DEPARTMENT of INFRASTRUCTURE, ENERGY and RESOURCES, TASMANIA

BRIDGEWORKS SPECIFICATION

B4 - PRECAST CONCRETE PILES April 2003

Includes previous B3 and B4

Contents **Page**

B4.1 SCOPE

This Specification sets out the requirements for the manufacture, handling, transport, storage and driving of precast, reinforced and prestressed concrete piles.

B4.2 REFERENCES

The following Australian and British Standards apply:

A.S. 1310 Steel wire for tendons in prestressed concrete

A.S. 1311 Steel tendons for prestressed concrete- 7 wire stress relieved steel strand.

A.S. 1313 Steel tendons for prestressed concrete-cold worked

A.S. 1349 Bourdon tube pressure and vacuum gauges

A.S. 1391 Methods for tensile testing of metals

A.S. 1554 Structural steel welding Part 3 Reinforcing steel

A.S. 1554 Structural steel welding Part 6 Stainless steel for structural purposes

A.S. 2074 Steel castings

A.S.2159 Piling design and installation

A.S. 3610 Formwork for concrete

A.S. 3799 Liquid membrane forming curing compounds for concrete

A.S. 4671 Steel reinforcing materials

H.B. 77 Australian Bridge Design Code (previously Austroads Bridge Design Code)

B.S. EN 10088-1 Stainless steels. Part 1 List of stainless steels

B.S. 6744 Austenitic stainless steel bars for the reinforcement and use in concrete

B4.3 MANUFACTURE

B4.3.1 General

All piles shall be manufactured to the dimensions shown on the Drawings and in accordance with Specifications:- B10 - Supply of Ready Mixed Concrete,

B11 - Reinforced, Pretensioned or Mass Concrete and

B14 - Precast Concrete Units

Cast steel pile shoes shall be of steel to AS 2074 - C4.

B4.3.2 Prestressing Tendons

Tendons used for longitudinal stressing shall consist of uncoated, stress relieved, low-relaxation 7-wire strand complying with AS 1311: 7-wire Stress-relieved Steel Strand for Tendons in Prestressed Concrete. Copies of Manufacturer's test certificates for the tendons shall be submitted to the Superintendent. All coils of tendons shall be capable of being identified with the test certificates.

In general, physical testing of tendons will not be required provided that a satisfactory correlation is obtained between the jacking force and extension during the stressing operation. However, if such correlation is not obtained, or if the tendon exhibits any peculiarities as referred to in AS 1310 to 1313, usage of such tendons shall cease until physical tests have been made at a N.A.T.A. registered laboratory. Two samples, each 1.4 metres long, shall be taken and tested for the ultimate tensile strength, 0.1% Proof stress, 0.2% Proof stress, secant modulus of elasticity at stressing load and percentage elongation at rupture on a 600 mm gauge length.

Coils of prestressing tendon shall be stored away from the weather and shall not be placed in direct contact with the ground.

Any lubricant used in the drawing of the tendon shall be thoroughly removed by a suitable degreasing agent. All loose rust shall be removed from the tendons before use. A very light film of rust is not considered detrimental providing that the steel is not visibly pitted. Badly rusted or pitted steel shall not be used. Any foreign matter adhering to the tendon after stressing shall be removed before concreting. The cleanliness of the tendon shall be such that bond with the concrete is not impaired. Tendons shall be supplied in coils large enough to be self straightening. Kinked or damaged tendons will not be permitted.

B4.3.3 Pretensioning

Prior to stressing the Contractor shall supply to the Superintendent his calculations showing how it is proposed to achieve the stressing force specified on the Drawings.

24 hours notice shall be given to the Superintendent prior to stressing. The stressing operations shall be performed under the supervision of a competent person provided by the Contractor. No tendons shall be stressed if they are at a temperature of 0^{o}C or below. In addition, the air temperature must be not less than 5^{o} C.

B4.3.4 Tensioning Equipment

All tensioning equipment shall be calibrated as a complete unit by an approved laboratory as necessary, but at least every six months in order to give a correlation between the force applied to the tendon and the reading indicated by the pressure gauge.

Pressure gauges shall comply with the requirements of AS 1349 for industrial gauges. NATA endorsed test certificates showing such compliance shall be kept in the site office of the Contractor and made available to the Superintendent on demand.

B4.3.5 Trimming of tendons after transfer

After the transfer of prestress, tendons shall be trimmed flush with the end of the piles using abrasive disc grinders without damaging the concrete.

After trimming, the ends of the tendons and the area immediately adjacent to the tendons shall be painted with an epoxy compound to provide a film thickness at least 0.3 mm dry. A minimum of two coats shall be applied.

B4.3.6 Stressing Records

The Contractor shall keep records of the prestressing operation as follows:

(i) Contract number

(ii) Pile reference number

(iii) Pile type

(iv) Date of casting

(v) Date of transfer of prestress

(vi) Identification numbers of dynamometers, gauges, pumps and jacks, identification particulars of the tendons.

(vii) Required overall elongation, calculated jacking force after allowing for all appropriate losses.

(viii) Force (or pressure) at the time tendons are marked initially for measurement of elongation.

(ix) Final force applied if dynamometer used; alternatively final pump or jack pressure.

(x) Draw-in losses, bed-movement (if any), other losses.

(xi) Elongation remaining immediately after anchoring.

Copies of the stressing records shall be submitted to the Superintendent not more than 24 hours after stressing.

B4.3.7 Stressing Procedure

The "stressing force" stated on the Drawings is defined as the average force remaining in the tendons, within the length of any member, immediately before concreting. The actual tensioning force applied shall allow for any anticipated slip or movement of the anchorage devices, relaxation of the tendons before concreting and friction through the forms.

The method of tensioning shall ensure that the required force is applied to all tendons.

Prior to establishing a datum mark on each tendon for the purpose of measuring elongation, a known initial tension of from 15 kN to 20 kN shall be applied to each tendon to lift it off the bed floor and to equalise sag effects. The measurement of elongation shall commence from this mark.

The true extension shall be considered to be the sum of the measured extension and the calculated value of the extension obtained by application of the initial tension minus the amount of pull-in at anchorages movements (if any).

The operation of stressing each tendon shall continue at a reasonably constant rate without interruption until the specified load/extension, is obtained and the tendon is anchored.

The actual tensioning force applied shall be increased to allow for any draw-in of the anchorage devices during locking-off and for any friction losses. Under no circumstances shall the force applied to a tendon exceed the rated capacity of the jacking equipment used or 85 percent of the guaranteed minimum ultimate strength of the tendon, whichever is the lesser.

Whenever the actual extension and the calculated extension differ by more than 5% the Superintendent shall be advised and a non-conformance report submitted. The method of measuring the prestressing force shall always be such that the final accuracy of measurement is within two percent. The prestressing force shall be determined by measuring both the elongation of tendon and the jacking force. The elongation shall be measured to an accuracy of 1% or 3 mm whichever is the lesser. Elongation shall be calculated on the basis of the secant modulus of the material being used.

B4.3.8 Transfer of Prestress

(i) Strength of concrete at transfer

Transfer of prestress shall not be carried out until the concrete has attained the specified transfer strength as proved by standard test cylinders, manufactured and cured for this purpose.

(ii) Transfer procedure

Prior to transfer of the prestressing force from the abutments of the casting bed to the piles, tendons shall be examined for tightness and the presence of any loose tendons shall be reported to the Superintendent in the form of a non-conformance report.

The Superintendent may require that tendons be marked at each end of any unit to allow measurement of the draw-in.

The prestress shall be transferred to the piles in such a manner that the tendons are released gradually and preferably simultaneously.

Large differences of tension between the tendons shall be avoided. If the tension is released from one end only or if there are several moulds in line, provision shall be made for the piles to slide, allowing a transfer of the force all along the tensioned line.

The transfer shall be carried out by jacks, detensioning screws or by other approved mechanical means. **Shock or flame releasing shall not be permitted.** If tendons should fail suddenly, the Superintendent may order load testing of any piles so affected. Care shall be taken that the force in any tendon never exceeds 85 percent of the specified ultimate tensile strength of the tendon. The Contractor shall detail the process of transfer of prestress in his Contract Management Plan.

B4.4 TESTING PILES

B4.4.1 General

If there exists in any pile, a defect which may be detrimental to the satisfactory performance and serviceability of the pile, the pile shall be load tested in accordance with this clause at the cost of the Contractor.

Load testing of piles will not be required provided that -

(i) concrete cylinder strengths exceed or equal the minimum requirements specified for transfer at 28 days.

(ii) manufacture has been carried out in accordance with the Drawings and this Specification.

(iii) piles do not suffer from cracking, splitting, defective workmanship or other structural defects.

The Contractor shall supply all necessary labour and equipment for testing the piles. He shall also measure hog, bow and length dimensions. Dial gauges to measure deflections shall be provided by the Contractor.

All samples of materials necessary for testing as required by this Specification shall be supplied free by the Manufacturer at his works. The cost of carrying out tests on materials will be the responsibility of the Contractor.

B4.4.2 Test Procedure

The test shall be performed not earlier than 28 days or later than 35 days after casting, except that if the concrete has attained the specified compressive strength at less than 28 days, piles may be tested earlier than the specified 28 days.

For testing purposes, the pile shall be supported so that there is at least 1 metre clearance between the underside and the ground to permit inspection. It shall be seated on rubber pads which extend over the full width of the pile and are at least 25 mm thick.

Test loads shall be applied through 25 mm thick rubber pads overlayed by an adequate thickness of hardwood, both of which extend the full width of the pile and are sufficiently long to limit the contact pressure to 5 MPa.

Generally the test loads shall be applied by calibrated jacks to two points through an equalizing mechanism.

The location and intensity of applied and support loads shall not be such as to induce stresses in the concrete greater than -

(a) 0.75 F'c in compression,

(b) 0.5 SQR (F'c) in tension at the extreme fibre,

(c) 0.38 SQR (F'c) in principal tension,

where F'c is the 28 day strength in MPa and SQR is the square root. Generally, where simply supported piles are being tested in flexure, the two-point loads shall be symmetrically disposed about the centre of the span so as to produce a stress approximately equal to the desired stress over a length of member not less than 0.25 times the span length.

The maximum test loads shall be maintained for a period of 5 minutes before determination of crack openings and measurement of maximum deflection.

Observation for cracking shall be made with the aid of a surface application of a volatile liquid such as methylated spirit or petrol.

The pile shall be deemed to have failed in the test if -

(a) it shows evident failure under the test force or

(b) visible cracking occurs. A visible crack shall be defined as a crack more than 0.05 mm wide as measured by a graduated optical device. or

(c) when no new cracking visible to the unassisted eye has occurred or where there is no visible evidence of an extension in previously existing cracking, the residual deflection immediately after the removal of the test force is more than 0.10 times the maximum deflection.

Should the pile fail to pass this test, the pile shall be rejected without payment.

B4.5 HANDLING, TRANSPORT AND STORAGE

Piles shall be handled, transported and stored in compliance with Specification B14.

B4.6 UNEXPECTED GROUND CONDITIONS

The Contractor shall report immediately to the Superintendent any circumstances that indicate, that in the Contractor's opinion, the ground conditions differ from those expected by him from his interpretation of the site investigation report. Any unexpected driving or boring conditions shall be noted in the records.

B4.7 DRIVING OF PILES

B4.7.1 Strength of piles

Piles shall not be driven until the pile concrete has achieved the specified design strength as demonstrated by test cylinders.

B4.7.2 Site Preparation for driving of piles

The Contractor shall be responsible for preparing the site for driving either by excavation or by compacting approved filling or other means as relevant to the site conditions.

Any material forced up between the piles during driving shall be removed to the correct level before concrete for the foundation is placed. At all times care shall be taken to avoid disturbing the site by excavation below the level of the base of the pile cap.

B4.7.3 Leaders and trestles

At all stages during driving and until incorporation in the substructure the piles shall be adequately supported and restrained such that damage to the pile does not occur.

B4.7.4 Performance of driving equipment

The Contractor shall detail in his Contract Management Plan the method of piling and the plant he proposes to use, including details of the efficiency and energy of the driving equipment.

The mass of the ram of a steam, diesel, hydraulic or compressed air driven pile hammer shall be not less than one-third of the mass of the pile being driven.

The Contractor shall ensure the hammer is in good working condition and capable of delivering the calculated energy. The Contract Management Plan shall include provision for routine site measurements such as height of fall of ram or number of blows per minute to demonstrate correct functioning.

When driving with steam, hydraulic or diesel hammers in which the stroke cannot be adjusted, a head cushion of very low stiffness shall be used to ensure that the maximum set per blow is not exceeded.

B4.7.5 Driving Procedure

Piles shall be driven in the locations shown on the Drawings to a driving resistance (P) which is equal to or greater than the design loads shown on the Drawings.

The estimated pile tip levels shown on the Drawings are for general guidance only. The final pile levels shall be determined by achievement of the design resistance . The pile lengths specified on the Drawings should enable the piles to be driven to the estimated pile tip levels with approximately one metre of surplus length. This surplus is in addition to the length of reinforcement projection.

Should the piles drive so that the pile heads finish at a lower level than the cut off level shown on the Drawings, additional work shall be the subject of a variation to the Contract.

Each pile shall have its length marked clearly at 500 millimetre intervals.

Each pile shall be driven in the presence of the Superintendent, who shall be given 24 hours notice that pile driving is to take place.

B4.7.6 Measurement of Pile Capacity - Pile Driving Analyser

The driving resistance shall be calculated using the Pile Driving Analyser.

(i) Equipment and Software Specification

Pile capacities shall be determined by field use of a "Pile Driving Analyser" (PDA) as manufactured by Pile Dynamics Inc of Ohio, U.S.A. Unless otherwise approved by the Superintendent all piles will be tested by this method in the final blows of driving. Pile resistance calculations shall be carried out for each pile to satisfy the requirements of this Specification as follows:

$$P = RU / FS$$

where P = Safe load in kiloNewtons

RU = Ultimate Bearing Value in kiloNewtons

FS = Factor of Safety of 2.5

The PDA shall be capable of producing pile analysis using an externally input value of soil damping constant and the closed form solution of the one-dimensional wave equation. This method is referred to herein as the Case - Goble Method.

In addition, off-site software "CAPWAPC", as produced by Goble, Rausche, Likens and Associates Inc, Ohio, U.S.A. shall be used for further analysis. This method is referred to herein as the CAPWAPC method.

(ii) Driving of Piles

Whilst each pile is being driven, blows per 500 millimetre shall be recorded over the full length of the pile and during the last 3 metres of driving, sets shall be taken at intervals to establish the behaviour of the pile.

At least 25 percent of all piles being driven shall be redriven not less than 12 hours after initial driving and monitored by PDA. At least 20 hammer blows shall be maintained during redrive.

At least 15 percent of all piles being driven shall be analysed by the CAPWAPC method. The piles nominated for analysis by the Contractor shall be approved by the Superintendent. The analysis shall be used to determine the optimum value of soil damping constant J to be used in the Case - Goble Method. Previous Case - Goble results shall be adjusted for this value of J. In addition, a relationship between ultimate pile resistance and set (bearing graph) shall be obtained. Where under Clause B4.7.7 (i) approval is given by the Superintendent not to test all piles using PDA this relationship shall be used to control the driving of all remaining piles in the pile group which are not monitored using PDA with the following exceptions:

(a) where there is a change in hammer

(b) where there is a change in operation of the hammer

(c) where there is a change in helmet thickness or characteristics of packing material.

In the case of (a), (b) or (c) above the PDA calibration procedure shall be repeated.

B4.7.7 Final Set

When a final set is being measured, the following requirements shall be met:-

(i) The exposed part of the pile shall be in good condition without damage or distortion.

(ii) The dolly and packing, if any, shall be in sound condition.

(iii) The hammer blow shall be in line with the pile axis and the impact surfaces shall be flat and at right angles to the pile and hammer axis.

(iv) The hammer shall be in good condition and operating correctly.

(v) The temporary compression of the pile shall be recorded.

The precise technique for measuring the pile sets shall be detailed in the Contract Management Plan.

B4.7.8 Records

The Contractor shall keep records of the installation of each pile as follows:

(i) Contract Number

(ii) Pile reference number

(iii) Pile type

(iv) Nominal cross-sectional dimensions

(v) Length of pile

(vi) Date cast

(vii) Date and time of driving and/or redriving

(viii) Pile tip level at the commencement of driving

(ix) Working level

(x) Depth of working level to pile toe

(xi) Toe level

(xii) Type, weight, drop and mechanical condition of hammer

(xiii) Number and type of packing used and type and condition of dolly used driving the pile.

(xiv) Set of pile in mm per 10 blows

(xv) Sets taken at intervals during the last 3 m of driving.

(xvi) Temporary compression of ground

(xvii) Blows per 500 mm intervals, when required

(xviii) All information regarding obstructions, delays, and other interruptions to the sequence of work.

(xix) Calculations of driving resistance of pile and PDA records where applicable

(xx) Site measurement of hammer performance.

The Contractor shall submit two signed copies of these records to the Superintendent not later than noon of the next working day after the pile has been installed.

B4.7.9 Noise and disturbance

The Contractor shall carry out the work in such a manner and at such a time as to minimise noise and disturbances and in compliance with Occupational Health and Safety requirements.

B4.7.10 Damage to Piles

The Contractor shall ensure that damage does not occur to completed piles. He shall be responsible for all costs of repairing or replacement of damaged piles.

B4.8 PREBORING

Piles driven through abutment fill shall be pre-bored to the depth of the fill. The diameter of the prebored hole shall not exceed 50 mm less than the diagonal dimension of the pile.

After pile driving is completed all voids shall be filled with grout or sand.

B4.9 TOLERANCES IN DRIVING

For a pile cut off at or above ground level the maximum permitted deviation of the pile centre from the centre point shown on the setting out Drawing shall be 75 mm in any direction.

The maximum permitted deviation of a finished vertical pile from the true vertical shall be 1 in 75.

The piling rig shall be set and maintained to retain the required rake for raker piles. The maximum permitted deviation of a finished pile from the specified rake is 1 in 25.

Forcible corrections to the alignment of piles shall not be made. In the event of a pile being driven out of tolerance the Contractor shall submit his proposals for rectifying the matter to the Superintendent in a non-conformance report.

B4.10 CUTTING OF PILE HEADS

Not less than five days after the submission of pile-driving records to the Superintendent the concrete of the head of the pile shall be cut off to the level shown on the Drawings.

The length of reinforcing bars and strands projecting above this level shall be as specified on the Drawings.

Care shall be taken to avoid shattering or otherwise damaging the rest of the pile. Any cracked or defective concrete shall be cut away and made good with new concrete properly bonded to the old.

B4.11 PAYMENT

The rate in the Bill of Quantities for the manufacture of precast concrete piles shall include pile shoes and cutting, bending and placing of reinforcement. For the purposes of payment, an approved precasting yard shall be considered as part of site.

The rate in the Bill of Quantities for the manufacture of precast pretensioned concrete piles shall include pile shoes, handling and placing tendons, stressing, prestress transfer and cutting, bending and placing of reinforcement. For the purposes of payment, an approved precasting yard shall be considered as part of site.

The rate in the Bill of Quantities for driving of piles shall include setting up of piling plant at each pile, handling of piles from store yard to piling plant, pitching the piles, driving the piles to the approved set and on completion of driving, moving the piling plant to another position.

The rate shall also allow for driving of the "test-piles", marking of piles, providing the means of checking the sets and any stand-by time associated with the "test-piling" eg. redrive test or time involved by Superintendent in considering results of driving and advising a new set, if necessary. If it is necessary to drive any pile below the estimated pile tip level as shown on the Drawings, then the extra work involved shall be the subject of a variation to the Contract.

The rate in the Bill of Quantities for breaking and cutting the tops of piles shall include cleaning and bending of reinforcement as shown on the Drawings and for disposing of surplus materials off the site. No extra payment will be made for increased cut off lengths, where piles are not driven to the estimated pile tip levels shown on the Drawings.

Where measurement of pile capacity is specified as by Pile Driving Analyser, the item in the Bill of Quantities for providing this monitoring shall include all costs associated with hire of equipment together with personnel trained in its use, performance of tests to the number specified by the Superintendent, performance of off-site analysis and reporting of results and performance of drive and redrive checks. In addition, the cost of any delays to the works caused by delays in receipt of

analysis shall be deemed to be covered by this item. Such delays shall not be grounds for extension of time.

B4.12 HOLDPOINTS

The following hold points have been identified in this Specification:

- Stressing proposal and calculations (B4.3.3)
- Anomaly during stressing (B4.8)
- Testing of defective piles (B4.4)
- Unexpected ground conditions (B4.6)

B4.13 INFORMATION TO BE INCLUDED IN CONTRACT MANAGEMENT PLAN

The following information to be included in the Contract Management Plan has been identified in this Specification:

- Tendon manufacturers test certificates (B4.3.2)
- Competent person for stressing procedure (B4.3.3)
- Test certificates for stressing equipment and gauges (B4.3.4)
- Details of epoxy compound for patching over cut tendons (B4.3.5)
- Stressing records pro-forma (B4.3.6)
- Stressing procedures (B4.3.7)
- Stress transfer procedures (B4.3.8)
- Pile driving equipment and procedures (B4.7)