

SPECIFICATIONS FOR BRIDGE CONSTRUCTION

SECTION 3

BEARING PILES

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REFERENCE DRAWINGS

Drawing No.

Standard Timber Pile Splice	S-1413-87
Standard Pipe Pile Splice	S-1414-87
Standard H-Pile Splice.....	S-1415-87
Standard Closed Pipe Pile End Plate	S-1479

3.1 General

This specification is for the supply and installation of steel H-piles, plain and galvanized steel pipe piles, timber piles, precast concrete piles, and cast-in-place concrete piles. It includes driven bearing piles, drilled cast-in-place concrete bearing piles, and drilled cast-in-place concrete/steel pipe composite bearing piles.

3.2 Materials

3.2.1 Steel "H" Piling

Steel "H" piling shall meet the requirements of Specification ASTM A36 or CSA G40.21M 350W. Where piling is designated in metric dimensions, imperial equivalent piling will be acceptable. Mill certificates shall be provided to the Consultant for review prior to pile installation.

Splice plates shall be fabricated to the dimensions shown on Standard Drawing S-1415 "Standard H-Pile Splice".

3.2.2 Steel Pipe Piling

Steel pipe piling shall meet the requirements of Specification ASTM 252 Grade 2, except that hydrostatic testing is not required. Although piling is designated in metric dimensions, imperial equivalent piling will be acceptable. Mill certificates shall be provided to the Consultant for review prior to pile installation. Some out-of-roundness of the pipe is acceptable provided an acceptable splice can be completed.

Galvanized piling shall be galvanized by the hot dip method, in accordance with the current edition of the ASTM A123/A123M Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.

Splice backup rings and closed pipe pile end plates shall be fabricated as shown on Standard Drawing S-1414 "Standard Pipe Pile Splice" and Standard Drawing 1479 "Standard Closed Pipe Pile End Plate".

3.2.3 Timber Piling

Treated timber piling shall be fir or pine, and untreated timber piling shall be fir, spruce, pine or a species that is equal to or better as determined by the Consultant. Timber piling shall conform to Section 23 - "Dimensional Structural Lumber and Piling", and shall be of the length specified on the drawings.

Timber pile splices shall be fabricated as shown on Standard Drawing S-1413 "Standard Timber Pile Splice".

3.2.4 Pile Concrete

Concrete shall meet the requirements of Pile Concrete as specified in Section 4 "Cast-In-Place Concrete".

3.2.5 Reinforcing Steel

Steel reinforcement incorporated in the pile concrete shall meet the requirements specified in Section 5 "Reinforcing Steel".

3.3 Handling

Piling shall be handled, hauled and stored in a manner that avoids damage to the piling materials. Loading and unloading shall be by crane, loader or other appropriate hoisting equipment.

Care shall be taken in order to prevent damaging the galvanized surface on galvanized piling. Fabric slings, wood blocking or other approved methods shall be used to support and separate galvanized piling when handling, hauling or storing. Piling on which the galvanized coating has been damaged shall be replaced or repaired as determined by the Consultant, at the Contractor's cost. Where repair of damaged galvanizing is required, the repair shall be by metallizing in conformance with ASTM A780, Method A3, to a thickness of 180 μm .

Special care shall be taken to avoid breaking through the surface treatment of treated piles, and cant-hooks, dogs, or pike poles shall not be used. Cuts or breaks in the surface of treated piles shall be given three brush coats of creosote oil of approved quality, and creosote oil shall be poured into all bolt holes.

3.4 Driven Bearing Piles

3.4.1 Equipment and Driving Methods

All pile driving equipment, driving methods and procedures shall be reviewed by the Consultant before any driving is started. Acceptable driving equipment includes diesel hammers, hydraulic hammers, vibratory hammers, driving frames or other equipment as may be required by the Consultant. The use of multi-component drop hammers will not be permitted under any circumstances. The use of gravity hammers will not be permitted except when the required bearing value is less than 350 kN, and the Consultant deems the gravity hammer and leads to be suitable. Where the use of a gravity hammer is acceptable, the Contractor shall furnish to the Consultant acceptable proof of its weight including the weight of the follower.

The driving of piles with driving extensions shall be avoided if practicable, and shall be done only under written permission of the Consultant. When driving extensions are used, one pile from each group of 10 shall be a long pile driven without extensions, and shall be used as a test pile to determine the average bearing power of the group. For the special types of piling, driving heads, mandrels, or other devices in accordance with the manufacturer's recommendations shall be provided so that the pile may be driven without damage and without unnecessary trimming.

The Contractor shall take adequate precautions to ensure that the piles are in proper alignment, including the use of installation frames, fixed leads or other means as are necessary. The method of alignment and maintaining alignment shall meet the acceptance of the Consultant.

For pile installation monitoring purposes, the Contractor shall paint markings on each pile at 0.25 m intervals, with a label at each 1.0 m interval, starting from the toe of the pile.

Piles shall be driven with a variation of not more than 20 mm per metre from the vertical or from the batter shown on the drawings, except that piles in exposed bents shall not be out of position at the ground line by more than 50 mm and shall not be out of position more than 25 mm in the pile cap. Foundation piles shall not be out of the position shown on the drawings more than 150 mm after driving.

3.4.2 Bearing Values

The piles shall all be driven to the tip elevations shown on the drawings, or lower, to achieve the required stability and specified minimum bearing capacity. The pile bearing capacities shall be estimated by the Bearing Formulas of this Specification.

After the pile driving operations have been started, the Department and Consultant may revise the required pile tip elevations, if necessary, using the pile driving data and the Bearing Formulas as a guide.

In the event pile tip elevations are not given on the drawings, the pile bearing capacities shall be estimated by any or all of the methods outlined under Bearing Formulas Test Piles, or Pile Capacity Test Methods, as determined by the Consultant.

In the case of friction piles, the piles shall be driven to the tip elevations shown on the Drawings, or lower, in order to achieve the required stability and design load carrying capacity.

Bearing Formulas

When not driven to practical refusal, the bearing values of piles may be required to be determined by test methods as specified above. In the absence of the above noted tests, the safe bearing values for piles shall be determined by the following formulas:

For Diesel and Hydraulic Hammers

$$P = \frac{165 \times E \times F}{S + 5}$$

Where P - Pile reaction at Service Limit State (SLS) (kilonewtons)
 E - Energy output of hammer (kilojoules)
 F - Efficiency factor
 S - The average penetration per blow for the last 10 to 20 blows (mm per blow)

The Consultant will determine the efficiency factor of the hammer at site by comparing the actual recorded blows per minute to data provided by the manufacturer of the hammer.

The above formula is applicable only when:

- (1) The head of the pile is not broomed, crushed, or deformed.
- (2) The penetration is reasonably quick and uniform.
- (3) A driving extension is not used.

For Gravity Hammers (When accepted for use by the Consultant)

$$P = \frac{1650 \times W \times H}{S + 25}$$

Where P - Safe bearing value (kilonewtons)
 W - Weight of striking parts of hammer (tonnes)
 H - Height of fall (metres)
 S - The average penetration per blow for the last 5 to 10 blows.

The above formula is applicable only when:

- (1) The hammer has a free fall.
- (2) The head of the pile is not broomed, crushed, or deformed.
- (3) The penetration is reasonably quick and uniform.
- (4) There is no sensible bounce after the blow, or twice the height of the bounce shall be deducted from "H" to determine its value in the formula.
- (5) A driving extension is not used.

The Contractor shall provide performance specifications for the type of hammer to be used. He will be required to demonstrate that the hammer is performing within the specified limits.

Test Piles

Test piles shall be driven where they are specified on the drawings or as required by the Consultant. Test piles shall be longer than the length assumed in design, in order to provide for variations in soil conditions and to explore conditions below the tips of permanent piles. Other dimensions of test piles shall be the same as permanent piles, and shall be driven with the same type and size of equipment.

3.4.3 Steel Piles

Steel piles shall consist of structural steel shapes or pipes of the section shown on the drawings or otherwise specified.

When pipe piles are to be driven closed-ended, one section of pipe for each proposed pile shall be supplied with the end-plate welded-on, in conformity with Standard Drawing S-1479 "Standard Closed Pipe Pile End Plate" included with these Specifications.

When pipe piles are to be driven open-ended and the interiors cleaned out, a power screw rotary auger, acceptable to the Consultant shall be used to remove the required material. All loose material and all material adhering to the walls of the piles shall be removed.

After installation closed ended or open ended pipe piles shall be filled with pile concrete.

The total energy developed by the hammer shall be sufficient to achieve the required bearing value or tip elevation, but in no case shall the total energy developed be less than 35 kJ per blow.

The head shall be cut squarely and a driving cap or follower shall be provided to hold the axis of the pile in line with the axis of the hammer. The follower shall be of adequate dimensions to allow driving the pile without trimming or reducing the cross-section of the pile. When damage or buckling is evident at the driving end of the pile in order to obtain the desired bearing capacity or penetration of the pile, the Contractor shall at his own expense reinforce the driving end of the piling, or provide other suitable equipment or procedures, to prevent such damage.

Piles shall be cut off level at the required elevation. If capping is required, the connection shall be made according to details shown on the drawings.

The Contractor shall supply and secure temporary caps on all open pipe piles or drilled holes.

3.4.3.1 Steel Pile Splices

When splicing, the Contractor shall employ whatever means necessary to match out-of-round piling. Exposed pile splices shall be avoided. Refer to Standard Drawing S-1415 "Standard H-Pile Splice" and Standard Drawing S-1414 "Standard Pipe Pile Splice" included with these Specifications. All welding in the field shall be in accordance with section 13.4.1.

Where the upper portions of piling are specified to be galvanized, excess piling shall be removed from the ungalvanized portion of the piling to ensure that the galvanized portion extends to the elevation shown on the drawings. Splicing within the galvanized portion of the piling shall be avoided; however if splicing becomes necessary due to unforeseen circumstances, the damage galvanized area shall be metallized by the Contractor at his cost.

The Contractor shall advise his staff and his welding personnel of the hazardous fumes which are generated during welding or cutting of the galvanized steel.

3.4.3.2 Testing by the Contractor

The Contractor shall perform Ultrasonic testing for a minimum of 20% of all full penetration compression splice welds for all piles for each bridge component. Ultrasonic testing shall be done for welds for which visual inspection may indicate having some defect. Additional testing may be required for the full penetration compression splice welds to ensure the integrity of the structure. In addition, the Contractor shall inspect 100% of the full penetration tension splice welds, as defined on the Detailed Designs. The NDT shall be done by a company certified to CAN/CSA W178.1. Ultrasonic testing technicians shall be certified to Level II of Canadian General Standard Board (CGSB). A copy of test results shall be provided to the Consultant for his review within three days of the inspection. The Consultant may require additional inspection if deemed necessary.

All costs associated with non-destructive inspection of welds shall be the responsibility of the Contractor.

3.4.4 Timber Piles

Gravity hammers when accepted for driving timber piles shall weigh not less than 1.5 t, and in no case shall the weight of the hammer be less than the combined weight of driving head and pile. The fall shall be so regulated as to avoid injury to the piles and in no case shall exceed 3 m. When a diesel hammer is used total energy developed by the hammer shall be not less than 15 kJ per blow.

The pile head shall be cut squarely and a driving cap or follower shall be provided to hold the axis of the pile in line with the axis of the hammer. The follower shall be of adequate dimensions to allow driving the pile without in any way trimming or reducing the cross-section of the pile.

The Contractor shall provide and install collars, bands, or other devices to prevent timber piles from splitting or brooming.

When the area of the head of any timber pile is greater than that of the face of the hammer, a suitable follower shall be provided to distribute the blow of the hammer throughout the cross-section of the pile and thus avoid splitting or shattering the pile.

Timber piles shall be pointed where soil conditions require it. When necessary, the piles shall be shod with metal shoes, supplied by the Contractor, of a design satisfactory to the Consultant, the points of the piles being carefully shaped to secure an even and uniform bearing on the shoes.

Full length piles shall be used where practicable. In exceptional circumstances splicing of piles may be permitted. The method of splicing shall be as shown on the drawings or as reviewed and accepted by the Consultant. Refer to Standard Drawing S-1413 "Standard Timber Pile Splice" included with these Specifications.

The tops of all piling shall be trimmed to a true plane at the elevation shown on the drawings or fixed by the Consultant. Piles which support timber caps or grillage shall be sawed to conform to the plane of the bottom of the super-imposed structure. In general, the length of pile above the elevation of cut-off shall be sufficient to permit the complete removal of all material injured by driving, but piles driven to very nearly the cut-off elevation shall be carefully trimmed and freed of all "broomed", splintered or otherwise injured material.

3.4.5 Defective Piles

The procedure incident to the driving of piles shall not subject them to excessive and undue abuse producing deformation of the steel, injurious splitting, splintering and brooming of the wood, or crushing and spalling of the concrete. Manipulation of piles to force them into proper position, considered by the Consultant to be excessive, will not be permitted. Piles damaged by improper driving, or driven out of proper location, or driven below the cut-off elevation, shall be corrected, at the Contractor's expense, by one of the following methods accepted by the Consultant:

- (a) The piles shall be withdrawn and replaced by new and, if necessary, longer piles, or
- (b) Replacement piles shall be driven adjacent to defective or low piles, or
- (c) The piles shall be spliced or built up, as otherwise provided herein, or a sufficient portion of the footing extended to properly embed the piles. Timber piles shall not be spliced without specific permission of the Consultant. All piles, pushed up by the driving of adjacent piles or by any other cause, shall be driven down again.

In case the required penetration and bearing capacity are not obtained, the contractor shall provide a hammer of greater energy, as applicable, or when accepted by the Consultant/Department, resort to pre-drilling. This will be considered incidental to the work of achieving acceptable penetration and bearing capacity, and not claimable as extra work.

3.4.6 Measurement and Payment

Supply of Piling

Payment for **Supply of Piling** will be made on the basis of the unit price per metre bid for each type of piling supplied, which price shall include full compensation for the cost of furnishing and delivering the material to site. The unit prices shall include full compensation for the cost of all labour, tools, equipment and other necessary or incidental costs of handling, loading and hauling the piling.

The number of metres of piling to be paid for shall be the total number of metres acceptably driven and remaining in the completed structure. Where portions of steel piling are specified to be galvanized, only the lengths requiring galvanizing will be included in supply of galvanized steel piling. All steel piling below the level of the galvanized piling length shown on the drawings will be included in supply of plain steel piling.

Re-stocking Steel Piling

When quantities of plain Steel Pipe or H Piles are reduced by 15% or more due to conditions beyond the Contractor's control, the Department will reimburse the "re-stocking" costs for 6.0 metre lengths or longer, incurred by the supplier to the Contractor.

The Contractor shall present vouchers giving details as to dates, quantities, rates, third party invoices, and such other supporting documentation to the Consultant. Payment will be made on the cost of Re-stocking@ and based on the invoices excluding labour burden, overhead and profit.

Pile Set-up

Payment for **Pile Set-up** will be made on the basis of the unit price per pile bid, which price shall include the expense and time to set the equipment over the pile, ready to commence driving. Payment will be made only for piles acceptably driven as determined by the Consultant.

Pile Driving

Payment for **Pile Driving** will be made on the basis of the unit price per metre bid, which price shall include full compensation for the cost of furnishing all labour, tools, and equipment, and other necessary or incidental costs of handling, driving, splicing, cutting off of piles, reinforcement of pile heads and all other incidental work connected therewith. It shall also include full compensation for all drilling, blasting, splice plates, splice rings, or other work or materials necessary to obtain the required penetration or bearing values of piles.

The number of metres to be paid for shall be the total number of metres of piling acceptably driven and remaining in the completed structure.

Pile Tip Reinforcement

When the Contract contains a bid item for **Pile Tip Reinforcement**, payment will be made on the basis of the unit price bid, which price shall include full compensation for all labour, materials, equipment, tools and all incidentals necessary to complete the work.

Pile Splicing

When the Contract contains a bid item for **Pile Splicing**, piles which penetrate in excess of 20% of the estimated length, splicing will be paid for at the assigned unit price for **Pile Splicing** and will include all labour, materials, equipment, tools and incidentals necessary to complete the work. Only one splice for each additional length of pile, up to twelve metres, will be paid for.

Pile Concrete

Pile Concrete shall be measured and paid for in accordance with Section 4 "Cast-In-Place Concrete".

Reinforcing Steel

Reinforcing Steel incorporated in the piling will be paid for in accordance with Section 5 "Reinforcing Steel".

Test Piles

Test piles retained in the structure will be paid for at the bid price of other piling used.

If, however, piling is not used in the structure, the test piles will be paid for as Extra Work, due to consideration being given to the cost of bringing the pile driver to the site and removing it from the work.

3.5 Drilled Cast-in-place Concrete Bearing Piles**3.5.1 General**

In addition to drilled cast-in-place concrete bearing piles this section shall include drilled cast-in-place concrete/steel pipe composite bearing piles. The work shall include drilling and belling the holes, as required, supplying and placing the steel pipe and reinforcing steel, and supplying, placing, protecting and curing the concrete.

3.5.2 Equipment and Drilling Methods

Due to the nature of the work, the Department requires that the drilling subcontractor have adequate equipment and a proven record of competence in this work.

All pile drilling equipment, drilling methods and procedures shall be reviewed by the Consultant before drilling is started. Unless otherwise specified only powered screw rotary type augers will be acceptable.

The Contractor shall not proceed with the installation of further piling, if for any reason the quality of the adjacent piling is compromised due to the effects of vibration or other reasons.

3.5.3 Cast-In-Place Pile Bearing Values

Where cast-in-place piles are designed based on the use of semi-empirical methods, supported by a geotechnical investigation with soil strength parameters determined by laboratory, field testing and local experience, and with appropriate levels of construction monitoring and verification the ultimate bearing capacity may be adjusted for Limit State Design by a geotechnical resistance factor of 0.4. If working state design methods are used the allowable loads shall be as determined by the Consultant.

3.5.4 Drilling Pile Holes

The drilled pile holes shall be stabilized and sealed by means of temporary casings or other methods to prevent the possible collapse of the pile holes or ingress of water. The Contractor shall make every attempt necessary to obtain “dry” pile holes prior to placing the pile concrete.

Temporary casing, if used in drilling operations, shall be removed from the hole as pile concrete is being poured. The bottom of the casing shall be maintained below the top of the concrete during withdrawal and pouring operations unless otherwise permitted by the Consultant. Separation of the concrete during withdrawal operations shall be avoided by hammering or otherwise vibrating the casing.

The elevations shown on the drawings of the bottoms of the pile holes shall be considered approximate only, and the Department and Consultant may order further drilling as necessary to secure satisfactory bearing of the piles.

Where bellling of the piles is specified, bellling shall proceed only after the pile hole has been drilled to an elevation acceptable to the Consultant.

The walls and bottoms of the pile holes shall be cleaned to remove all loose and extraneous material. The Contractor shall determine if any gas is present in the pile holes and shall provide whatever means and equipment necessary to ensure a safe work site. Pile reinforcement and pile concrete shall not be placed without the acceptance of the pile holes by the Consultant.

3.5.5 Open Drilled Holes

The Contractor shall be responsible for covering all open drilled holes on the site until the time they are filled with concrete or otherwise properly backfilled. The covers shall be of adequate strength and securely fitted so that machinery and workmen are protected against cave-in and surface water is prevented from running into the pile hole.

3.5.6 Reinforcement

Steel reinforcement shall be fabricated in the sizes and to the dimensions shown on the drawings and shall be placed, centered and braced in the pile hole to the acceptance of the Consultant.

Particular care shall be taken in locating projecting “column dowel bars”, to a tolerance not exceeding 10 mm in any direction, and pouring will not be permitted until the Consultant is satisfied that adequate provisions have been made.

Adequate “shoes” or spacers shall be firmly anchored to the reinforcement to ensure the reinforcement is kept centered in the concrete.

3.5.7 Concrete Placement

When the reinforcement has been acceptably placed, concrete shall be immediately deposited in the pile hole. The concrete shall be “Pile Concrete” and the provisions of Section 4 “Cast-In-Place Concrete” shall apply.

Suitable forms shall be used to maintain the specified dimensions of concrete piles above ground level.

Pile concrete placed under water will require validation by Crosshole Sonic Logging (CSL) in accordance with section 4.15.3 "Concrete Placed under Water".

3.5.8 Cold Weather Conditions

In cold weather, which shall be considered to exist if nighttime low temperatures are expected to be below 0°C, heated concrete shall be used. Such concrete shall have a temperature of between 15°C and 25°C when placed.

When the ground against which pile concrete is placed is below -5°C, the concrete shall be protected from heat loss. The pile boring shall be made oversize down to the depth of 2 m, and the concrete shall be poured in an insulated form. Concrete at the top of the pile is to be insulated. After four days the form and insulation may be removed, and the space is to be backfilled immediately with compacted non-granular fill or lean concrete to the elevation of top of pile.

In a region where the ground temperature is above -10°C but below -5°C, the hole may be bored 100 mm diameter oversize, and filled directly with pile concrete, as an alternative to the procedure described above. Concrete at the top of the pile is to be insulated.

If the top of the pile extends above the existing ground surface, in cold weather, it is to be adequately protected from the cold for a period long enough to ensure proper curing.

3.5.9 Pile Tolerance

Piles shall be accurately located, and shall be installed plumb or at the batter specified on the drawings. The maximum tolerance allowed shall be 50 mm for variation off the centre of any pile at the cut-off elevation, and no pile shall be out of plumb or specified batter by more than 20 mm per metre. Any pile out of centre or plumb beyond the tolerances specified shall be corrected at the Contractor's expense.

3.5.10 Measurement and Payment

Drill Rig Set-up

Payment for **Drill Rig Set-up** will be made on the basis of the unit price per pile bid which shall include full compensation for the cost to set up the drilling equipment over the pile location ready to commence drilling, and the cost to supply, install and remove temporary casing as required. Payment will be made only for piles acceptably constructed, as determined by the Consultant.

Pile Installation

Payment for **Pile Installation** will be made on the basis of the unit price per lineal metre bid which shall include full compensation for the cost of supplying all materials including piles, drilling, dewatering and cleaning out the holes to the dimensions shown, removal and disposal of the augered material, detection and purging of any gas hazard, and providing safe inspection access. The quantity to be paid for **Pile Installation** shall be the number of lineal metres required to install

the piles in accordance with the drawings and specifications (measured from the pile tip to the underside of pile/pier cap). Drilling will be considered as part of pile installation and no separate or additional payment will be made.

Pile Concrete

Pile Concrete will be measured and paid for in accordance with Section 4 "Cast-In-Place Concrete".

Reinforcing Steel

Reinforcing Steel incorporated in the piling will be paid for in accordance with Section 5 "Reinforcing Steel".

3.6 Pile Capacity Test Methods

3.6.1 Static Load Testing

When specified in the Special Provisions, the load carrying capacity of piles shall be determined by static load tests. In general static load tests can be performed on any pile type. Static load tests shall consist of the application of a test load on a suitable platform supported by the pile, or through the use of adjacent reaction piles, with suitable apparatus for accurately measuring the test load and the settlement of the pile under each increment of load. Tests shall be in general conformance with ASTM D3689-90 (1995). Osterberg or Statnamic tests may be used in place of static load tests.

Where sufficient static load testing has been done to satisfy Limit State Design, Load and Resistance Factor Design (LRFD), or reliability-based design statistical requirements, the factored geotechnical resistance may be taken as 0.6. Where allowable or working state design methods are used in the design, or where the requirements of Limit State Design are not fulfilled, the allowable load shall be considered as 50% of that load which, after a continuous application of 48 hours, produces a permanent settlement not greater than 6 mm measured at the top of the pile. This maximum settlement shall not increase by a continuing application of the test load for a further period of 60 hours or longer. At least one pile for each group of 100 piles shall be tested unless a different testing frequency is specified in the Special Provisions. The frequency of testing shall be increased to account for changing soil conditions, pile sections and types, and construction methods.

3.6.2 Dynamic Load Testing / Pile Driving Analyzer (PDA) Testing

Dynamic Load Testing provides useful data on piling stresses and can be used as part of a quality control method during pile installation. Pile Driving Analyzer (PDA) testing can be used as an alternate or supplemental test method to static load tests for the determination of pile capacity. This method involve installing instruments on the pile head with accelerometers and strain gauges, then impacting the pile head using a pile driving hammer or similar device over a very short period of time (3-4 milliseconds). The impact imparted on the pile should be sufficient to fully mobilize the pile skin friction and end bearing resistances of the pile. In general, this requires that a net permanent set per blow of at least 3 mm (and not greater than 8 mm) be achieved upon impact from the pile hammer.

The PDA test can be conducted on either driven or cast-in-place piles. For driven piles, the PDA test shall be conducted at the end of the initial driving stage, such that the end bearing and skin friction resistances can be determined upon initial installation of the pile. Where time dependant changes in the soil conditions are anticipated, such as pile setup or relaxation, additional tests shall be conducted upon re-strike on a sample of previously tested piles to determine the bearing parameters after driving induced pore pressures have dissipated. The re-strike should be conducted approximately one to two weeks or longer after initial driving, as directed by the Consultant. It is permissible to initially drive piles to a capacity below the required ultimate capacity and rely on pile setup to produce the required capacity. Where the capacity of the pile at re-strike is relied upon for design, a minimum of one third of piles tested during initial drive should be tested again during re-strike.

If dynamic testing is only undertaken upon re-strike, then a minimum of 10% to 15% of all piles shall be PDA tested on re-strike.

The hammer energy used during PDA tests at the end of initial drive and during re-strike driving shall be such that the required ultimate pile capacity can be mobilized in a single blow without additional data interpretation.

For cast-in-place piles, the PDA test should be conducted at least one week after the installation of the pile, as directed by the Consultant.

The results of the test can be processed in the short term using the Wave Equation Analysis of Piles (WEAP) method to provide real time monitoring of pile stresses, pile integrity, hammer performance, and pile capacity; and in some cases can be used to confirm pile termination depths when borehole information is not available. This method should only be used as an initial determination of bearing capacity though, and where the test is being used to determine the capacity of the pile for design methods, a signal matching analysis using a Case Pile Wave Equation Program (CAPWAP) should be utilized.

To ensure good quality data resulting from the PDA test, ASTM D4945-08 should be followed. In addition, at least two accelerometers on a driven pile and four accelerometers on a cast-in-place pile should be installed. All accelerometers and transducers should be calibrated and inspected to ensure proper attachment to the pile.

Since the PDA test method indirectly calculates the load and settlement characteristics of the pile based on strain and acceleration measurements, PDA testing is deemed secondary in accuracy to Static Load Tests. As a result, where the PDA methods are used strictly as a QA/QC tool, a minimum of 5% to 10% of production piles should be monitored dynamically. When used as a design or confirmatory tool, a minimum of 10% to 15% of piles (including tests at such substructure associated with the project or where soil conditions are expected to vary) should be tested, or as required for statistic validation of a LRFD design whichever is greater. The piles selected for testing should be representative of other piles in the same structure. Where driven piles exhibit lower driving resistances and/or shorter penetrations than normal, or where cast-in-place piles experience extraneous soil, ground water, and/or installation conditions, additional tests over and above minimum number of tests specified earlier may be required. Further, additional tests should accompany changes in piling equipment, procedure and pile requirements.

In the situation where one pile in a pile group does not meet capacity requirements, additional tests may be necessary to confirm that this pile is an isolated case. In such case, it may be permissible to rely on group effects to compensate for the lower pile capacity. The geotechnical and structural consultants will have final say in this situation. Under no circumstances will superposition of axial and shaft capacity from different strikes, re-strikes or any combination thereof be permitted.

Where sufficient dynamic load testing has been done to satisfy Limit State Design, LRFD or reliability-based design statistical requirements, the geotechnical resistance factor for design of pile foundations may be taken as 0.5.

Pile driving equipment shall be sized such that piles can be driven with reasonable effort to the specified ultimate bearing capacity, without damaging the pile. Approval of the pile driving equipment by the Consultant will be based on the WEAP analysis and/or PDA testing. The Contractor shall submit details of the proposed pile driving equipment for review by the Consultant a minimum of 14 days prior to the commencement of pile installation. The information provided shall include the following:

- Hammer Data: Hammer type, manufacturer, model number, serial number, maximum rated energy and range in operating energy, stroke at maximum rated energy and range of operating stroke, ram weight, modifications.
- Striker Plate Data: weight, diameter, thickness, composition
- Hammer Cushion Data: Manufacturers, area, thickness per plate, number of plates, total thickness, and composition
- Helmet Data: Weight, composition
- Pile Cushion Data: Material, area, thickness per sheet, number of sheets, total thickness of cushion

The PDA testing agency shall prepare a daily field report summarizing the preliminary test results including driving stresses, transferred energy and estimated pile capacity to the Consultant within 24 hours of testing. The final test results shall be presented to the Department within 7 days of testing. The testing report shall be prepared in accordance with the requirements of ASTM D4945-08. As a minimum, the report shall include the following:

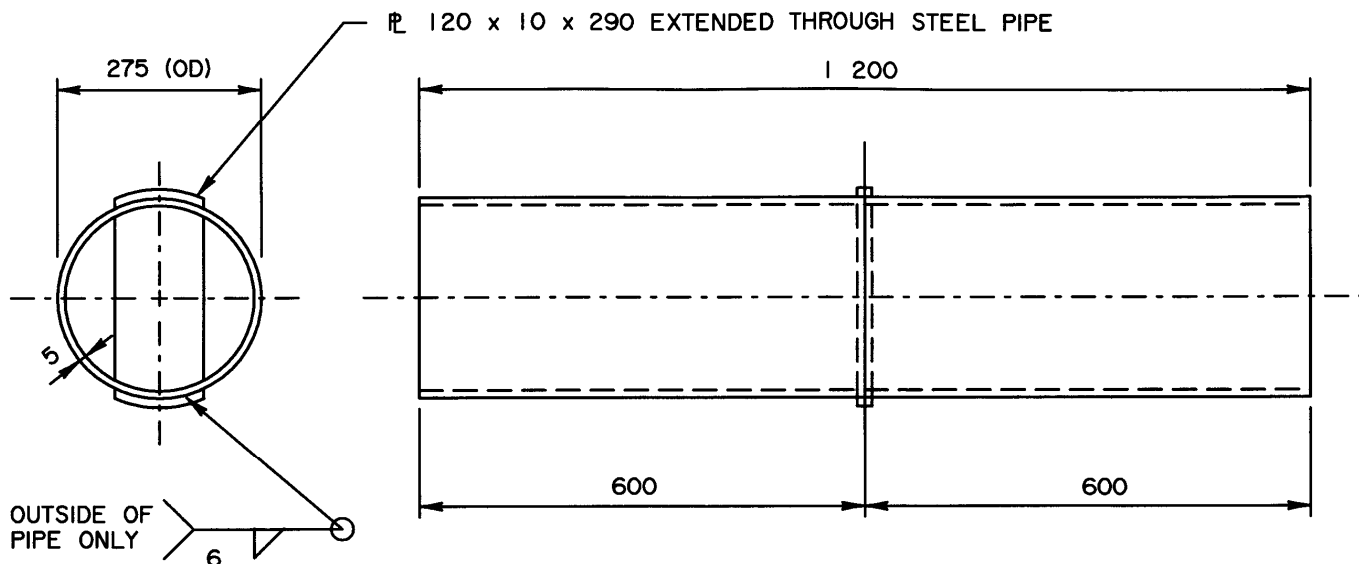
- Pile and driving system information
- Pile installation data
- PDA testing equipment and procedure
- Energy imparted
- Maximum driving stresses
- Hammer blow rate
- CAPWAP input parameters including quake and damping factors
- Shaft friction, end bearing and total pile capacity

The Consultant will use the test results to determine the subsequent termination criteria, requirements for modification of driving procedures or equipment, and pile acceptance. Any work done on the foundation elements (pile caps, cut-off, welding, etc) prior to received approval of test results from the Consultant will be at the Contractor's own risk.

3.6.3 Measurement and Payment

When the contract contains a bid item for **Static Load Testing**, payment will be made at the unit price bid and will be full compensation for static load testing and all labour, equipment, tools and incidentals to complete the work.

When the contract contains a bid item for **Dynamic Load Testing/Pile Driving Analyzer (PDA) Testing**, payment will be made at the unit price bid and will be full compensation for dynamic load testing and PDA testing, pile set up for re-strike, pile re-striking and all labour, equipment, tools and incidentals necessary to complete the work.



PIPE SLEEVE DETAIL

GENERAL NOTES



- DIMENSIONS ARE GIVEN IN mm. DETAILS ARE NOT TO SCALE.
- STEEL SHALL CONFORM TO ASTM A36 OR CSA G40.21M 300W.

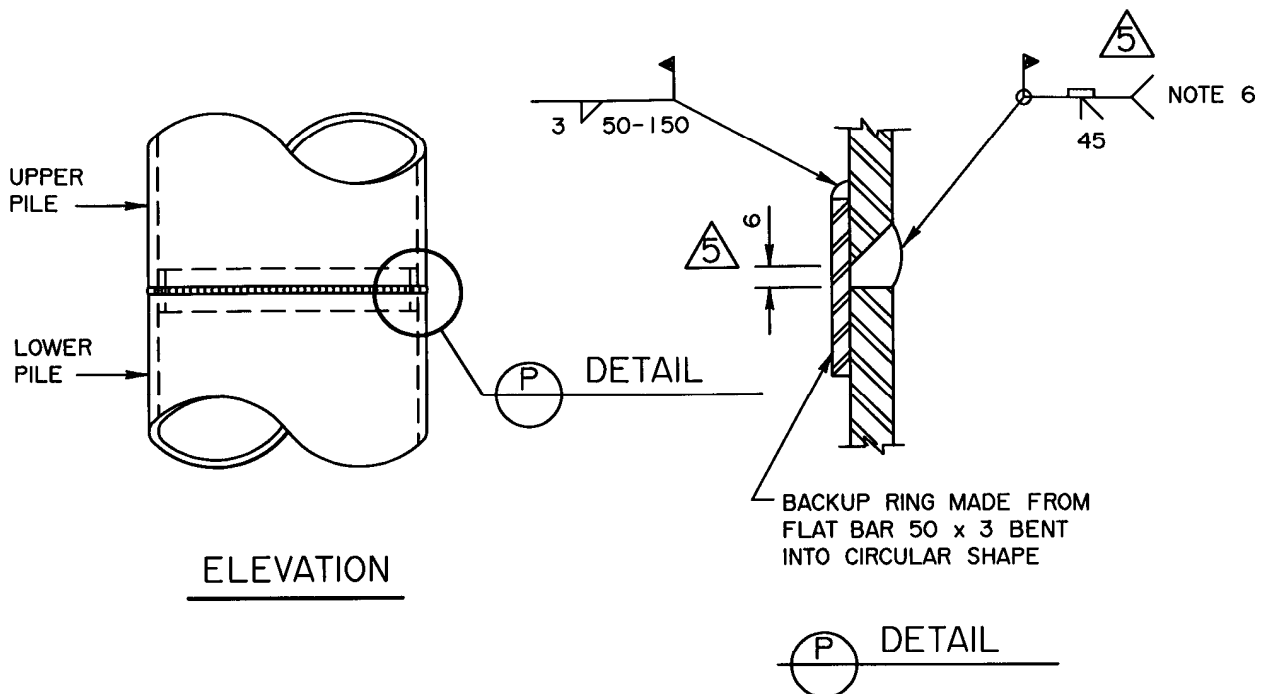
REQUIREMENTS AND PROCEDURE FOR SPLICING TIMBER PILES

1. THE PILE ENDS BEING SPLICED SHALL HAVE DIAMETERS OF 280 mm OR GREATER.
2. DRIVING OF THE BOTTOM PILE SHALL BE STOPPED APPROXIMATELY 600 mm ABOVE GROUND OR WATER LINE.
3. DAMAGED PILE ENDS SHALL BE TOTALLY REMOVED BY MAKING SQUARE CUT-OFFS.
4. THE PIPE SLEEVE SHALL BE CENTRED, AND TAPPED PARALLEL, THE FULL 600 mm DISTANCE ONTO THE PILE.
5. THE UPPER PILE END SHALL BE SQUARED, CENTERED ON THE TOP OF THE PIPE SLEEVE, AND TAPPED DOWN INTO THE SLEEVE, KEEPING THE UPPER PILE ALIGNED WITH THE LOWER PILE.
6. THE TOP OF THE PILE SPLICE SHALL END UP NOT LESS THAN 2500 mm BELOW GROUND LINE.

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DRAFTING STANDARDS PAGE: 3.8

DESIGNED DHQ	DRAWN MIK	DATE 87-03-05	APPROVED EXECUTIVE DIRECTOR	SIGNATURE <i>[Signature]</i>	DATE 11/2/87	PAGE 3.19	DRAWING S-1413-87
4	99-03-29	BEB CHANGED TO TSB	RY	Alberta TRANSPORTATION AND UTILITIES TECHNICAL STANDARDS BRANCH STANDARD TIMBER PILE SPLICE			
3	94-11-30	GENERAL NOTES AND PAGE NUMBER	RJR				
2	87-03-05	REDRAWN FROM S-1413	DHQ				
1							
NO	DATE	REVISIONS		BY			



GENERAL NOTES

- DIMENSIONS ARE GIVEN IN mm. DETAILS ARE NOT TO SCALE



REQUIREMENTS AND PROCEDURE FOR SPLICING PIPE PILES



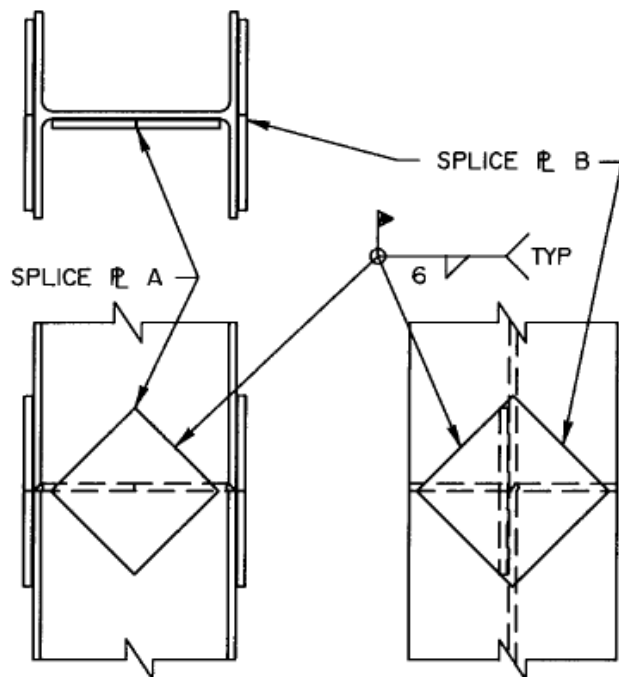
1. FIELD WELDING SHALL BE IN ACCORDANCE WITH SECTION 13.4
2. THE LOWER PILE SHALL BE TRIMMED TRUE AND SQUARE.
3. THE BEVEL ON THE UPPER PILE SHALL BE FLAME CUT USING A MECHANICAL PIPE BEVELLING MACHINE.
4. THE BACKUP PLATE SHALL BE WELDED TO THE UPPER PILE.
5. THE UPPER PILE SHALL BE POSITIONED WITH THE BACKUP RING FITTED INTO THE LOWER PILE.
6. SPLICE WELD SHALL PENETRATE BACKUP RING. TWO PASSES ARE REQUIRED IF THE PILE WALL IS GREATER THAN 8 mm. GRIND WELD SMOOTH IF THE SPLICE IS LOCATED ABOVE GROUND LEVEL.

5	2005-05-19	DETAIL "P" REVISED	AW
4	2001-06-19	GENERAL NOTES	AW
3	99-03-29	BEB CHANGED TO TSB	RY
2	94-11-30	GENERAL NOTES	RJR
1	87-03-09	REDRAWN FROM S-1414	DHQ
NO	DATE	REVISIONS	BY

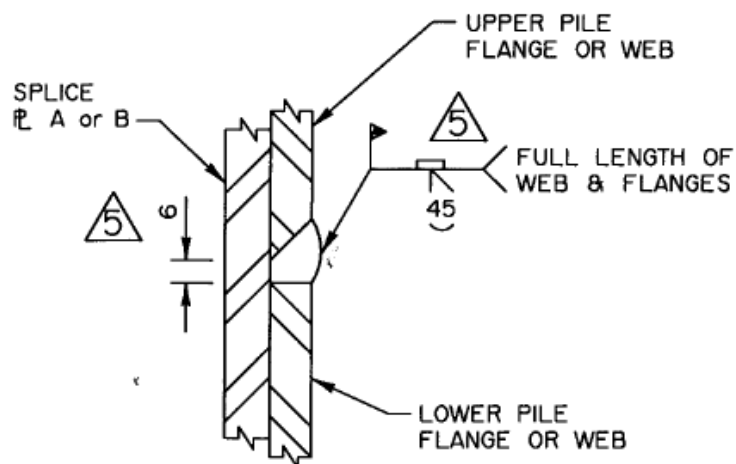
Alberta TRANSPORTATION AND UTILITIES
TECHNICAL STANDARDS BRANCH

STANDARD PIPE PILE SPLICE

DESIGNED DHQ	DRAWN MIK	DATE 87-03-09	APPROVED EXECUTIVE DIRECTOR	SIGNATURE <i>[Signature]</i>	DATE 11/8/87	PAGE 3.15	DRAWING S-1414-87
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SPLICE DETAILS



FLANGE & WEB WELDS

PILE DESIGNATION	SPLICE PLATE DIMENSIONS	
	PLATE A (WEB)	PLATE B (FLANGE)
HP 310 x 79	12 x 160 x 160	12 x 200 x 200
HP 310 x 94	12 x 160 x 160	12 x 200 x 200
HP 310 x 110	12 x 160 x 160	12 x 200 x 200
HP 310 x 125	12 x 160 x 160	12 x 200 x 200
HP 360 x 108	12 x 190 x 190	12 x 250 x 250
HP 360 x 132	12 x 190 x 190	12 x 250 x 250

GENERAL NOTES

- DIMENSIONS ARE GIVEN IN mm. DETAILS ARE NOT TO SCALE.
- STEEL SHALL CONFORM TO ASTM A36 OR CSA G40.21M 350W.

REQUIREMENTS AND PROCEDURE FOR SPLICING H-PILES

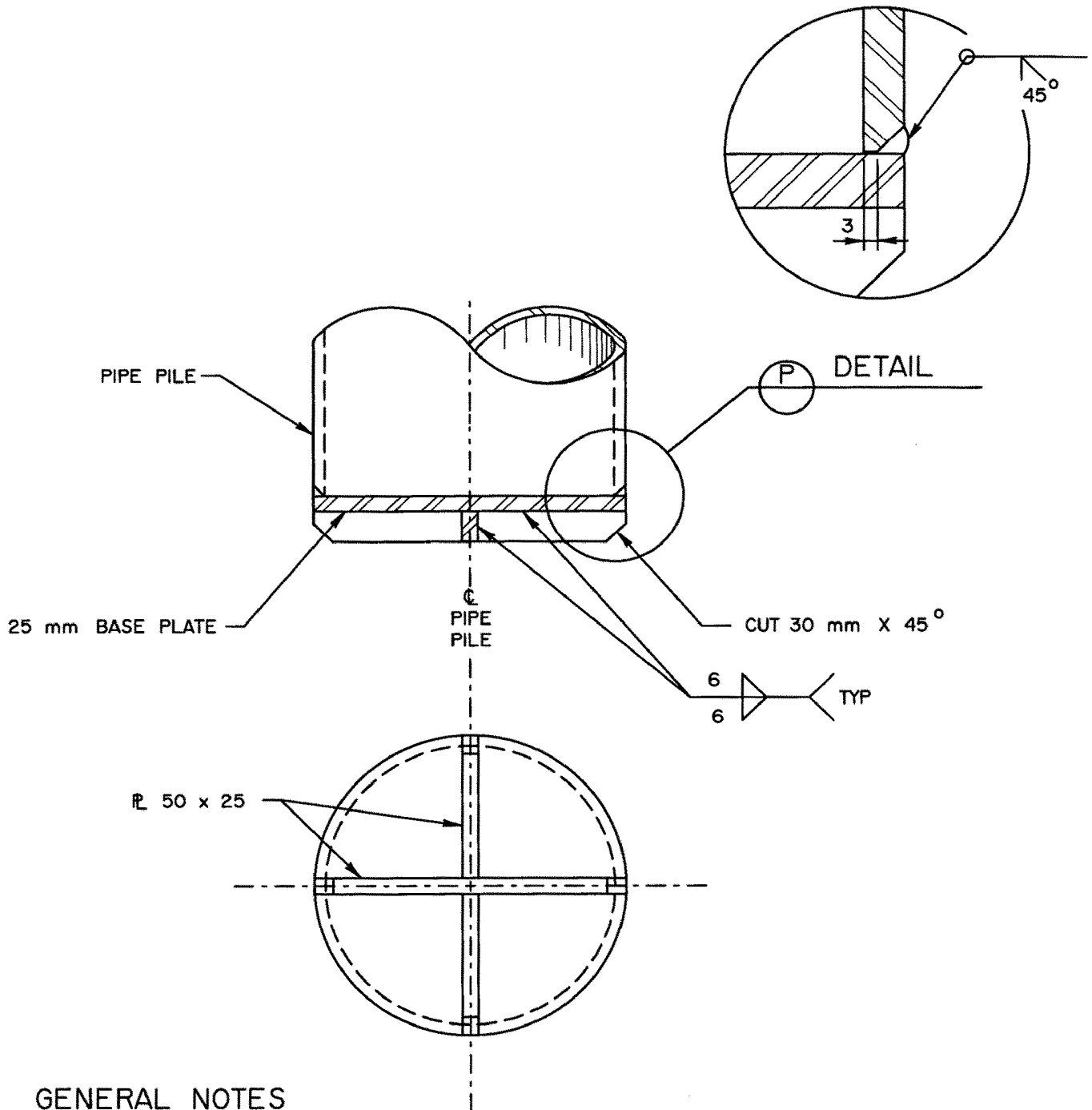
1. FIELD WELDING SHALL BE IN ACCORDANCE WITH SECTION 13.4
2. PILE ENDS TO BE SPLICED SHALL BE FLAME CUT USING A STEEL GUIDE TO OBTAIN A SQUARE AND EVEN CUT. BEVEL CUTS SHALL BE MADE AT 45°.
3. SPLICE PLATES A & B SHALL BE WELDED TO THE UPPER PILE BEFORE POSITIONING IT.
4. THE UPPER PILE SHALL BE POSITIONED ON AND THE SPLICE PLATES WELDED TO THE LOWER PILE; BUTT WELDS SHALL THEN BE MADE.

2009-05-21	PILE TYPES ADDED TO CHART	WEM
2005-05-19	FLANGE & WEB WELDS REVISED	AW
2001-06-19	GENERAL NOTES	AW
99-03-29	BEB CHANGED TO TSB	RY
94-11-30	GENERAL NOTES	RJR
87-03-11	REDRAWN FROM S-1415	DHQ
NO	DATE	REVISIONS
DESIGNED	DRAWN	DATE
DHQ	MIK	87-03-11
APPROVED	SIGNATURE	DATE
EXECUTIVE DIRECTOR	<i>[Signature]</i>	May 8/87

Alberta TRANSPORTATION AND UTILITIES
TECHNICAL STANDARDS BRANCH

STANDARD H-PILE SPLICE

DESIGNED	DRAWN	DATE	APPROVED	SIGNATURE	DATE	PAGE	DRAWING
DHQ	MIK	87-03-11	EXECUTIVE DIRECTOR	<i>[Signature]</i>	May 8/87	3.13	S-1415-87



GENERAL NOTES

- ① • DIMENSIONS ARE GIVEN IN mm. DETAILS ARE NOT TO SCALE.
- STEEL SHALL CONFORM TO ASTM A36 OR CSA G40.21M 300W.
- ③ • SHOP WELDING SHALL BE IN ACCORDANCE WITH SECTION 6

4

DRAFTING STANDARD PAGE: 3.9

④					Alberta TRANSPORTATION AND UTILITIES TECHNICAL STANDARDS BRANCH
③	2001-06-19	GENERAL NOTES	AW		
②	99-03-29	BEB CHANGED TO TSB	RY		
①	94-11-30	GENERAL NOTES AND PAGE NUMBER	RJR		
NO	DATE	REVISIONS	BY		
DESIGNED	DRAWN	DATE	APPROVED	SIGNATURE	DATE
DHQ	MIK	87-03-30	EXECUTIVE DIRECTOR	<i>[Signature]</i>	11/4/87
					PAGE 3.17
					DRAWING S-1479

