be made of the elevation of bearing seats on the piers and abutments before erection of structural steel is scheduled to begin. If bearing seats are found that need correction, it shall be performed in the manner and to the tolerances described in 704.3.2.1.

The findings of this final check should be filed in the project records.

804 Erection

804.1 Methods

The plan the Contractor proposes for erection should be reviewed with his representative in charge. The purpose of this review is to cover details that may have been overlooked by him and to agree on procedures which will not cause damage to the members.

Methods and equipment approved for erection of members shall be used in handling during transportation to the bridge site and unloading.

The erection drawings, usually the "E" sheets, of the approved shop drawings shall be used to locate the members on the bridge and may give special instructions for the erector to follow.

Deviations from the approved erection procedure shall not be permitted. If the erector proposes deviations in procedure that appear to have merit, they must be referred to the Office of Structural Engineering for review prior to use.

804.1.1 Required Erection Procedures

The specifications require that the Contractor submit an erection procedure for the following:

1. All plate girder bridges.
2. Rolled beam bridges except single span bridges with spans less than 24.4 m (80 ft.)
3. Structures carrying railroad traffic.
4. Truss and arch bridges.

804.1.2 Typical Erection Procedures Items

Typical items which should be included in the proposed erection procedure are:

1. A drawing of the complete framing plan showing each girder or beam section by "piece mark" and numbered in the order of proposed erection. A print of the erection sheet of the shop drawings may be used.
2. The number of pieces and load capacity of erection equipment to be used and method of lifting members.
3. Field splices to be made on the ground.
4. The number of field splice holes to be filled before erected members are released and allowed to deflect (50 percent required - preferably one-half with pins and one-half with bolts).
5. Methods and details for supporting the first beams or girders at the abutments and piers in each unit. Where some sort of attachment to the pier is used, it should be fully described as to size of members and method of attaching to the pier and steel. In addition to supporting the beams at the abutment and piers, there may also be additional bracing of the top flange at midspan to prevent the beam from twisting or buckling under its own weight.

804.2 High Strength Bolting

The following described operations are intended to clarify some of the important requirements of the specifications.

804.2.1 Joint Assembly

The beams or girders to be spliced shall have their ends brought together at the correct relative elevation with respect to points of support and held at the elevation and in correct alignment so that heavy drifting is not necessary to align the holes.

Sufficient pins shall be installed to obtain accurate alignment to parts and sufficient bolts to compact the joint. Before the beams or girders are released and allowed to deflect, at least 50 percent of the holes shall be filled with pins and snug tightened bolts. A minimum of 25 percent pins is desired, however, if less than 25 percent will carry the stress and if matching of holes cannot be improved by additional pins, a lesser number will be satisfactory. If less than 25 percent pins is used, the remaining holes should be filled with

snug tightened bolts. Some joints that will be highly stressed probably will require more than 50 percent of the holes filled with drift pins and snug tightened bolts and it is intended to note such cases on the approved erection procedure. When the splice is made on the ground all operations to complete the splice shall be performed.

Pins shall be cylindrical and not more than 1 mm (1/32 inch) smaller than the diameter of the hole.

Every splice shall have the same percentage of holes filled in each part if practical. If a beam splice requires 25 percent pins, 25 percent of the holes in the webs and 25 percent of the holes in each flange shall be filled with pins unless some in the flanges fall through.

All holes not filled with pins shall be filled with bolts and both tightening operations performed on them before removal of any pins.

804.2.2 Bolt Tightening

Bolts shall be tightened or tensioned in two distinct and separate operations. All bolts first shall be snug-tightened and later final-tightened in another operation.

When the snug-tight conditions is performed with power wrenches, greater variation in tension usually is obtained. More consistent tension is obtained with spud wrenches. When the steel surfaces are flat and compact, the snug-tight condition is obtained when bolt tension is between 22,222 and 44,444 newtons (5,000 and 10,000 pounds).

Final tightening shall be accomplished by the turn-of-the-nut-method. Turn-of-the-nut is accomplished by first tightening the bolt to a snug tight condition, the protruding end of the bolt and adjacent surface of the nut are match marked and then the nut is tightened the additional specified rotation.

Snug tight is accomplished by either an impact wrench or an ordinary spud wrench. If an impact wrench is used, snug tight is achieved when the impact wrench begins to impact or hammer on the bolt. This will happen almost immediately after tightening with the impact wrench begins. When a spud wrench is used, snug tight is achieved when the full effort of a man is applied to the spud wrench and the nut can not be tightened any further.

After the bolts have been tightened to a snug tight condition, they are to be match marked. The purpose of the match mark is to measure to amount of rotation of the nut relative to the bolt. In order to measure this rotation, it is important that the match marks be properly placed. The match marks are to be placed on the end of the bolt and the adjacent surface of the nut. There are several other locations where the contractors will place the match marks, however, none of these locations will allow the relative rotation of the nut to the bolt be measured. (See figures 804.2a and 804.2b)

During final tightening, all of the specified rotation must be performed. Although the bolts may be over tightened in the snug-tight condition by power wrenches, the full specified rotation still is required. A maximum tension is not specified and excessive tension is not cause for rejection.

The first complete joint on a project shall be inspected by testing. If certain conditions are met, inspection of subsequently completed joints by testing may be waived by the Engineer. These conditions are:

1. The Engineer has approved the compactness of the joint.
2. The snug-tight operations have been witnessed and approved by the Engineer.
3. Match-marking of the protruding end of the bolt and nut had been performed and indicates the required rotation. The Engineer must be satisfied that these conditions have been met completely before the joint will be considered approved and testing waived.

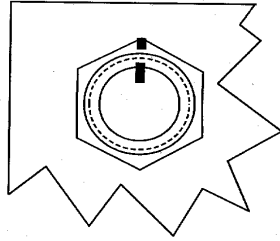
A 325 M (A 325) black (ungalvanized) bolts may be reused if approved by the Engineer. Galvanized A 325 M (A 325) bolts shall not be reused. Retightening previously tightened bolts which may have been loosened by the tightening of adjacent bolts is not considered reuse.

804.2.3 Inspection

Even though a joint may appear to have all the bolts in the joint properly matched marked and tightened, there is still the possibility that these bolts were not properly tightened. Therefore, it is necessary for the contractor to provide a torque wrench and a recently calibrated tension testing device.

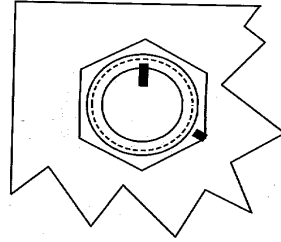
Prior to inspecting the bolts with the torque wrench, it is first necessary to determine minimum torque required. This is accomplished with the aid of the tension testing device. A bolt is first placed in the tension testing device and tightened to the required tension as given in Table 1 of section 513.15. The torque wrench is then used to determine how much torque is required to turn the nut on the bolt after the minimum tension has been achieved. When calibrating the torque wrench, the Engineer should hold his hand on the nut being tightened in order to detect movement or rotation of the nut on the bolt. The required torque is based on the average torque of three bolts.

The torque wrench should be calibrated at the beginning of each day it is used and for each diameter or length of bolt being tested. Also if the coating varies, ie. galvanized bolts as opposed to uncoated bolts, the torque wrench should also be calibrated.



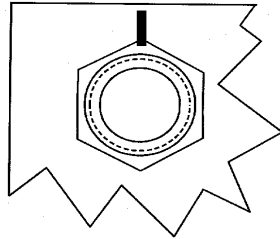
BEFORE

In the above detail, the nut and bolt are properly match marked. The match mark is placed on one portion of the bolt and also on the adjacent portion of the nut.



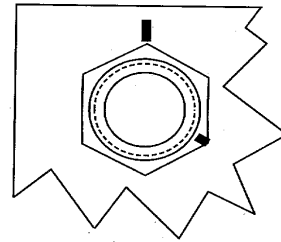
AFTER

After the tightening process has been completed, it can be determined how far the nut was turned relative to the bolt.



BEFORE

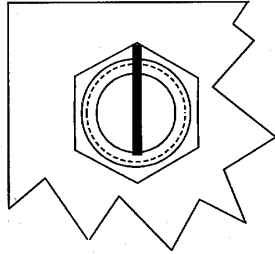
In this case, the match marks were **incorrectly** placed on the nut and on the adjacent splice plate.



AFTER

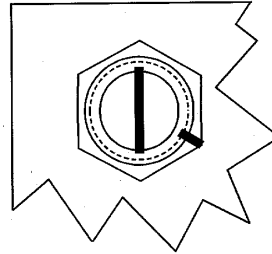
After the tightening process has been completed, it can be seen that the nut has been turned approximately 1/3 of a turn relative to the splice plate. However, with the possibility of the bolt turning during the tightening process, it is not possible to determine how much the nut rotated relative to the bolt.

FIG. 804.2a



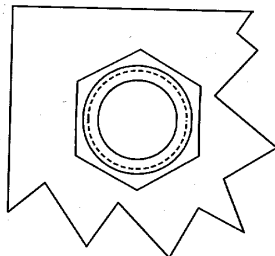
BEFORE

In the above detail, the nut and bolt were **incorrectly** match marked with a line going across the entire diameter of the bolt in lieu of only marking one side.



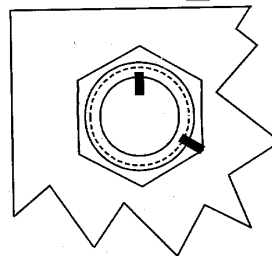
AFTER

In the above detail, it is not possible to tell if the nut was rotated approximately 1/3 of a turn or over 3/4 of a turn.



BEFORE

In the above detail, the contractor failed to match mark the nut and bolt when they were in a snug tight condition. This allows the contractor to speed up the operation since the impact wrenches was not removed until the nuts were fully tightened



AFTER

In the above detail, it is obvious that the contractor placed the match marks after the bolt was tightened. This can be detected due to the fact that the match mark on the nut also extends partially onto the threads of the bolt.

FIG. 804.2b

Torque wrenches must have the capacity of the maximum job inspection torque required for any bridge.

Inspection shall be accomplished by the contractor applying the torque only up to the job inspection torque since minimum tension only is specified.

The erector must furnish the Engineer with evidence that the tension testing device has been checked by the manufacturer or a laboratory within one year.

804.2.4 General

The Contractor is required to furnish the necessary access and area for inspection of all operations. The inspector should not occupy the same float or suspended platform used by the workmen for safety reasons.

804.3 Welding

Requirements for welding shall be according to the current ANSI/AASHSTO/AWS "Bridge Welding Code" except as modified by Supplement 1011 and the Construction and Material Specifications.

No attachments, other than specified by the plans, shall be made by welding to any main structural members such as beams, girders, cross bracing, truss members, etc., unless approved by the Director.

804.3.1 Approval of Welders

All welds must be performed by welders qualified for the specific welding method to be used, according to Supplement 1011. Welders must be approved by the Office of Material Management prior to the performance of any welding. If written notice has not been received by the time the welder is ready to start work, verbal approval may be received from the Office of Material Management.

804.3.2 Electrodes

Electrodes used to make all permanent welds to steel shall be of the low hydrogen type and shall be on the list of approved electrodes issued by the Office of Material Management.

Only the welding procedure using shielded metal arc electrodes (stick welding) is pre-approved. Any other electrode which the contractor proposes to use must first have a welding procedure qualification test approved and submit a welding procedure specification.

Electrodes must be dried in an oven at 232 to 260°C (450 to 500°F) for two hours and stored in a suitable container which will maintain a temperature of not less than 121°C (250°F). After removal for use, electrodes exposed to the atmosphere for more than one hour at a relative humidity of 75 percent or more than four hours in any event shall be redried at a temperature of 232 to 260°C (450 to 500°F) before use. Electrodes which have been wet shall not be used.

804.3.3 Weather Restrictions

When the base metal is below the temperature listed in the following table for the thickness of the material being welded, it shall be preheated in such a manner that surfaces of the parts on which weld metal is being deposited are at or above the specified minimum temperature for a distance equal to the thickness of the part being welded but not less than 76 mm (3 inches), both laterally and in advance of the welding.

Minimum Preheat and Interpass Temperatures **

| Thickness of Thickest Part at Point of Welding in mm (inches) | Minimum Temperature ASTM A36 Steel Using Low Hydrogen Electrodes |
|---|--|
| To 19 (3/4), incl..... | 10°C (50°F)* |
| Over 19 to 38 (3/4 to 1-1/2), incl..... | 20°C (70°F) |
| Over 38 to 63.5 (1-1/2 to 2-1/2), Incl..... | 65°C(150°F) |
| Over 63.5 (2-1/2)..... | 110°C (225°F) |

* When the base metal temperature is below 0°C (32°F), the above specified should be preheated to minimum temperature of at least 20°C (70°F). Preheating is only necessary where the welding begins. Continued welding will make further preheating unnecessary.

** Welding shall not be done when the ambient temperature is below -18°C (0°F).

804.3.4 Inspection

The welding operations should be observed and complete welds inspected for conformance to the plans and shop drawings. Fillet welds shall be measured with the use of a weld gage or other method that will show the length of the sides in contact with the steel. Deficient welds shall be built up to the required size. Badly shaped welds or welds containing defects such as cracks, pits, craters and undercutting shall be corrected to the satisfaction of the Engineer.

When radiographic examination of welds is required the report and film shall be submitted to the Office of Structural Engineering for review and approval before any work is performed that would interfere with corrective work if found necessary.

804.3.4.1 Arc Strikes

Occasionally, during the welding operation, the electrode will come in contact with an area of steel that is not to be welded. This contact will result in a small burnt spot or arc strike in the steel. If not properly removed, an arc strike has the potential of propagating fatigue cracks.

Arc strikes are to be removed by grinding. However this situation can result in unacceptable hard spots or small cracks. Therefore, after the arc strikes are removed, it is necessary for the contractor to check every location where they occurred. The contractor shall perform a magnetic-particle test on all arc strike locations to assure that no cracks are present. Hardness tests are also to be run on all locations to assure that no unacceptable hard areas are present. Hardness values shall not exceed Rockwell C30 or the hardness value measured in the steel outside the location of the arc strike, whichever is higher. If the above testing reveal unacceptable results, the flaw can be removed by grinding and the steel again be retested to assure that the flaw has been completely removed.

Normally the contractor is not equipped nor has the knowledge to perform the above test. Therefore, he will normally arrangements for a private testing laboratory to perform the required testing.

804.3.5 Cleaning

The finished weld shall have all slag removed and be neutralized by vigorous wire brushing to remove any film that will effect the proper adherence of paint.

804.3.6 Stud Welding

Shear studs are short rods which have been welded to a piece of steel for the purpose of anchoring that steel to concrete. There are additional requirements to inspect the weld joining the shear stud to a piece of steel.

804.3.6.1 Qualified Stud Welder Operator

Prior to allowing any production welding, it is first necessary to assure that the stud welder operator is qualified. This is accomplished at the project site as apposed to reviewing a list maintained by the Office of Material Management.

To be qualified, it is necessary to successfully weld two studs of the same type and size as will be used during the production welding. The studs shall be welded to a piece of steel which is similar to the production member in thickness and property or they may be welded to the production member.

After the studs have been welded, they should be visually examined. If they were welded properly there should be weld metal completely around the base of the stud (360 degree flash).

In addition to a visual examination, the studs shall bent to an angle of approximately 30 degrees from their original axis. This should be accomplished by either striking the studs with a hammer or bending the stud by use of a pipe.

If the visual examination does not reveal a 360 degree flash or if the weld fails when the studs are bent over, the contractor shall make corrections to his procedure and two more studs shall be welded and tested. This should continue until two consecutive studs are tested and found to be satisfactory.

804.3.6.2 Qualifying the Stud Welding Procedure

Prior to production welding, it is necessary to qualify the stud welding procedure. This should be accomplished at the beginning of each days shift, when welding has been interrupted for an hour or more, when attaching the welding cable to a different ground, when changing weld settings, when changing loops in the cable or when 500 studs have been welded after testing.

The actual testing shall be the same as detailed in section 804.3.6.1.

804.3.6.3 Post Testing

After the studs have been welded, it is necessary to test the studs to insure that they have been installed correctly. This is accomplished by giving each one of them a light blow with a hammer. When the studs are tapped, they should emit a ringing sound. Any stud which does not emit a ringing sound should be bent approximately 15° from its original axis.

In addition to tapping the studs with a hammer, a visual inspection should be performed. Any stud which does not show a 360° flash may be repaired by the contractor by fillet welding the missing flash. Any stud which the contractor elects not to repair, or any stud which the contractor has not repaired properly shall be bent to an angle of approximately 15° from its original axis.

Any stud which does not pass the bend test shall be replaced. All studs which have been bent and have not failed shall not be straightened.

804.4 Bearing Adjustment

When steel beams or girders are first landed and before sole plates are fastened, bearings may be set approximately plump. After all beams or girders between expansion joints are in place and the overall length has been checked, correction in the plumpness of the bearings for temperature shall be made. The length of bridge from the fixed bearing and the deviation in temperature of the steel from 16°C (60°F) shall be used in calculating the tilt to the bearings when rockers are used.

The coefficient of expansion to multiply with the length and temperature difference is 0.0000117 (0.000006). For example, for a two-span length of 149 m (160 feet) and at 4°C (40°F) for a difference of -7°C (20°F degrees), the calculation is $149 \times 11 \times 0.0000117 = .0060$ m or 6 mm ($160 \times 20 \times 0.000006 = .0192$ feet, or 1/4 inch) that the rocker should be inclined from the vertical toward the fixed bearing to compensate for the existing temperature.

The same factors shall be used to determine the offset in sliding plate bearings and to adjust the opening in expansion joints. Adjustments should be made on a cloudy day when a temperature differential in the steel is not caused by the sun's rays.

A final check of correct bearing adjustment shall be made after the deck has been completed.



900 Field Painting of Structural Steel

In order to protect structural steel and protect it from corroding, it is necessary to apply a protective coating system. The coating system normally consists of three coats which are applied by airless spray. On existing steel all three coats are applied in the field. On new steel, normally the primer is applied in the fabrication shop and the remaining two coats are applied in the field.

901 Quality Control Specialist

When applying coating systems it is very important for the contractor to constantly monitor the quality of the work. Due to the his many duties and responsibilities, the foreman is not able to properly monitor the quality of the work. Therefore, the contractor is required to assign one person the duties of a quality control specialist. If there is no quality control specialist on the project, the contractor is not allowed to proceed with any production work.

This person is to be formally trained as a quality control specialist. Prior to allowing the quality control specialist begin working, the contractor shall provide documentation to the Engineer verifying that the quality control specialist has been trained by either KTA Tator, S.G. Pinney, or Quality Control Consultants.

The quality control specialist is only to be involved in quality control work while production work is going on. He is not to be a foreman or a member of the contractor's production staff. He is not allowed to abrasive blast, apply coating, recover spent abrasive, mix paint, run errands, set up or maintain the traffic control, run or work on the equipment, etc. If the quality control specialist is involved in any work other than quality control work while production work is proceeding, all production work should be halted until corrections are made.

The quality control specialist is to be properly equipped with all the necessary testing equipment, and able to climb to all parts of the structural steel. He is to have the authority to stop the contractor's work if necessary, and to inform the foreman of all work which does not meet the requirement of the specifications.

902 Surface Preparation

One of the most important items of work is surface preparation. It is also the most labor intensive and expensive phase of the work.

902.1 Solvent Cleaning

If required by plan note, the surface of the steel shall be solvent cleaned to remove asphalt

cement, oil, grease, etc. Diesel exhaust is not necessarily detrimental if it only contains carbon black and no grease or oil. It is not necessary for the contractor to solvent clean the entire surface of the steel to be coated, but only those areas depicted in the plans. If additional areas not identified in the plans are discovered to contain asphalt cement, oil, grease, etc., these areas should also be solvent cleaned.

All solvent cleaning should be completed prior to the start of the abrasive blasting operation. If this is not accomplished, the abrasive blasting operation will remove the grease, oil, etc. but drive it into the steel.

In order to remove all residual solvent, grease, oil, etc. after the solvent cleaning, all solvent cleaned areas are to be washed with a water at a pressure of at least 7 Mpa (1000 PSI). In order to be effective, the nozzle must be held no further than 300 mm (12 inches) from the surface being washed.

902.2 Abrasive Blasting

The prime coat contains zinc which protects the steel by reacting chemically with the surface of the steel. Therefore, it is important to remove all foreign material from the surface of the steel to allow the zinc particles to come in contact with the bare steel. It is also important to roughen up or produce a profile on the surface of the steel. The profile aids the coating in adhering to the surface of the steel.

Steel surfaces to be painted are to be abrasively blasted to a near white metal, SSPC-SP10. During inspection, special attention should be paid to areas which are more difficult to blast or areas which might be difficult to inspect. These areas include under cross frames, around bolt heads and nuts, end dams, cross frames next to or close to back walls and any areas where the contractor suspects that the inspector will not go. After the steel is blasted, it shall be maintained in that condition until it is painted. The back side of cross frame assemblies which are 75 mm (3 inches) or closer to backwalls may be commercial blast cleaned according to SSPC-SP6.

The abrasive shall be either steel, ferric oxide, or aluminum oxide grit. The abrasive is to be recycled to minimize the volume of waste material placed into landfills. The size or gradation of the grit is not specified, but shall be such as to provide a profile of between 40 μm to 90 μm (1.5 mils to 3.5 mils). The profile should be continuously monitored during the blasting operation since the size of the abrasive can be reduced due to being recycled, which can in turn reduce the size of the profile. The size of the profile can also be reduced if the air pressure at the blasting nozzle is reduced or the contractor changes the type of grit he is using.

Some abrasives, when they are received by the contractor, can be contaminated with oil. Therefore the abrasives should be checked to insure that they are free of oil. This check should be made by placing a small amount of abrasives in a jar with tap water. The abrasives and water should then be stirred or shook up. The top of the water should then be checked for signs of oil. If oil is detected, the abrasives should not be permitted to be used.

Due to the possibility of condensation, any abrasive blasting which is done when the steel temperature is less than 3° C (5° F) above the dew point shall be reblasted when the temperature of the steel exceeds 3° C (5° F) above the dew point.

All steel surfaces are to be painted the same day they are blast cleaned. If the steel surfaces are not painted the same day they are painted, they can begin to rust and become contaminated. Any steel surface which is not painted the same day it is cleaned, shall be reblasted.

After abrasive blasting is completed, all abrasive and dust shall be removed from the surface to be painted. Dust and abrasive is also to be removed from any adjacent painted surface which also includes any adjacent structure. Dust and abrasive should be removed as soon as possible to prevent rust staining of adjacent surfaces. Rust stains can be very difficult to remove.

Occasionally the compressed air used to propel the abrasive can become contaminated with oil or water from the compressor. This oil or water, if deposited on the surface of the steel to be painted, can be detrimental to the coating system. To prevent this problem, the quality control specialist is required to blow air from a nozzle for 30 seconds onto a white cloth or blotter held in a rigid frame. This testing is to be done at the start of each shift, and at 4 hour intervals. If any oil, water, or other contaminants are present on the cloth or blotter, the blasting operation shall be suspended until the problem is corrected. After the operation is corrected, and before the blasting operation is permitted to proceed, another test should be made to insure that the problem has been corrected.

902.3 Containment and Waste Disposal

Due to the possibility of the existing coating containing lead, which is considered a toxic substance, the contractor is required to erect an enclosure to completely surround the area where he is going to remove the existing coating. Not only should the enclosure be placed vertically around the sides of the blasting operation but it should also be placed on the ground under the blasting operation. In addition to containing lead, the enclosure also prevents fugitive dust from escaping into the environment.

The enclosure is to be constructed of materials which are free of tears, cuts, or holes to prevent dust and lead from escaping into the environment. Holes, cuts, or tears which do occur should be repaired immediately. If flexible materials such as tarpaulins or containment screens are used, they should be weaved to contain a maximum of 15 percent holes and a minimum of 85 percent material. The perimeter of the enclosure should also extend up between the beams to the bottom of the concrete deck. All seams should be fastened or lapped in a manner that insures a seal and does not allow any openings between the screens or materials of the enclosure. The area where workers enter and exit the enclosure should also be sealed.

In addition to placing an enclosure around the contractor's blasting operations, he shall also place ground covers under all of his equipment. This ground cover is to be placed under the equipment for its entire length and not just a portion of its length. If the ground is not properly covered, there is the possibility that it could become contaminated with toxic

waste.

After the abrasive blasting debris has been picked up at the end of the day, it is to be stored in steel containers which have the lids locked. Normally the contractor will store the debris in 55 gallon drums with lids. The lids have a ring around them which are capable of being locked. Normally, the contractor will lock the lids by means of a bolt. This method is acceptable as long as there is a nut placed on the bolt and tightened by the use of a wrench. Many times all of the lids are not properly locked at the end of the day. They should be checked at the end of the day or the first thing in the morning to insure that the contractor is locking the lids at the end of the day.

If the debris is toxic, the contractor is to dispose of it within 60 days after it is generated. The time for the 60 days is to start as soon as the contractor generates the debris and not after the completion of the abrasive blasting operation. If the debris remains on the project site over 90 days, the State and the contractor could be cited by the Environmental Protection Agency. On smaller structures the debris can be removed in one operation. However, on larger structures for which the abrasive blasting operation extends over a period of several months, it will be necessary to make several trips in order to comply with the 60 day limit. If after the 60 days, the contractor has not properly disposed of the toxic debris all abrasive blasting and painting of the structural steel on the project shall immediately cease until the toxic waste is properly disposed. At this time, the Department shall cease processing all pay estimates and notification shall be sent to the contractor's surety that he has breached the contract.

903 Applying Coating

903.1 Temperature and Weather Restrictions

Paint shall not be applied when the temperature of the air, steel surface, or paint is below 10°C (50°F) or is expected to be below 10°C (50°F). At lower temperatures the paint will not cure and in some cases the paint may not resume curing when the temperatures warm up. It becomes important to pay closer attention to the temperature in the early spring and the late fall. During the early spring and the late fall, the temperatures will be above 10°C (50°F) during the day, but the temperature will drop during the early evening hours before the paint has had enough time to properly cure.

Paint is not to be applied until the temperature of the steel is at least 3°C (5°F) above dew point. Applying paint to steel at temperatures below 3°C (5°F) could result in condensation on the surface of the steel.

Heated enclosures may be used to maintain the temperatures above the minimum specified temperatures. If combustion type heating units are used the exhaust fumes must not be permitted in the enclosure but should be vented away from the enclosure. If exhaust fumes are not properly vented they can leave a deposit on the surface which could affect the ability of remaining coats of paint to properly bond to the steel. These exhaust deposits could also contaminate the freshly applied paint.

If a heated enclosure is used, a recorder thermometer should be used to insure that the

minimum temperature is maintained until the coating has cured. The thermometer should be placed close to the perimeter of the enclosure since this is the area subject to cooler temperatures.

903.2 Mixing and Thinning

Prior to applying paint it will be necessary to thoroughly mix all the ingredients together. This is to be accomplished with a high shear mixer. Paddle mixers are not allowed due to the fact that they will not do an adequate job of mixing the different ingredients together. Using compressed air to cause a stream of bubbles in the paint and paint shakers also is not allowed since it will not properly mix the ingredients.

During the application of the primer, it is important that it be continuously mixed. If it is not continuously mixed, the zinc particles in the primer will settle to the bottom of the container and will not be applied to the structural steel. To insure that the mixing process is not interrupted, it is also important that the mixer be an automated mixer, and not a hand held mixer.

Normally thinning of the paint is not required. However if the contractor elects to thin the paint, it is important that it be thinned with the correct type and volume of thinner. In order to insure that the contractor is using the proper type of thinner, only thinner recommended and supplied by the manufacture of the paint is to be used. The maximum rate of thinner is to be as per the manufactures printed instructions.

In an effort to insure that the thinner the contractor is using, is the thinner recommended and supplied by the manufacture, only thinner which has been supplied to the project in unopened containers with the labels intact, shall be used. The amount of thinner used from each container should be monitored to prevent the contractor from refilling container with other types of thinner.

The above restrictions do not apply to the thinners which the contractor uses to clean his equipment.

903.3 Application Equipment

Paint is only to be applied by the use of brush or spray equipment. Rollers can cause bubbling and other irregularities in the coating and are not permitted except in certain detailed locations.

Certain areas are difficult to properly coat with spray equipment, therefore it is permissible to use daubers, small diameter rollers or sheepskins for these areas. Daubers, small diameter rollers, or sheepskins are required to be used where cross frames angles are located within 50 mm (2 inches) of the bottom flanges, where end cross frames are within 150 mm (6 inches) of the backwall and the bottom of the bottom flanges around bearings which are less than 150 mm (6 inches) in height.

903.4 Time Limitations

The prime coat is to be applied the same day the surface is blast cleaned. Any surface not painted the same day it is blasted, is to be reblasted.

The maximum time allowed to elapse between the application of any portion the prime coat and the application of the intermediate coat is 30 days. The maximum time allowed to elapse between the application of any portion of the intermediate coat and the application of the finish coat is 13 days. The maximum recoat times shall also not exceed the maximum recommended by the manufacture. Extending the time beyond that mentioned above could adversely affect the bond of the coating. No additional time is to be allowed due to weather related delays. Any coat which has been allowed to cure more then the above allotted time is to be removed and the steel reblasted to SP10.

903.5 Enclosure

During spray application of the paint the operation is to be totally enclosed. The enclosure is to be identical to the enclosure used during the abrasive blasting operation. Failure to properly utilize the enclosure could result in overspray damage to private property including automobiles, the ground, public property, vegetation, streams, lakes, etc. The enclosure is not required if the paint is being applied by brush or other means.

903.6 Quality of the Coating

Each coat of paint is to be applied as a continuous film of uniform thickness. It is to be free of all defects such as holidays, runs, sags, etc.

Many time holidays in the form of pinholes are difficult to detect. The best way to view pinholes is with the aid of a flashlight after the finish coat has been applied. The flashlight should be placed to shine a beam of light parallel to the painted surface. If pinholes are present, they will appear as small white specs about the size of end of a needle.

Repairing pinholes can be very difficult. Applying another coat of paint over the pinholes will only result in the pinhole reflecting through the additional coat of paint. It is the contractor's responsibility to repair the pinholes, however the best way to correct pinholes is by removing the coating at least down to the prime coat of paint. If the prime coat is not removed, measurements should be taken to insure that the required minimum thickness of prime paint is still present. If the contractor elects to attempt to leave the prime coat, he will probably remove the top coats with sand paper. If a large area needs to be repaired, it will probably be more prudent for the contractor to abrasively blast the coating down to bare metal and reapply it.

A small number of runs can be expected and are acceptable around bolts and areas where the cross frames attach to the beams. Runs, sags, etc. in other parts of the steel, are not acceptable and must be removed.

904 Repair Procedures

If it is necessary to make repairs, the intent of the specifications is that he repair be made in a manner that the repaired areas will blend in with the surrounding area so that it is not evident that a repair was made.

If the area to be repaired does not cover a large area, abrasively blasting the surface may not be advisable due to the fact that it will damage the surrounding coating which does not need to be removed. In lieu of using abrasives, it is acceptable to use machine tools such

as grinders. However, whatever method is used, it is still necessary to prepare the surface in a manner which will give a surface profile of between 40 to 90 μm (1.5 to 3.5 mils).

In order to produce a smooth transition, it will be necessary to feather the adjacent coatings. This cannot be accomplished through the use of abrasives. The new coat of paint should only be applied to the same coat as was feathered, ie. the prime coat should only be applied to the feathered prime coat, the intermediate coat should only be applied to the feathered intermediate coat, and the finish coat should only be applied to the feathered finish coat. Applying the finish coat to existing finish coat which has not been feathered or in any other way abraded, will result in finish with a dull frosty appearance in lieu of a bright glossy finish.

905 Measuring Coating Thickness

Prior to measuring coating thicknesses it will be necessary to determine the affect of the blasted surface of the steel on the paint gage. Due to the fact that the steel has received a profile of between 40 to 90 μm (1.5 to 3.5 mils), this profile will cause the paint gage to read high. To compensate for this additional height it will first be necessary to take a reading on the blasted surface immediately prior to applying the prime coat. Preferably three or more readings should be taken and averaged out. This average reading should then be subtracted from all paint film thickness readings. As an alternate to subtracting the thickness attributed to the surface profile, from the paint film thickness, recalibrating the paint gage to read 0 μm (0 mils) on the blasted steel, is also acceptable.

The coating thickness is to be determined by taking the average thickness in the manner specified in the specifications. Measurements are to be taken on flanges, webs, cross bracing, stiffeners, etc. It is acceptable to use readings from one type of member to comprise an area, ie. all cross bracing, or all stiffeners, or all flange edges, etc. as this will more accurately determine the thickness of the coating applied to that type of member. However it is still important to take coating thicknesses measurements on all members.

906 Caulking

Normally caulking is used to seal a void around the perimeter of adjacent steel plates. This void is normally caused by rust forming between the plates and forcing the plates apart to the extent that it is not possible to seal the void with paint. Caulking is not normally specified to be placed around the perimeter of adjacent plates which are in intimate contact with each other.

If caulking is specified, the plans are to either depict or describe the areas which are to be caulked.

907 Inspection Access

Proper inspection cannot be accomplished unless the inspector has access to every surface to be painted. To accomplish this, the contractor is required to provide, erect, and move scaffolding and all other equipment necessary to provide the inspector access to closely inspect the work. On bridges with tall girders, placing scaffolding only under the girders is not adequate to provide proper access to the work. The inspector should not climb around on the structural steel to inspect the work. If the contractor fails to provide

proper access to inspect the work, he should not be allowed to continue since proper inspection cannot be performed.

All scaffolding of any width, rather it is supported by a wire rope, mounted on the back of a truck, or supported by any other means, that is at least 533 mm (21 inches) or more below the surface to be painted must have guard rail placed on all sides. It is not necessary for scaffolding which is less than 533 mm (21 inches) below the surface to be painted to have guardrail, but in this case the scaffolding must be at least 711 mm (28 inches) wide.

One row of guard rail is required to be placed around the scaffolding when it is at least 533 mm (21 inches) but less than 1092 mm (43 inches) below the surface to be painted. Two rows of guard rail are required when the scaffolding is placed 1092 mm (43 inches) or more below the surface to be painted.

908 Work Limitations

Abrasive blasting and painting is to be done between April 1 and October 31. However, if the contractor only needs a few more days to finish painting a structure after October 31, he should be allowed to continue as long as the weather permits. The contractor should not plan on starting work on a structure around the end of October with the intent of completing work on the structure well after October 31.



1000 Pneumatically Placed Mortar

This item of work consists of repairing concrete structures by spraying the area to be repaired with dry premixed sand and cement which is blended with water in a mixing nozzle. The pneumatically placed mortar is then finished and cured.

1001 Surface Preparation

Prior to placement of pneumatically placed concrete, the area to be repaired is to be properly prepared. All soft, loose, and disintegrated concrete plus an additional depth of 6 mm (1/4 inch) of sound concrete is to be removed. Failure to remove soft, loose, and disintegrated concrete will adversely affect the bond of the mortar and shorten the life of the repair.

The edges or shoulders of the repair areas are to be square or slightly undercut. If this is not accomplished, the mortar placed at the edges of the repaired area will be feathered. These feathered areas will not have adequate strength and will scale off.

After all concrete has been removed from the repair area, all dowels and expansion hooks placed, all steel areas restored, and not more than 24 hours prior to placement of mortar, the area to be repaired shall be abrasive blast cleaned. The abrasive blast cleaning shall be done to remove spalls, laitance and any other foreign material which might be detrimental to achieving a bond with the pneumatically placed mortar. The contractor should select an abrasive blast method which will control or minimize the amount of fugitive escaping into the atmosphere. Suitable blast methods may include high pressure water blasting with abrasives in the water, abrasive blasting with containment, or vacuum abrasive blasting.

Unless otherwise specified, the contractor shall wet the area to be repaired with water at least 2 hours prior to placing the mortar. The area shall be kept wet until the mortar is placed. At the time of placement of the mortar, all free water is to be removed.

1002 Reinforcing

All existing reinforcing steel bars are to have a minimum cover of 25 mm (1 inch). If the existing location of the reinforcing bars would result in less than 25 mm (1 inch) of cover, the are to be driven back into recesses cut into the existing concrete to achieve that coverage. If this is not practical, due to the large number of reinforcing bars, the coverage shall be obtained by modifying the finished surface.

Where the depth of the patch exceeds 38 mm (1 ½ inch) in addition to any existing

reinforcing steel, wire fabric is also required. Where the depth of the patch exceeds 100 mm (4 inches) a layer of fabric is to be placed for each 100 mm (4 inches) thickness of patch or fraction thereof.

1003 Preconstruction Testing

Due to past experiences with pneumatically placed mortar which was improperly placed and prematurely failed, it is necessary for each operator to demonstrate his ability to construct a sound, durable repair prior to allowing him to place mortar on the structure. This is accomplished by gunning the mortar onto a test panel. The mortar on this test panel will then be tested for strength and examined for hollow areas, sand pockets and bond to the reinforcement.

1004 Curing

After the mortar is placed, it is to be cured. This curing shall consist of covering the patch with burlap or cotton mats and keeping them wet for 7 days. If it is not practicable to use mats, the surface of the patch shall be kept wet by sprinkling the surface with water for 7 days. If it is determined that the above methods are impracticable due to isolated areas being inaccessible, they are to be cured according to the requirements of 511.14, Method (b).

1005 Inspection and Testing

After the curing of the patched areas has been completed and before they are accepted, they are to be sounded and every 20 m² (200 sq. ft.) cored. All unsound areas, or areas which exhibit cracking shall be removed and replaced. The cores shall be inspected for hollow areas, sand pockets, voids around reinforcing steel and lack of bond to the underlying concrete. The cores are also to be tested for compressive strength. Any defective patches as determined by the cores shall also be removed and replaced at the contractor's expense.



1100 Sectional Corrugated Metal Arch Structures

This work consists of the sectional corrugated metal arch as described in 522. Excavation and concrete for structures are covered in 503 and 511 respectively.

1101 Quality Control

Quality of the galvanizing should be examined. Some added thickness occurs at the bolt holes and may appear to be stripping when the bolts are installed. Peeling as evidenced by separation of galvanizing around bolts or near the edges of the plates when pried with a knife or impacted with a hammer is cause for rejection.

1102 Assembly

Assembly of the plates shall be according to the manufacturer's instructions which usually are sent with the shipment

1103 Documentation

Documentation consists of the average of properly validated measurements made of the length of structure at the points of bearing on the abutments.

APPENDIX 1

PILE HAMMER DATA

| Hammer | Energy Joules (Ft.-Lb.) | | Speed - B/M | RAM Wt.- Kg (Lb.) | Stroke | Recommended Pressure kPa (PSI) |
|---------------|----------------------------------|----------------------------------|--------------------|--------------------------|----------------------------------|---------------------------------------|
| | State's | MFR's | | | | |
| Delmag D-12 | 15,000-20,370 (11,000-15,000) | 22,357-30,406 (16,500-22,400) | 50-60 | 1,244 (2,750) | 1.83 - 2.44 m (6.0' - 8.2') | Diesel |
| Delmag D-15 | 12,000-34,930 (8,800-25,800) | 17,886-52,140 (13,200-38,478) | 35-60 | 1,493 (3,300) | 1.22- 3.55 m (4.0'-11.66') | Diesel |
| Delmag D12-32 | 10,240-29,850 (7,760-20,000) | 15,284-44,553 (11,280-32,881) | 35-60 | 1,269 (2,820) | 1.22-3.55 m (4.0'-11.66') | Diesel |
| Delmag D16-32 | 12,800-37,345 (9,455-25,000) | 19,120-55,740 (14,112-41,136) | 35-60 | 1588 (3,528) | 1.22-3.55 m (4.0'-11.66') | Diesel |
| Delmag D-22 | 39,295(29,000) | 53,794(39,700) | 50-60 | 2,195 (4,850) | 1.83 - 2.44 m (6.0' - 8.0') | Diesel |
| Delmag D-30 | 21,600-49,250 (15,950-36,350) | 32,249-73-509 (23,888-54,350) | 39-60 | 2,986 (6,600) | 1.52 - 2.90 m (5.0' - 9.5') | Diesel |
| FEC 1500 | 9,840-24,600 (7,260-18,157) | 14,688-36,720 (10,840-27,100) | 40-60 | 1,500 (3,300) | 1.35-3.29 m (4'-5" - 10"-11¾) | Diesel |
| Hera 1500 | 27,506(20,300) | 41,249(30,442) | 40-50 | 1,500 (3,300) | | Diesel |
| ICE 40S | 14,525-36,315 (10,720-26,800) | 21,680-54,200 (16,000-40,000) | 38-55 | 1,814 (4,000) | 1.22-3.05 m (4'-0" - 10'-00") | Diesel |
| ICE 42S | 14,525-38,130 (10,720-28,140) | 21,680-56,910 (16,000-42,000) | 37-56 | 1,855 (4,088) | 1.18-3.12 m (3.93'-10.28') | Diesel |

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| | | | | | | |
|------------------------------|---|---|---------------------------------------|---------------|--------------------------------|-----------|
| Kobe K-13 | 13,000-22,150 (9,600-16,350) | 19,450-33,055 (14,350-24,400) | 40-60 | 1,300 (2,870) | 1.52 - 2.59 m (5.0'-8.5') | Diesel |
| Kobe K-22 | 22,000-37,400 (16,250-27,600) | 32,860-55,800 (24,250-41,200) | 45-60 | 2,195 (4,850) | 1.52 - 2.59 m (6.0' - 8.5') | Diesel |
| Link Belt 440 | Gage | Gage | 86-90 | 1,810 (4,000) | 937 m (36.9") | Diesel |
| Link Belt 520 | Gage | Gage | 80-84 | 2,262 (5,000) | 1.097 m (43.2") | Diesel |
| McKiernan - Terry DE30 | 15,260-20,350 (11,260-15,000) | 22,764-30,325 (16,800-22,400) | 48-52 | 1,267 (2,800) | 1.83 - 2.44 m (6.0' - 8.0') | Diesel |
| MKT DA35C (Double acting) | Gage | Gage | 78 to 82 | 1,273 (2,800) | 3.98m (13'-3") | Diesel |
| MKT DA35C (Single acting) | 15,250-21,600 (11,250-15,590) | 22,765-32,250 (16,800-23,800) | 40 to 50 | 1,273 (2,800) | 3.98 m (13'-3") | Diesel |
| Raymond 65C | 26,423 (19,500) | 26,423 (19,500) | 110 | 2,941 (6,500) | .410 m (16.0") | 828 (120) |
| Vulcan 1 | 20,325 (15,000) | 20,325 (15,000) | 60 | 2,262 (5,000) | .915 m (3.00') | 552 (80) |
| Vulcan 50C | 20,460(15,100) 18,022(13,300) 16,260(12,000) 14,769(10,900) 13,550(10,000) 12,602(9,300) | 20,460(15,100) 18,022(13,300) 16,260(12,000) 14,769(10,900) 13,550(10,000) 12,602(9,300) | 120 115 110 105 100 95 | 2,262 (5,000) | .394 m (15.5") | 828 (120) |
| Vulcan 06 | 26,423 (19,500) | 26,422(19,500) | 60 | 2,941 (6,500) | .915 m (3.00') | 552 (80) |
| Vulcan 65C | 26,061(19,200) 23,035(17,000) 20,325(15,000) 18,970(14,000) | 26,061(19,200) 23,035(17,000) 20,325(15,000) 18,970(14,000) | 117 110 105 100 | 2,941 (6,500) | .394 m (15.5") | 828 (120) |

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| | | | | | | |
|------------|-----------------|-----------------|-----|---------------|----------------|-----------|
| Vulcan 0 | 33,028 (24,375) | 33,028 (24,375) | 50 | 3,394 (7,500) | .991 m (3.25') | 552 (80) |
| Vulcan 80C | 33,130(24,450) | 33,130(24,450) | 111 | 3,620 (8,000) | .419 m (16.5") | 828 (120) |
| | 28,320(20,900) | 28,320(20,900) | 105 | | | |
| | 25,474(18,800) | 25,474(18,800) | 105 | | | |
| | 23,306(17,200) | 23,306(17,200) | 95 | | | |
| | 21,680(16,000) | 21,680(16,000) | 90 | | | |
| | 20,393(15,050) | 20,393(15,050) | 85 | | | |

For pile hammers not listed, the States energy rating shall be as follows;

Compressed air hammers - Same as manufacture's rated energy

Single acting or opened diesel hammer - 67% of the manufacture's rated energy

Closed end diesel hammers - The energy indicated by the bounce chamber gage or 67% of the manufacture's maximum rated energy.