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SECTION TS 9. CONCRETE REPAIRS

SECTION TS 9. CONCRETE REPAIRS

9.1 GENERAL

This section of the Technical Specification covers the general and specific requirements of concrete repairs. It shall apply wherever concrete repairs are required within the works or specified in this and other Technical Specification clauses.

This section covers the repairs of concrete as shown on the Drawings or ordered by the Engineer. The supply and placing of concrete and reinforcement and the supply and use of epoxy resins are covered in Sections TS 3 and 12 respectively of this Specification excepted as modified below.

9.2 IDENTIFICATION OF DEFECTS

The defects to be repaired shall be as shown on the Drawings or as directed by the Engineer. The extent of the areas to be repaired shall be subject to the decision of the Engineer who may direct that additional concrete be removed to allow assessment of the defect to be made. In addition the Engineer may direct that the defect be exposed or further exposed prior to giving consent to the method of repair.

9.3 REPLACEMENT OF CONCRETE

9.3.1 Removal of Concrete

Where shown on the Drawings or ordered by the Engineer areas where concrete is to be replaced shall have the existing concrete to the limits assigned by the Engineer.

The Contractor shall submit details of the proposed of removal of the concrete to the Engineer for his consent prior to commencement of any removal operations.

Where concrete is to be removed from a load bearing structure the Contractor shall submit for the consent of the Engineer details of his proposed method of support of the structure.

The area to be removed shall be marked with saw cuts 20 mm deep, cut on straight lines. Corners shall be rounded to obtain good contact between the existing concrete and the new material. Edges shall be undercut to eliminate feather edges and to provide a keyed joint. Where the extent of the area to be removed is not known beforehand the Engineer may consent to the use of a jackhammer to mark the edge. The type and weight of hammer and the type of pint on the tool to be used shall be subject to the consent of the Engineer.

The Contractor shall ensure that the reinforcement is not damaged during the concrete removal process. Any reinforcement damaged by the Contractor shall be repaired at the Contractor's expense in a manner as directed by the Engineer.

After removal of concrete the area shall be flushed with high pressure water or other approved method to remove loose materials and dust. Air blowing may be used if the compressor is lifted with a functioning oil trap.

9.3.2 Reinforcement

Where more than the perimeter of a reinforcement bar is exposed concrete shall be removed to a minimum of one and one half bar diameters beyond the bar.

Loose scaly rust on the reinforcement shall be removed. Tightly adhering mortar, if sound, may be left on the steel.

Where the Engineer so directs the surface of the reinforcement shall be prepared to Class SA 2 ½ in accordance with AS 1627 "Metal Finishing – Preparation and Pre-treatment of Surfaces" or equivalent standard. This shall be carried out using water blasting.

Where replacement of reinforcement is required due to corrosion or other causes new bars may be added by splicing onto the walked bars, by welding new bars to the existing with full strength welds or by additional bars into holes drilled into concrete. The Engineer shall direct which method, if any, of the above is to be adopted.

Coating of reinforcement shall only be carried out if ordered by the Engineer.

9.3.3 Concrete

Prior to replacement of concrete the existing concrete surface shall be treated as directed by the Engineer. This treatment may consist of saturating the existing concrete and/or coating the existing concrete with a bonding agent.

The concrete may be replaced with either a Portland cement concrete or an epoxy concrete as directed by the Engineer.

Replacement of concrete, including formwork, placing and curing shall be in accordance with the requirements of Section TS 3 and TS 12 of this Specification except as modified below.

Details of the mix design for concrete intended for use in repair work to be carried out in accordance with this Section shall be submitted to the Engineer at least six (6) weeks before concrete work is to commence.

The mix shall have a minimum cement content of 410 kg/cm^3 and a maximum water cement ratio of 0.40. Where directed by the Engineer a mixture of 65 % Portland cement and 35 % silica fume shall be used for the cement. The maximum aggregate size shall be 10 mm.

No concrete shall be placed until the excavated area has been inspected by the Engineer and his consent obtained in writing.

9.4 REPAIRS TO CONCRETE

9.4.1 Non-Injection Repair

This clause covers the repairs of cracks which are wider than 0.1 mm and which are clean or are capable of being cleaned.

Where shown on the Drawings or ordered by the Engineer repairs shall be carried out by "V" ing the crack to a width of 5 mm at the surface.

Where the cracks are in horizontal surfaces and are to be filled with epoxy by gravity flow the top surface shall be chipped or sawn to form a small trough to provide an inlet for the pouring of epoxy into the crack.

Cracks wider than 6 mm at the surface shall be filled with an epoxy concrete which contains a mineral filler. The Contractor shall submit details of his proposed method of repair for the consent of the Engineer.

Any lines or spills of epoxy shall be immediately removed and the repair finished to an even surface.

Where pouring of epoxy cannot be used an approved epoxy adhesive putty or drypack cement mortar shall be placed into crack and finished to a smooth even surface.

9.4.2 Structural Crack Repairs by Epoxy Injection

Where epoxy injection repairs are shown on the Drawings or ordered by the Engineer the Contractor shall submit to the Engineer for his consent details of an epoxy resin suitable for crack injection.

The crack shall be "V"ed to a width of 25 mm at the surface. The surface shall be then be cleaned free from dirt and broken concrete and any area oil or grease shall be cleaned with solvent. Hole10 mm in diameter shall be drilled to intersect the crack 50 mm below the surface with spacings as shown below.

a. Where the crack does not extend the full depth of the member holes shall be spaced at the desired depth penetration. For cracks less than 0.15 mm wide the maximum spacing shall be 150 mm.

b. Where the crack extends the full of the member the holes shall be spaced as shown:

(i) For members 0.3 m or less in thickness holes shall be drilled in the crack on one side only and spaced at the thickness of the member.

(ii) For members greater than 0.3 m thick and less than 0.6 m thick holes shall be drilled on all available sides and spaced at the thickness of the member.

(iii) For members greater than 0.6 m thick holes shall be drilled generally as in (ii) above but subject to the direction of the Engineer.

The Engineer may direct that intermediate holes be drilled to monitor the flow of injected epoxy.

Nipple stems shall be bonded in each hole and the winded crack filled with an approved epoxy putty. If the crack extends through the member back sealing shall be done to prevent run out. After the epoxy putty has hardened, the heads of all nipples shall be removed except for the nipple at the lowest point.

The resin shall be pumped into the nipple until the epoxy appears at the adjacent stem. After a nipple to the adjacent stem the pumping shall continue through this nipple until the epoxy resin appears at the next stem. This procedure shall be repeated until all the nipples have been injected. On vertical or sloping members the first nipple to be injected shall always be the lowest and the injection shall progress upwards.

Final cleaning of the concrete surface shall be carried out after the grout is seven days old. The injection valves and the hardened sealing compound shall be removed from the surface of the concrete.

9.4.3 Repair of Spalled Concrete

The repair of spalled concrete as shown on the Drawings or ordered by the Engineer shall be carried out in accordance with the requirements of the various clauses of this Section of the Specification as appropriate.

9.5 MEASUREMENT AND PAYMENT

Measurement and Payment for Concrete Repairs will not be made exclusively and all costs incurred by the Contractor in complying with the requirement of this clause shall be deemed to be included in the rates and lump sum prices entered in the priced Bill of Quantities for works which may need to incorporate the requirements of Concrete Repairs. These shall include the entire cost of completing the work including materials, labour, equipment, transportation and any other associated costs and, in particular, shall be deemed to include, but not be limited to, the following:

1) Removal and replacement of concrete, surface preparation, cleaning existing reinforcement, supply and placement of new reinforcement, coating of reinforcement (if ordered) and supply, resurfacing aggregate exposed concrete and repair of spalled concrete, placement and curing of new concrete.

2) crack surface preparation, supply and placement of epoxy to be injected into cracks, drilling of holes for injection valves and supply and placement of injection valves

3) surface preparation, supply and application of sprayed concrete and curing of finished concrete.

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SECTION TS 10. FALSEWORK AND SCAFFOLDING

SECTION TS 10. FALSEWORK AND SCAFFOLDING

10.1 GENERAL

This section of the Technical Specification covers the general and specific requirements of falsework and scaffolding. It shall apply wherever falsework and scaffolding is required within the Works, such as for construction of bridges, weirs, buildings and the like, or specified in this and other Technical Specification.

This section covers design, erection and removal of falsework used to support steel or concrete during erection.

Supply and placement of concrete shall be in accordance with the requirements of Section TS 3 of this Specification.

Falsework is defined as the structural system required to support the permanent structural components, material, plant, equipment and personnel required in the construction of the works.

The structural system comprises foundations and all structural members supporting the formwork, or supporting permanent structural components.

10.2 FALSEWORK PROPOSALS

All erection gear, falsework, props, access ways, scaffolding, platforms, railings, erection and dismantling procedures and the like shall comply with the relevant requirements of any local scaffolding regulations.

If required by the Engineer details drawings and design calculations shall be submitted for consent at least four (4) weeks prior to commencement of falsework manufacture. Submission of falsework proposals and subsequent consent by the Engineer shall in no way affect the responsibility of the Contractor for the proper design and construction of the falsework system.

The submitted computations and drawings shall have been certified by an engineer experienced in structural design.

10.3 DESIGN

Falsework shall be of sufficient strength to carry all applied loads, including erection loads, vibration effects, and load concentrations produced by prestressing operations, wind and water loads, including flood debris and drift where applicable. Falsework for prestressed concrete shall be of a design which shall permit the application of prestress without damage to the completed structure. The design shall allow removal of the falsework without damage to the finished work.

Falsework shall be designed to withstand all forces resulting from the loads as specified in this Clause or, in the case of falsework used to support concrete works, from the loads specified in ACI 347 'Recommended Practice for Concrete Formwork' and the Indonesian Loading Code (PMI 1970 - N.I. 18), whichever produces the most significant effect, and any additional loads that may be imposed on the falsework during construction. The design shall take into account the magnitude, direction and duration of these forces individually and collectively.

The design loads (other than those in ACI 347 or PMI 1970 - N.I. 18) shall be –

1. Dead load - this shall include the weight of form, falsework, wet concrete, reinforcement, steel sections and any other material. The density of wet concrete, including reinforcement shall be taken as 2700 kilograms per

cubic metre. The density of steel shall be taken as 7850 kilograms per cubic metre.

2. Superimposed load -- this shall include the weight of workmen, plant, equipment and runways, stacked material and an impact allowance equal to 25 per cent of the all up weight of any mechanically operated plant.

   In no case shall the superimposed load be less than 2 kPa (0.02 kg/cm^2) (plus the weight of stacked material) on the plant area of the finished concrete or a single isolated load of 2.5 kiloNewtons applied at any point of the structure, whichever is the more severe.

3. Wind load - this shall be 2.4 kPa (0.024 kg/cm^2) minimum acting on the exposed area of falsework, formwork and any object supported by the falsework or formwork.

4. Other loads – these shall include any special conditions likely to occur during construction, the effects of prestressing, construction stages and removal of falsework. Reference shall be made to the relevant section on Bridge Loads I the Bina Marga Bridge Design Code.

5. Horizontal loading – this shall include wind loading, horizontal surge loading equal to 25 percent of the all up weight of any mechanically operated plant and loading occurring during construction.

In no case shall the design value of the horizontal load acting and any direction be less than 1.5 kiloNewtons per metre applied at the edge of deck or 3 per cent of the total dead load, whichever is the greater.

Unless specified otherwise, the design of all falsework members and connections shall comply with AASHTO HB-14 'Standard specifications for highway Bridges' and ACI 347.

Falsework members supporting concrete shall be design to limit deflections to prevent cracking of previously cast sections due to subsequent casts. Deflections of beams and dimensional changes in other members and connections shall be limited to ensure that the erected steel members or finished concrete (as appropriate) is within the specified tolerances for line level.

The Contractor shall make allowance for the deflections and foundations settlements due to loading prestressing (if any) during the progress of the work, to ensure that the completed work shall conform in respect of all levels and dimensions shown on the Drawings or specified elsewhere

The falsework shall be such as to produce the least practicable obstruction in the waterway area or vehicular or other access. Clearances in the falsework shown on the Drawings or specified shall be provided.

The computations submitted to the Engineer shall state all design assumptions and shall include a detailed analysis of the forces, stresses, stability, deflections and other dimensional changes due to loading In all members of the falsework.

The drawings shall be fully detailed including all member sizes and materials, dimensions, levels, erection procedures and other relevant details including bracing, connections and foundations.

10.4 ERECTION AND USE

10.4.1 General

Falsework shall be erected on firm and secure footings and, in the case of bridges over streams, shall be safe from scour.

Materials shall be sound and sufficiently durable for the purpose intended. Particular consideration shall be given to protection of timber against marine organism in brackish or tidal waters.

10.4.2 Provision for Adjustment

The falsework shall have provisions for making adjustment to level. where the falsework is of tubular construction, screw jacks shall be provided at both top and bottom of the standards.

For other types of falsework construction, provision for a similar form of adjustment shall be made.

10.4.3 Provision for Longitudinal and Lateral Movements

The structural members of the falsework shall be designed for loads which may result from longitudinal or lateral movements caused by thermal or shrinkage effects. Alternatively, provisions shall be incorporated in the falsework to permit these movements.

10.4.4 Bracing

Adequate bracing shall be provided longitudinal and transversely to ensure that the falsework is stable and that significant horizontal movements resulting from the applied loads are limited. Additional bracing shall be provided after erection of the falsework if, in the opinion of the Engineer, the falsework is not sufficiently rigid.

10.4.5 Foundations

The foundations of the falsework shall be designed to prevent excessive settlement, including relative settlement between adjacent supports, and rotation of supports.

Individual footings and groups footings shall be designed also to satisfy stability criteria.

Where the foundation material can become saturated with water, the foundation material can become saturated with water, allowance shall be made for possible reduction in bearing capacity, consequent changes in stability, and increased settlement or heave of foundation. Bearing surfaces of footings shall be horizontal.

Footings shall not be founded directly on filled ground without the consent of the Engineer. Refer also to Clause 10.4.6 below.

Foundation material such as soil, filling, or other materials which are soft and compressible, or which may be subject to erosion by water, shall be removed as required to expose a suitable foundation.

Where such materials have been removed, the excavation may be backfilled to the required level by compacted stabilised crushed rock or equivalent containing not less than three (3) percent cement, to the satisfaction of the Engineer. No such excavation shall be backfilled without the prior examination and the consent of the Engineer.

Footings supported directly on the ground near surface level shall comprise concrete bases, timber and bed logs, or other types of materials approved by the Engineer. Where Contractor proposes to use timber bed logs, they shall comprise sound timber of dimensions not less than 200 mm wide and 100 mm deep.

Timber bed logs, which in the opinion of the Engineer do not satisfy these requirements, shall be removed from the site immediately. Unless approved otherwise, each bed log shall be bedded for its full length on net freshly placed concrete of thickness not less than 150 mm.

The concrete used for footings or under bed logs shall be Class K220 (220 kg/cm^2) or stronger.

Base plates for the falsework standard shall be located to ensure uniform bearing pressure under each footing. Where timber bed logs are used base plates shall be placed not less than 600 mm from the ends centrally within the width of bed logs. Comprise driven piles, bored cast-in-place concrete piles or other suitable type of foundation.

10.4.6 Test Loading

The Contractor shall allow for the falsework, or the foundations of falsework to the best loaded if so required by the Engineer. The test load shall be applied for a period of 48 hours and shall be equivalent to the design load.

The deflection and settlement under test shall not exceed 1/300 of the span of the member being supported. Testing shall be at the Contractor's expense.

10.4.7 Drainage

The Contractor shall provide adequate for stormwater to prevent scour of falsework foundations. Prior to commencement of erection of the falsework, the ground surface under the falsework shall be shaped, and if necessary filled to bring the site to a suitable level, to prevent ponding of water in the vicinity of the falsework footings. Foundations on batters shall be protected against scour directing drainage away from the falsework.

All drainage trenches, pipes and diversion channels shall at all times be maintained to the satisfaction of the Engineer. Where roadside drainage channels pass through the site, the Contractor will be responsible for maintenance of this drainage.

10.4.8 Settlement of Falsework

If falsework settles during construction to and extent which in the Engineer's opinion appreciably alters levels of the supported materials those shown on the Drawings, the Engineer may stop the work and require removal of the supported materials and a through remodelling of the falsework. This work shall be carried out at the Contractor's expense.

10.5 REMOVAL OF FALSEWORK

As soon as practicable all falsework, including fill and other material placed to facilitate construction shall be removed and ground levels as existing prior to the commencement of the work by the Contractor shall be restored, unless shown on the Drawings or as directed by the Engineer.

The Contractor shall submit details of the method he proposes to use to release falsework two weeks prior to commencing this operation.

No falsework shall be released until the Engineer gives his written consent.

Provision shall be made to permit an even and gradual release of the falsework. Where shown on the Drawings the Contractor shall provide for the release of defined sections of the falsework.

For bridgework over navigable waters removal of the falsework shall include complete withdrawal of falsework piles and footings. After falsework has been dismantled, temporary piles shall be cut back to a depth of 300 mm below ground level.

Under the proposed road pavement the piles shall be cut back 1 metre below finished surface level. All temporary footings shall be removed and excavations associated with the falsework shall be backfilled in accordance with the requirements of Section TS 2 of this Specification.

10.6 PAYMENT

Measurement and Payment for Falsework and Scaffolding will not be made exclusively and all costs incurred by the Contractor in complying with the requirement of this clause shall be deemed to be included in the rates and lump sum prices entered in the priced Bill of Quantities for works which incorporate the requirements of Falsework and Scaffolding. These shall include the entire cost of completing the work including materials, labour, equipment, transportation and any other associated costs.

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SECTION TS 11. BEARINGS

SECTION TS 11. BEARINGS

11.1 GENERAL

This section covers the general and specific requirements for the supply and installation of the bridge bearings for the approach and maintenance bridges at the Simongan Weir, which shall be in accordance with the requirements of this Specification and as shown on the Drawings.

The Contractor shall exercise the utmost care in setting out and fixing all bearings in their correct positions, and in ensuring that uniformity is obtained in all bearing surfaces. Bearings shall be handled with care and stored under cover by the Contractor. The Contractor shall be responsible for any costs involved in making good damaged which may occur after delivery.

Expansion bearings are designed and dimensioned for installation at a nominated temperature. Where the temperature is likely to vary by more than ±5 degrees Celsius from the nominated temperature, the Contractor shall request the Engineer to give a direction regarding any allowance which shall be made insetting the bearings.

11.2 ELASTOMERIC BEARINGS-LAMINATED-SUPPLY

11.2.1 General

All bearings shall comply with the requirements of AASHTO M 251 'Laminated Elastomeric Bridge Bearings' except where modified by this Specification.

Bearings shall be made from natural rubber and other materials so compounded and cured as to give the properties specified. However, consideration will be given to the use of elastomeric materials other than natural rubber, subject to approval of the Engineer to any variations proposed to the properties specified. Layers of elastomeric material shall be bonded to the steel plates during the vulcanisation in a mould under pressure. Bearings shall comply with the dimensional and shear and compressive stiffness requirements specified in Tables 11.1, 11.2 and 11.3.

11.2.2 Elastomer

The elastomer to be used in the manufacture of the bearings shall be tested as set out in Table 11.1 These tests shall be done at an approved laboratory and two days notice shall be given so that preparation and /or testing of the specimens may be observed by the Engineer, if so required. Three samples shall be taken from every 250 kg batch of mixed elastomeric material and each sample shall meet the requirements specified.

Materials which does not comply with the requirements stated in Table 11.1 shall not be used in the manufacture of the bearings.

All testing shall be at the Contractor's expense.

11.2.3 Bearings

a. Tolerances on dimension

Bearings shall be manufactured to the dimensions as shown on the Drawings within the tolerances given in Table 11.2 . Bearings which do not comply with the requirements specified may be rejected.

b. Testing

i. General

All bearing shall be tested at the Contractor's expense. Tests shall be done at an approved laboratory and in presence of the Engineer or his Representative who shall be given days notice of the tests. The equipment used for testing shall be capable of determining compressive and shear loads to within ±3% and deflections to within ± 1%. Where necessary to achieve the specified accuracy of testing, equipment shall be calibrated and results obtained corrected accordingly. Bearings shall only be tested after a minimum period of two days elapsed after pressure moulding.

ii. Stiffness in Compression

Each bearing shall be tested for stiffness in compression. The rated load at zero shear is as shown on the Drawings.

Bearings which exceed the relevant tolerance given in Table 11.3 on the compressive stiffness as shown on the Drawings may be rejected.

iii. Stiffness in Shear

After completion on the tests on the stiffness in compression, all bearings shall be tested in shear. (The rated load at maximum shear deflection capacity are given on the Drawings).

The effective shear stiffness at zero shear is shown on the Drawings. Bearings which exceed a tolerance of ±20% on this shear stiffness shall be rejected.

iv. Test With Applied Rotation

One representative bearing selected by the Engineer from every twenty bearings, or part thereof, of each size of bearing shall be tested. Bearings to be tested shall be subject to an angular rotation equivalent to the rotational capacity at rated load at zero shear rounded to the nearest 0.005 radian (or given on the Drawings in the case of non-standard bearings). The angular rotation shall be applied at right angles to the long axis of the bearing while applying the rated load at zero shear.

On completion of rotation test the bearing shall again be loaded in compression in accordance with Clauses 11.3.3.b.ii, above and its compressive stiffness determined. Should this stiffness differ from that previously determined by more than 10%, the bearing, and those bearings represented by it, may be rejected.

v. Visual faults

During the tests for compression and shear stiffness and under rotation, close observation of the bearings shall be maintained so as to detect any fault or variation due to lack of elastomer to steel bond, misplaced plates or inadequately cured elastomer etc.

Should any bearing exhibit any sign of failure such as:

- splitting
- permanent deformation or
- significantly irregular or unsymmetrical surface bulging.

then, unless the Contractor can demonstrate to the Engineer that the fault can be rectified satisfactory, such bearings shall be rejected.

11.2.4 Delivery of Bearings

No bearings shall be delivered to site prior to the Engineer notifying the Contractor in writing that the proposed bearings are acceptable. The issue of

such notification will be dependent on each individual bearing complying with Clauses 11.2.2 and 11.3.3 of this Specification and exhibiting satisfactory workmanship.

11.2.5 Test Certificates

The Contractor shall supply a copy of the test certificates showing details of the results from the tests set out in Clauses 11.2.3, and 11.3.3.b for each sample of the elastomer used in the manufacture of bearings, and of the hardness and stiffness in compression of the bearings and note whether any tolerances have been exceeded or whether any faults have been observed.

Table 11.1 – Properties of Elastomer

Properties	Methods of Test	Requirements
Hardness	ASTM D 2240	48 min
Ultimate Tensile Strain		5.75min
Tensile Strength	ASTM D 412	17.5 MPa min
Tear Resistance	ASTM D 624 - Die. C	40.0 kN/m min
Compression Set	ASTM D 395 Method B (22 hrs 70 degrees Celsius)	25% max
Ozone resistance *	ASTM D 1149 20% strain at 40 degrees Celsius ±1 and 1 ppm	No cracking visible by eye after 100 hrs
Accelerated Ageing	ASTM D 573	Maximum Permissible change in properties : Hardness +4 Tensile Strength ±10% Ultimate Tensile Strength -15%
Statistic Modulus in compression and shear **	ASTM D 945	Values to be recorded

* Evidence of recent testing of identical material may be accepted by the Engineer

**Three samples per job where required by the Engineer.

Table 11.2 – Tolerances on Dimension

Dimension	Tolerance (mm)	
	Rectangular ≤ 350x170 mm and Circular ≤ 330 mm Ø	Rectangular ≤ 350x170 mm and Circular ≤ 330 mmØ
Plan dimensions	±2.0	±4.0
Bearing thickness T≤ 100 mm T> 100 mm	 ±1.0 ±2.0	 ±1.0 ±2.0
Rubber side cover	±2.0	±4.0
Outer rubber layer thickness *	±0.5	±0.5
Inner rubber layer thickness *	±0.5	±0.5
Out of parallel between top and bottom surfaces, or between any two non-adjacent plates *	≤ 1.0	±2.0

* These dimensions may be determined be probing or drilling a small diameter hole subsequently plugged with identical material to that used in the manufacture of the bearings.

Table 11.3 – Tolerances on Compressive Stiffness

Compressive Deflection * (mm)	Layer Thickness (mm)	Tolerance (%)
< 0.75	6 9,12,15,18	30 25
0.75 to 1.25	6 9,12,15,18	25 20
1.25 to 4.0	6 9,12,15,18	25 20
2.5 to 4.0	6 9,12,15,18	20 15
> 4	6 9,12,15,18	15 15

Note The tolerance for compressive stiffness is based on allowances for variations in properties of elastomer, layer and overall bearings thicknesses and measurement of compressive deflection.

* As measured from 0.1 to 1.1 times the rated compressive load at zero shear.

11.3 ELASTOMERIC BEARINGS-INSTALLATION

11.3.1 Marking and Delivery of Elastomeric Bearings

Each elastomeric bearing shall be clearly labelled or marked with the part number or type, or other specified identification number.

The bearings shall be wrapped in a double thickness of reinforced paper, lapped and taped. They shall be packed in timber crates, with styrene inserts and packing to prevent movement and to protect corners and edges. The crates shall be of substantial construction, well braced and strapped and marked with the contents.

Care shall be taken to avoid damage to the bearings during transport and handling prior to and during installation.

11.3.2 Installation of Elastomeric Bearings

a. Bearing Pedestals

Pedestals shall be cast monolithic with the substructure concrete with aggregate not less than 10 mm diameter. Alternatively they may be cast afterwards with a construction joint set at least 25 mm below the top of the supporting concrete or bonded to the concrete with an approved bonding agent after scabbling.

Pedestals shall be cured in accordance with the requirements of Section TS 8 this Specification for a minimum period of 7 days.

The bearing pedestals shall not loaded before 10 days after casting.

Cored holes shall be provided in the position as shown on the Drawings.

Upper surfaces of pedestals shall receive a Class 2 finish in accordance with the requirements of Section TS 3 of this Specification.

Tolerances on line and level of the bearing surfaces shall in accordance with the requirements of Section TS 3 of this Specification with the additional requirement that the permissible deviation at any point under a 300 mm straight edge placed level in any direction is 1mm.

b. Mortar Pads

Mortar pads, where shown on the Drawings, shall be a stiff cement mortar as specified in Section 3 of this Specification.

Concrete surfaces shall be treated as for pedestals before placing mortar and shall be cool and damp immediately before mortar placing.

Mortar shall be compacted by hammering and shall be trowelled and extended a minimum of 25 mm beyond the bearing edge and finished to a neat inclined face.

Finish and tolerance shall be as for pedestals. The mortar shall be cured under damp hessian for 7 days, or alternatively as consented to by the Engineer.

c. Installation

Elastomeric bearings shall be accurately aligned of the pedestals or mortar pad in the position shown on the Drawings.

The superstructure concrete, if cast in place, may be cast directly over the bearings provided that there is no disturbance to the bearing during these operations and also that there is a minimum 25 mm horizontal extension of the concrete soffit all around the bearing edge.

Where steelwork or precast concrete is to be placed on the bearing the member may be placed directly onto the elastomeric bearing. If any gaps greater than 1

mm occur then the member shall be lifted to permit coating the top of the bearing with an excess amount of an approved epoxy mortar and the member reseated. Any excess of mortar squeezed out is to be removed immediately before it has set and the bearing cleaned and adjacent surfaces made good.

Placing of the bearing, mortar and steel or concrete member shall only be carried out in the presence of the Engineer's Representative and the bearing shall be temporarily restrained as necessary to avoid any disturbance in position during member placing operations.

11.4 MEASUREMENT AND PAYMENT

Measurement, for payment, for bearings shall be based on the number of bearings of the various sizes specified, supplied, inspected and accepted by the Engineer and installed in accordance with this Specification.

Payment for bearings will be made at the rates entered in the priced Bill of Quantities which shall include full payment for providing all labour, materials tools, equipment and any other work incidental to the supply and installation of the bearings.

Payment for the item will include handling, storage, temporary supports, placing, construction or bearing pedestals (where applicable), placing holding down bolts (where applicable) and finishing and no separate payment will be made for any of these.

The following pay items shall be measured and paid for under this clause:

Pay Item No.	Description	Unit of Measurement
E.3.5	Elastomeric Bearing Pad (350x280x73)	No
E.3.6	Elastomeric Bearing Pad (310x210x24)	No
E.4.9	Elastomeric Bearing Pad (310x210x24)	No

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SECTION TS 12. EPOXY RESINS

SECTION TS 12. EPOXY RESINS

12.1 SCOPE

This Specification covers the supply and application of epoxy resins as coatings, adhesives and structural systems in the construction, maintenance and repair of concrete structures.

12.2 GENERAL

The Contractor shall employ, or seek the advice of, personnel experienced in the use and application of epoxy materials in the construction of the works, and shall provide the Engineer with evidence of such experience before of commenced.

Epoxy resins may be modified by the use of flexibilisers, plasticisers, dilutants, filters, and pigments, subject to the consent of the Engineer. The choice of the proper system for a given application shall be based on the modulus of elasticity, creep characteristic, rate of heat development, and quantity of head developed during curing. The Contractor shall seek the manufacturer's guidance as to the most suitable system for the required application and shall abide by the manufacturer's recommendations as to properties of the materials to be used.

Adverse environmental conditions will severely affect the performance of the epoxy resin, and the Contractor shall schedule his work to coincide with suitable environmental, conditions or provide a favourable artificial environment at his expense.

The Contractor shall be solely responsible for the performance of the epoxy resin and its compliance with the requirements of this Specification and the Drawings.

12.3 MATERIAL

12.3.1 General

Epoxy Resins shall, unless otherwise shown on the Drawings or consented to by the Engineer, comply with the requirements of ASTM C 881 Type 1, 2 or 3 as appropriate.

The epoxy resin used for a particular job shall have properties suited for the job application as recommended by the manufacturer.

12.3.2 Definitions

For the purpose of this Specification the following definitions will apply :

Adhesive	An adhesive is a substance capable of holding solid materials together by surface attachment.
Epoxy Resin	A resinous polymer containing more than one epoxide group per molecule and which is capable of being converted to a useful thermoset form by reaction with a second component called a hardener. The converted materials are also referred to as epoxy resin.

Hardener	Chemicals resinous in form capable of reacting with epoxy groups in epoxy resins to produce a cross-linked polymer. They usually contain amine or amide groups.
Flexibilisers and Plasticisers	These are usually long chain liquid compounds added to the epoxy resin. Some react during curing to impact a degree of resilience and toughness to a normally rather rigid system. Other are non-reactive and are commonly described as plasticisers.
Fillers, extenders	These are finely divided, non-reactive inert materials added to epoxy and Pigments resins to modify certain properties such as consistency density, and colour.
Aggregates	Stable, non-reactive minerals of specified size grading, which have adequate hardness and strength. Aggregates and sands used for Portland cement concrete are usually satisfactory, but must be dust free and oven dry.

12.3.3 Physical Requirements

The epoxy resin shall not react chemically with the environment in which it is placed and shall remain stable. The curing period of the epoxy shall be such as to allowed adequate time to complete the required operations at the maximum operation temperature.

12.3.4 Sampling and Testing

Epoxy resins shall generally comply with the requirements of AASHTO M 235 'Epoxy Resin Adhesive' and/or ASTM C 881 as applicable.

At least eight weeks prior using and epoxy resin, and on request at any time during the Contract period, the Contractor shall make available an amount of epoxy material sufficient to carry out tests as determined by the Engineer. No epoxy materials shall be used until the results of the tests on samples are known and/or the Engineer gives his consent to proceed.

The Engineer may, at his discretion, arrange to take samples from each separate batch of the delivered epoxy resin. These samples shall be submitted to such test as are deemed to be necessary by the Engineer to prove their conformity with the manufacturer's advance samples and with the details given in the manufacturer's product data sheets.

12.3.5 Information to be Provided by the Contractor

- mixing directions for the base/hardener components of the system
- surface preparation needed or other conditions for use
- minimum and maximum application temperature in degrees Celsius
- curing conditions including maximum and minimum curing temperature in degrees Celsius and curing time
- percentage by mass of volatile material in the mixed resin system
- modulus of elasticity of the cured epoxy resin

- viscosity
- batch number and date of manufacture
- pot or working time for various air temperature between 5 degrees Celsius and 30 degrees Celsius
- safety precautions
- storage temperature of epoxy resin
- shelf life

12.3.6 Rejection and Replacement

If, in the opinion of the Engineer, the samples taken from the epoxy resin delivered to the work are of inferior quality to the advance samples, the Engineer may reject all material delivered to the work which, in this opinion, is represented by the samples. Rejected material shall be replaced by the Contractor at his own cost, or the Engineer may cancel the order for further supplies for the epoxy resin.

12.3.7 Test Methods

The basic procedures of the epoxy resin shall be assessed in accordance with the following Test Methods which are attached as Appendix 'A' and are an integral part of this Specification.

- Preparation of Epoxy Concrete
- Making and curing Epoxy Concrete Test Specimens for determining Compressive Strength and Flexural Strength
- Inspection and capping of Epoxy Concrete Compressive Test Specimens
- Composite Cylinder test for Evaluation of Wet-to-dry concrete adhesive
- Tensile Bond Strength of Epoxy Concrete
- Compressive strength of Epoxy Concrete.

12.3.8 Properties Prior to Curing

a. Shelf Life

The two part epoxy components shall comply with all properties specified for a minimum period of 18 months after delivery. The expiry date of the shelf shall be marked on each container.

b. Work Time

Unless otherwise consented to by the Engineer, after blending of both component parts of a 4 litre mix at 30 degrees Celsius ± 2 degrees Celsius, the viscosity of the mixture shall remain within a workable range for at least 30 minutes.

c. Hardening Time

When mixed in the proportions recommended for a project, the compressive strength of epoxy resin mortar or concrete at 24 hours after mixing and curing at 30 degrees Celsius shall be not less than 75 percent of the strength developed in 7 days at 23 degrees Celsius ± 2 degrees Celsius.

12.3.9 Properties in the Cured State

Adhesion. When tested in accordance with Test Method No. 5 the strength of the composite cylinder shall be at least 90 percent of the control specimens at 14 days.

Compressive Strength. When tested in accordance with Test Method No. 7 the compressive strength shall be not less than 70 MPa (700 kg/cm^2) at 7 days.

12.3.10 Supply

The materials shall be packed in standard commercial containers so constructed as to protect the product from contamination. The quantities of resin and hardener packed in their separate containers shall be such that when the contents of the containers are mixed the epoxy materials shall be in their required reacting ratio.

12.3.11 Safety Precautions

All personnel shall be fully instructed in the potential hazards of the material, correct use of equipment, protective clothing washing procedures, washing materials and barrier creams.

Particular care shall be taken to prevent the material from coming into contact with the skin. Before using the epoxy compound, the manufacturer's technical data shall be read with particular reference to information on protective measures.

Personnel shall be informed that toxic fumes may be emitted from epoxy compounds and adequate provision shall be made for ventilation if conditions so dictate.

12.3.12 Storage

Component of epoxy resin shall be stored at a temperature recommended by the manufacturer. Components shall not be kept for more than 18 months and shall be checked before use for signs of crystallisation.

12.4 SURFACE PREPARATION

When removal of concrete is required the removal of dust, scale, oil, grease, dirt or any foreign matter shall be achieved by grinding, abrasive blasting, jackhammering, hand chipping, compressed air and water, or high pressure water jet. The use of hydrochloric acid may be consented to by the Engineer for selected applications.

The Contractor shall submit to the Engineer for his consent the proposed method of surface preparation. The method shall be in accordance with the relevant methods A to H inclusive of this Specification and with the consent of the Engineer. References shall also be made to AS 1627 'Metal Finishing-Preparation and pretreatment of surfaces'.

The Contractor shall be wholly responsible for adequate surface preparation prior to the application of epoxy resin.

12.4.1 Method 'A' Solvent Cleaning- Refer to AS 1627

This method shall be to remove oil, grease, wax, tar and other solvent soluble contaminants from the surface of non-porous materials. Large quantities of contamination shall be removed by hand or power tools prior to solvent cleaning.

Suitable solvents are Petroleum Solvents, Aromatic Solvents or Chlorinated Solvents except that petrol, Benzol or Carbon Tetrachloride shall not be used due to their flammable and toxic nature.

Surfaces may be cleaned by solvents using several techniques :

- Immersion in the solvent

- spraying with the solvent
- swabbing with rags or cloths
- immersion in boiling solvent vapour
- trichloroethylene using suitable equipment

Except for the last method repeated cleaning using fresh solvent shall be done for a completely clean surface.

The use of this method alone is subject to the consent of the Engineer who will usually direct that it be used in conjunction with another of the methods below.

12.4.2 Method 'B' Abrasive Blast Cleaning

Abrasive blast cleaning shall be used to prepare steel surfaces to a Class 3 standard as specified in AS 1627. Degreasing of steel surfaces shall be undertaken before abrasive blast cleaning commences. The abrasive used shall be subject to the consent of the Engineer. Abrasive blast cleaning may also be used in galvanised steel, concrete, plastics and ceramics.

Before abrasive blasting a surface, heavy rust, weld spatter or major irregularities shall be removed by mechanical means. Heavy deposits of oil, grease, wax, tar shall be removed by solvent cleaning (Method A) before abrasive blasting.

After abrasive blasting the surface shall be cleaned of any traces of any blast products by clean brushing, blowing with clean dry air or vacuum cleaning. After cleaning, the surface shall be promptly coated with the adhesive before contamination can occur.

12.4.3 Method 'C' Ferric Chloride Etching

This method shall be used to prepare copper, grass and bronze surfaces. These metals are subject to rapid surface and shall be coated with adhesive immediately after preparation.

The surface shall first be degreased by solvent washing (see Method A).

Ferric chloride solution shall be made by mixing ferric chloride, distilled water and nitric acid.

The ferric chloride shall be dissolved in the water in a glass or glazed earthenware container and then the nitric acid added with stirring.

The surface to be etched shall be immersed in the bath at 25 degrees Celsius for 1 to 2 minutes, then washed thoroughly with clean water and finally rinsed with distilled water.

12.4.4 Method 'D' Chromic Acid Etching

This method shall be used to prepare aluminium surfaces which have a tightly adherent film of inert aluminium oxide.

The aluminium shall first be degreased by solvent washing (Method A), followed by chromic acid etching.

Glass or glazed earthenware containers shall be used to hold the chromic acid solution. Eye protection and protective clothing shall be worn at all times when using chromic acid.

The Chromic Acid solution shall be made by mixing water, sodium dichromate and sulphuric acid.

The sodium dichromate shall be dissolved in the water and then the sulphuric acid added slowly with stirring. Water shall not be added to sulphuric acid as violent reaction will result.

The surface to be etched shall be immersed in the solution heated to a temperature between 60 to 70 degrees Celsius for 10 to 15 minutes. The surface shall then be washed thoroughly with clean water and finally rinsed in distilled water. After cleaning, the surface shall be promptly coated with the adhesive contamination can occur.

12.4.5 Method 'E' Hydrochloric Acid Cleaning

This method shall be used to clean sound concrete surfaces which have not been penetrated by contaminants.

If the concrete has been contaminated by oil, grease, paint, tar etc. other cleaning measures shall be adopted.

The hydrochloric acid solution of one part commercial hydrochloric acid to two parts of water by volume shall be made up in rubber, glass, glazed earthenware or plastic container. Suitable eye protection and protective clothing shall be worn when making of using this solution.

The acid shall be added to the water while constantly stirring.

The solution shall be applied to the surface of the concrete at the rate of 1 litre per square metre. When frothing ceases the surface shall be washed with water using a high pressure hose. If thorough hosing is not possible the surface shall be neutralised by washing with a weak solution of ammonia.

12.4.6 Method 'F' Preparation of Rubber Surfaces

This method shall be used to prepare rubber and neoprene surfaces.

Oil and bloom shall be removed from the surface with toluol to produce a uniform jet black appearance, then buffed with 80 grit emery paper or cloth to give a matt finish. All dust shall be removed and the adhesive applied in a uniform layer.

12.4.7 Method 'G' Preparation of Timber Surfaces

The surfaces to be joined shall be dry, sound and free from contamination by oil, grease, tars or old paint. Surface contamination and roughness shall be removed by planning and sanding. All dust shall removed.

12.4.8 Method 'H' Preparation of Bridge Decks

New bituminous road surfaces generally do not need preparation before mixing ceramic road markers. However, old surfaces which are uneven or contaminated with oil shall be prepared by one (or more) of the following methods :

• Grinding	A grinding wheel may be used to removed surface irregularities
• Burning	A burner may be used to remove oily residues
• Detergent	This mild but effective method may be used to remove
• Oily washing	Residues from bituminous surface. Neat detergent and a stiff bristle brush shall be used to clean the road surface then wash thoroughly with clean water.

12.5 MIXING

12.5.1 Mixing Equipment

All equipment and materials required for mixing of epoxy components shall be to the approval of the Engineer. All equipment shall be clean and free from harmful residue or foreign particles.

12.5.2 Mixing

Mixing shall be done in accordance with the manufacturer's directions.

The mixing of epoxy components shall in strict accordance with the manufacturer's instructions. Before any mixing is carried out, the correct proportions of components as recommended by the manufacturer shall be arranged into separate batches. All materials shall be conditioned to the temperature recommended by the manufacturer before mixing, usually 20 to 30 degrees Celsius. The base resin shall be stirred by a mixer for 10 seconds or until homogeneous prior to adding the hardener. The hardener shall then be added gradually to the base resin with constant mixing until the components are uniformly mixed.

Mixing shall be performed in a manner which will prevent frothing or air entrainment as this will considerably reduce the strength of the finished product. Mechanical mixing is preferable to hand mixing. The minimum time of mixing is five minutes.

The minimum time of mixing is five minutes.

Only small quantities (less than 1 litre) will be approved fir hand mixing.

When preparing epoxy mortars or epoxy concretes, aggregates shall be added after the epoxy components have been mixed thoroughly mixed prior to adding the next larger grade. Mixing shall then continue until a uniform mixture is produced.

All mixing shall occur as near as possible to the place of application. Mixing time shall not exceed five minutes. Part mixes will not be permitted.

12.6 METHODS OF APPLICATION

12.6.1 General

An epoxy resin shall not be applied over an epoxy application which has already hardened. No epoxy resin shall be applied until the consent of the Engineer's Representative has been obtained as to surface preparation and method of application.

12.6.2 Bonding

The epoxy resin shall be applied to the prepared surface by brush, roller, broom, squeegee, rubber gloves or spray equipment.

The epoxy resin shall be applied at a thickness to fill, with slight excess, the gap between substrate and the element to be bonded. Unless the date is available from the manufacturer the Contractor shall determine on the basis of trial joints an approximate applied rate of epoxy resin per square metre. The Contractor shall monitor the consumption of epoxy resin during the application to ascertain if significant variations occur which may indicate that either too much or too little epoxy is being applied.

Elements to be bonded shall be positioned within the contact time of the epoxy resin, as recommended by the manufacturer. If the movement of the element to be bonded is likely, the element shall be temporarily stressed or shored, within the contact time. The joint shall be checked to ensure uniform bearing and fit. Temporary fastenings or shores shall not be removed without permission of the Engineer. The joint shall not be disturbed until the epoxy resin has set.

Around cable ducts a distance of 25 mm should be kept free of epoxy resin to minimise flow into the ducts.

The Contractor shall have an experienced supervisor on site at all times during jointing operations.

Where it becomes necessary to stop work on joint after the application of epoxy resin has commenced, the Contractor shall scrape off as much of the epoxy resin as possible before it sets. The remaining hardened epoxy resin shall be removed by abrasive blasting and surface prepared according to Clause 18.4

12.6.3 Repair of Damaged Concrete

Repair of Damaged concrete shall conform to the requirements of clause 16 of this Specification.

12.6.4 Data``` To Be Recorded

The contractor shall keep records of all jointing operations which shall be made available to Engineer if required.

The information recorded shall include :

- Joint number
- date and time
- weather conditions
- shade temperature
- maximum temperature of mix
- time between adding components and initial application
- time between initial application and temporary stressing of elements to be bonded, or final application of surface coatings and fillers
- volume material used

12.6.5 Environmental Restrictions

The Contractor shall comply with the manufacture's recommendations as to environmental conditions under which the epoxy resin may be applied.

Epoxy resins shall not be applied when rains falling unless a non-moisture sensitive epoxy resin used. If rain falls on applied epoxy resin before the surfaces are brought together the application shall be stopped. If it become necessary to stop work on a joint the Contractor shall scrape off as much applied epoxy resin as possible before the material sets, and prepare the surface according to Clause 18.4 before re-applying epoxy resin.

12.6.6 Temperature

When the surface and atmospheric temperatures exceed 32 degrees Celsius difficulties may be experienced in mixing and application. Work shall scheduled when the temperature is generally lower, as in the early morning hours, or the work area should be shaded from direct sunlight prior to, and during the application.

12.6.7 Clean-up

The Contractor shall protect surface beyond the limits of surface receiving the epoxy application from spillage. Any epoxy spilled or applied beyond the desired area of application shall be immediately removed, and the area affected shall be cleaned with material recommended by the manufacturer. The Contractor shall avoid contaminating the work area with the clean-up materials.

All tools and equipment should be cleaned immediately after completion of the application.

12.7 MEASUREMENT AND PAYMENT

Measurement and Payment for Epoxy Resins will not be made exclusively and all costs incurred by the Contractor in complying with the requirement of this clause shall be deemed to be included in the rates and lump sum prices entered in the priced Bill of Quantities for works which incorporate the requirements of Epoxy Resins. These shall include the entire cost of completing the work including materials, labour, equipment, transportation and any other associated costs

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SECTION TS 13. PILES DRIVEN

13.1 GENERAL

This section covers the general requirements for piled foundations constructed using driven piles.

The specific requirements for the construction of driven concrete piles is covered by Section 14 of this Specification and the relevant clauses of this Section.

Concrete shall be supplied and placed in accordance with the requirements of Section TS 3 of this Specification. Precast concrete shall be manufactured and handled in accordance with the requirements of Section TS 4 of this Specification.

Piles shall be handled and driven in the locations and to the elevations shown on the drawings, or as directed by the Engineer. The Contractor shall ensure that piles are not damaged by improperly supporting, handling or transporting. Where damage to piles results from such improper handling the piles shall be replaced or, with the consent of the Engineer, concrete piles may be repaired in accordance with the requirements of Section TS 9 of this Specification. Such repair or replacement shall be at the expense of the Contractor.

Until incorporated in the permanent works the piles shall be adequately supported at all times by the use of suitable leaders, trestles, temporary supports or other arrangements to maintain position and alignment and to prevent damage to the driven pile.

13.2 TOE ELEVATIONS

The toe elevations or depths of penetration of piles as shown on the Drawings are nominal and are subject to confirmation or alteration and the Engineer may order in writing such changes of toe levels as may be necessary to ensure a satisfactory foundation.

13.3 DRIVING SYSTEM

Piles shall be driven with a driving system which delivers sufficient energy to produce a permanent set or penetration per blow as specified below.

The Contractor shall provide details of the driving system including the make, model and rated energy of the hammer, the mass of the helmet, and the proposed cap-block and cushion materials. These details shall be submitted to the Engineer at least 14 days prior to the commencement of pile driving, together with calculations which demonstrate that the proposed driving system has sufficient energy to successfully drive the piles to the required toe elevations or the nominated driving resistances without causing damage to the piles.

Unless otherwise consented to by the Engineer, Table 13.1 below shall represent the minimum values of pile hammer weight to be used for driving the appropriate type of pile.

Vibratory or hydraulic driving systems may be used only with the consent of the Engineer.

Table 13.1 - Pile Hammer to Pile Mass Ratios

Pile Type	Hammer Type	Mass Pile	Length of Pile	Mass Hammer / Mass Pile
Steel Tube or H Section	Diesel/Steam or Air	Any	Any	> 1.0
	Drop	Any	Any	> 1.5
Concrete	Diesel/Steam or Air	Any	Any	> 0.333
	Drop	< 7.5 tonnes	< 15 m	> 1.0[1]
			15 – 20 m	> 0.75[1]
			> 20 m	> 0.667[1]
		> 7.5 tonnes	Any	> 0.5

Note (1) Minimum Mass of Hammer shall be 2.5 tonnes.

For steel piles the calculated driving energy shall not exceed 50 kilojoules unless approved by the Engineer. This energy is equivalent to a drop hammer of 2.5 tonnes weight falling a distance of 2 metres.

For concrete piles up to 7.5 tonne mass the calculated driving energy shall not exceed 50.0 kilojoules unless otherwise consented to by the Engineer. This energy is equivalent to a drop hammer of 2.5 tonnes weight falling a distance of 2.0 metres. For heavier piles the maximum allowable driving energy shall be as consented to by the Engineer.

The effective drop height shall be chosen so as to avoid injury to the pile and shall not be greater than 1.5 m for concrete piles or 2.5 m for steel piles.

13.4 DRIVING

13.4.1 General

All piles shall be driven in the presence of the Engineer and the pile driver shall not be removed from the head of a pile without his consent.

Each pile shall be driven as a continuous operation and no pile shall be left partly driven unless otherwise consented to by the Engineer.

During driving piles shall be supported in line and position with suitable leads. Leads shall be constructed in such a manner as to afford freedom of movement to the hammer and shall be held in position to ensure rigid lateral support to the pile during driving.

Except where piles are driven through water, the leads shall, unless otherwise consented to by the Engineer, be of sufficient length to make the use of a dolly or follower unnecessary and shall be so designed to allow the placing of batter piles to within the tolerances specified.

Pile helmets shall be of substantial steel construction, loose fitting on the pile head with a steel diaphragm at approximately mid-height. Between the steel diaphragm and the pile head shall be placed a suitable cushion of softwood, loaded across the grain, at least 50 mm thick. On top of the diaphragm and fitting tightly into the helmet there shall be a suitable hardwood cap block. The helmet shall preferably slide in, and be guided by, the leaders of the pile frame.

13.4.2 Site Preparation

The Contractor shall be responsible for preparing the site by excavation or other means to ensure that the required levels of toes of piles are obtained.

For piles not founded on rock where the ground level is to be permanently lowered, such as for an excavated channel, piles located in the area to be excavated shall not be driven until such excavation is complete, and where the base of the pile cap is more than 2 metres below the ground surface level existing at the time of pile driving the excavation for the pile cap shall be completed prior to driving the piles unless otherwise approved by the Engineer.

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.

13.4.3 Tolerances

The following tolerances shall apply to piles after driving:

1. Pile head shall finish within 75 mm of the specified position.
2. Variation from the vertical or from the specified batter shall be not more than 20 mm in 1 m.
3. In case of piers with piles capped at crosshead level, the pile at ground level shall be within 50 mm of specified position.

The Contractor shall make every effort to drive the piles within the above tolerances. Should the tolerances be exceeded such remedial measures as are considered necessary by the Engineer shall be carried out by the Contractor at his own expense.

Piles shall not be bent or sprung into place during or after driving, but shall be effectively guided to finish in the position specified herein.

The dimensions of the concrete in the pile cap shall be increased, if necessary, at the expense of the Contractor to preserve the specified edge distance shown on the Drawings.

13.4.4 Penetration Requirements

The toe elevations shown on the Drawings are for general guidance only. The final toe levels of piles shall as be determined below.

For piles which are shown on the Drawings as being founded on rock the piles shall be driven to "nominal refusal". For this Specification "nominal refusal" shall mean a penetration of not more than 25 mm from twenty successive blows with a driving energy as specified above.

For piles which are shown on the Drawings as not being founded on the rock the piles shall be driven to "nominal refusal" or "permissible set". For this Specification "permissible set" shall be attained when the pile has been driven until the last four (4) blows of the hammer, using the driving energy as specified above, produce an average penetration or set greater than the values in table 13.2 unless specified otherwise on the Drawings or directed by the Engineer.

Table 13.2 – Permissible Sets per Blow for Piles not Founded on Rock

Type of Pile	Maximum Design Load (per pile)	Permissible Set per Blow
Steel	Any	5 mm
Concrete		
	Not greater than 25 kN	12 mm
	Over 250 kN and not greater than 350 kN	9 mm
	Over 350 kN and not greater than 450 kN	6 mm
	Over 450 kN and not greater than 500 kN	4 mm
	Over 500 kN	As specified on Drawings

Diesel hammers shall be driven with the throttle wide open when measurements of set or temporary compression are being taken.

When a pile does not obtain the specified driving resistance at the nominal toe elevation, it shall be driven on until the specified driving resistance is reached.

Alternatively, when requested by the Engineer, the Contractor shall stop driving, and then retest the pile in accordance with Clause 13.5.

Pile toes shall not finish above the Contract Levels without the written consent of the Engineer.

The Contractor shall use all means considered necessary, including pre-boring, jetting and preliminary excavation, to ensure the pile reaches the specified toe elevations within the accuracy of position as specified in Clause 13.4.3.

Details of the proposed work of this nature shall be submitted to the Engineer prior to implementation and no extra payment will be allowed on this account.

Whenever it is necessary to drive the head of the pile below the level of the underside of the pile cap, care shall be taken to minimise disturbance of the surrounding ground when driving or extending the pile.

13.4.5 Follower or Dolly

If during it is necessary to use a follower or dolly, driving shall be resumed within one hour of previous driving. Cushion material as consented to by the Engineer shall be placed between the dolly and the pile head. The penetration of the pile under the last ten (10) blows before the dolly is used and the penetration the first ten (10) blows using similar driving energy with the dolly in position shall be recorded.

From these two sets of records the proportional loss of energy when using the dolly shall be calculated and the drop of the hammer adjusted accordingly to give the specified set per blow or, in the case of a diesel or steam hammer, the nominated set per blow of the hammer shall be amended accordingly.

13.4.6 Test Piles

The Engineer may order test piles to be installed to verify the number and lengths of piles required for the structure. Test piles shall be of lengths as shown on the Drawings or ordered by the Engineer. The location in which the test piles are to be driven shall be as directed by the Engineer and may be inside or outside the perimeter of the foundation.

Where ordered by the Engineer, test piles will subjected to test loading in accordance with Clause 13.7 below.

For piles not founded on rock the first pile in any group, as selected or approved by the Engineer shall be considered as a test pile unless shown otherwise on the Drawings or directed by the Engineer. For such a pile, notwithstanding that the toe of the pile shall have reached the toe elevation as shown on the Drawings, or that the specified "permissible set" shall have been obtained, driving shall be continued (by means of a dolly or follower if necessary), if required by the Engineer to "nominal refusal", or until the top of the pile is at the level required by the Drawings, whichever gives the lower toe level. If further required by the Engineer the test pile shall be driven to a still greater depth by means of a dolly or by extending the pile.

After consideration of the driving record of a test pile the Engineer will advise the Contractor of any amended toe elevations for the group of piles considered to be represented by the test pile.

13.4.7 Splicing of Piles

Splicing of piles, where required, shall be carried out immediately driving of any section has ceased and redriving shall commence as soon as the splice is completed.

Spicing shall be carried out in accordance with the requirements of Section TS 7 for concrete piles or as recommended by the manufacturer.

Steel sheet piles shall be spliced with full penetration butt welds. Where welding of steel sheet piles is required the Contractor shall submit welding procedures and procedures for qualifications of welders to the Engineer for approval.

13.4.8 Jetting, Drilling and Firing and Pre-boring

When jetting is proposed, the number of jets and the volume and pressure of water at the jet nozzles shall be sufficient to freely erode the material adjacent to the pile and uniformly about the toe. The plant used shall have sufficient capacity to deliver at all times a pressure equivalent to at least 700 kPa (7 kg/cm^2) at two 80 mm jet nozzles. The jet pipes may, with the consent of the Engineer, be attached to the piles.

Jetting shall cease one metre above the specified toe elevation and the piles shall then be driven to the specified driving resistance.

Where piles are driven through abutment fill they shall be pre-bored to depths and hole diameter as specified on the Drawings.

Where pre-boring is used the diameter of the hole shall not be greater than the diagonal dimension of the pile less 100 mm. The actual depth of the pre-boring is to be determined by experiment and shall be such that the specified set (or less) is obtained when the pile is at the Contract Level. Pre-boring shall cease at least one metre above the Contract Level of the pile.

Firing shall only be used if shown on the Drawings or consented to by the Engineer. The procedure and charge shall be subject to the consent of the Engineer.

The amount of explosive charge (in kilograms) per hole shall not exceed 8 times D^2 where D is the distance (in metres) from the hole to the nearest structure or pile provided that at all times the peak practice velocity of the shock waves shall not exceed 50 mm/second.

In no case will firing be allowed at any pier or abutment where concrete piles have already been driven.

Any space remaining between the pile and the limits of the excavation, after the pile driving is finished, shall be backfilled with an approved granular material in accordance with the requirements of Section TS 2 of this Specification.

13.4.9 Replacement or Repair of Defective Piles

Should any pile split or crack during or become damaged in any way or become displaced from its specified position or alignment by more than the limits specified herein, the Contractor shall carry out any extra as directed by the Engineer to make good and incorporate the defective pile effectively in the structure, or to replace the pile.

A concrete pile shall be considered defective if it has a visible crack, or cracks, extending around the periphery of the pile or other defects which, in the opinion of the Engineer, will affect the strength or life of the pile.

The Engineer may order that piles to be replaced be withdrawn and replaced with a longer pile or a second pile be driven adjacent to defective pile.

Any piles forced up by the driving of adjacent piles shall be re-driven to the specified ultimate capacity and toe level.

This work shall be carried out at the expense of the Contractor.

13.4.10 Completion of Driving

On completion of driving, and filling where applicable, piles shall be cut back to the levels shown on the Drawings or as directed.

The Contractor shall carry out this operation in such a way as to avoid splitting, spalling or otherwise damaging the pile.

After driving piles the area shall be reinstated as directed by the Engineer.

13.5 RETESTING

Retesting shall be carried out not less than 24 hours after initial driving.

During retesting the pile shall be given ten consecutive blows with the energy per blow sufficient to produce a set of not less than 5 mm at the nominal driving resistance specified.

The pile will be accepted if the driving resistance calculated from the average set measured in the first 5 blows is equal to or greater than the specified driving resistance.

13.6 CAPACITY OF DRIVEN PILES

Each pile shall be driven to an ultimate capacity which shall be not less than that specified in the Drawings or as advised in writing by the Engineer.

The ultimate capacity achieved shall be calculated by the Engineer from one of the methods below or carrying out the load tests in accordance with Clause 13.7 below.

13.6.1 Ultimate Capacity based on the DANISH Formula

The ultimate may be calculated as:

$$R_u = \frac{e \times H \times W_r}{s + 0.5 \times s_o}$$

where $s_o = 1000 \times \sqrt{\frac{2 \times e \times H \times W \times r \times I_p}{A \times E}}$

R_u = Ultimate pile capacity in kiloNewtons

W_r = Weight of ram in Newton 9.81 x Mass of ram in kilograms

H = Height of free fall of hammer in metres

E = Modulus of Elasticity of the material of the pile (in MegaPascals)

e = Efficiency of fall of hammer

I_p[1] = Length of pile in metres

A[2] = Cross sectional area of the pile in square millimetres

E_n = W_r x H for drop hammers and is the rated hammer energy for diesel or steam hammers (in Newton metres and Joules)

s = Final set of pile in millimetres per blow using an average of 10 consecutive driving blows, or the first 5 full retest blows

s_o = Temporary compression allowance in millimetres as calculated from the above formula

The values of the coefficients e and E, which are dependent upon the type of equipment used, and the batter of piles, shall be as measured or as shown below or nominated by the Engineer:

e = 0.75 for drop hammers

e = 0.90 for steam hammers

e = 0.95 for diesel hammers

E = 21000 MPa (2.1 x 10^5 kg/cm^2) for concrete piles

E = 210000 MPa (2.1 x 10^6 kg/cm^2) for steel piles

[1] The value of I_p shall be the actual length of the pile for lengths greater than twenty times the value of the cross sectional dimension of the pile. For smaller lengths I_p shall be taken as 20 times the value of the cross sectional dimension of the pile.

[2] A for a steel pipe is the area of the steel.

13.6.2 Ultimate Capacity based on Wave Equation Methods

If the Contractor wishes to use the wave equation method to predict the ultimate capacity of the pile or wishes to instrument the pile with the dynamic testing

equipment a detailed proposal in writing shall be submitted to the Engineer not less than four weeks prior to the date the Contractor proposes to commence driving.

Pile driving shall not commence without the consent of the Engineer.

13.7 TEST LOADING

13.7.1 General

Where required by the Engineer the bearing capacity of the piles shall be checked by test loading on pile, and by measurement of settlement of the pile and of the adjacent piles in the pile group, which shall remain unloaded during the testing operation.

Test loading shall be carried out as described in this Clause and in general accordance with ASTM D 1143.

The test piles shall be the first piles at driven at each footing or distinct group of piles.

Loading of the test pile shall be achieved by jacking against kentledge. Adjacent piles shall not be used as jacking restraints.

The Contractor shall provide, at his own expense, all materials, equipment and labour required for the test loading of piles, including the provision of kentledge (together with any horizontal restraints required), the placing of kentledge and jacks in position, and all such work and material as may be incidental to the conduct of the test loading procedure as specified.

The method of test loading, and the loading and measurement procedures followed shall be subject to the consent of the Engineer.

Suitable, apparatus for determining the load on the pile and the settlement of the pile under each increment of load shall be supplied by the Contractor. The apparatus shall have a working capacity of three times of the design load shown on the Drawings for the pile being tested. Reference points for measuring pile settlement shall be sufficiently removed from the test pile to preclude the possibility of disturbance. All pile load settlement shall be measured by adequate devices, such as gauges, and shall be checked by means of a levelling instrument.

13.7.2 Procedure

The test loading procedure shall comply with the following requirements:

1. The initial loadings, and the subsequent increments and decrements of loading shall be achieved instantaneously or as nearly so as may be practicable.
2. Settlements shall be measured to an accuracy of 0.5 mm, and shall be recorded at the following intervals of time for a period of at least one hour, and until the rate of settlement shall have reduced to not more than 0.5 mm per hour:

   15 seconds

   30 seconds

   1 minute

   2 minutes

   3 minutes

4 minutes

5 minutes

30 minutes

1 hour

and at intervals of one hour thereafter as required.

3. Test loading shall follow the sequence set out hereunder, unless otherwise directed by the Engineer:

a) An initial load of the magnitude shown on the Drawings shall be applied to the test pile and shall be maintained as long as may be necessary to satisfy the requirements of 2. above.

b) The initial load shall be removed and the recovery of the test pile shall be measured not less than 10 minutes after removal of the load.

c) Recovery shall be measured to an accuracy of 0.5 mm.

d) The initial load shall then be reapplied, and the load shall be increased subsequently by increments of an amount as shown on the Drawings to a maximum of not less than the maximum value shown on the Drawings on directed by the Engineer.

e) Settlements shall be measured in accordance with the provisions of this Clause following re-application of the initial load and each subsequent increment of load.

f) The maximum test load shall be maintained for at least 24 hours or until the rate of settlement reduce to 0.5 mm per hour (whichever is the loner) or as the Engineer may direct.

g) The test load shall then be removed from the test pile in successive decrements until the load is reduced to the minimum value shown on the Drawings when the remainder of the load shall removed.

h) The recovery of the test pile shall be measured during the unloading process in accordance with the provisions of 2. above.

i) Measurements of settlement and recovery of adjacent unloaded piles shall be taken concurrently of the loaded pile at each stage of the testing procedure.

13.7.3 Report

The Contractor shall prepare a report on each load test as outlined below and shall submit a report to the Engineer within four (4) days of completion of the rest.

The report shall include at least the following information:

- Pile Construction and installation.

  A description of the pile type, length as driven, length as tested, length embedded, will thickness, head and tip details and dimensions, date pile was driven and pile mass.

  A description of the forming or driving of the pile including details of concreting, driving records and description of drilling.

- Test Layout and Equipment

  Sketches and if possible photographs showing location and size of reaction and loading equipment, deflection measuring equipment, test pile and cap and position of reference level marks.

An assessment of the accuracy of the deflection measurement and results of calibrations of the load measuring apparatus.

- Test Procedure and Results

  A tabulation of the readings during and unloading of the pile together with the relevant times and dates.

  A graphical representation of the test results in the form of load-settlement and time-settlement curves (together with all necessary corrections for calibration, movement of datum pints and other influences).

  An assessment of the effect of the reaction system on the deflections and the ultimate bearing capacity.

13.7.4 Acceptance

The criterion for acceptance of the pile shall be total settlement of the test pile under the maximum test load shall not exceed the value shown on the Drawings when the rate of settlement has reduced to not more than 0.5 mm per hour.

Where not shown on the Drawings this settlement may be taken as 6 mm at a maximum test load of 150 % of the maximum pile load shown on the Drawings.

The settlement of adjacent pile shall be within limits acceptable to the Engineer.

Should the test fail to comply with this criterion, tow additional piles shall be tested.

If both of the additional piles subsequently comply with the test criterion, all piles shall be deemed acceptable.

Should either of two piles subsequently tested fail to pass the test, the Contractor shall construct such additional piles as the Engineer may deem to be necessary to provide the required load capacity.

13.8 MEASUREMENT AND PAYMENT

Measurement and Payment for Piles Driven will not be made exclusively and all costs incurred by the Contractor in complying with the requirement of this clause shall be deemed to be included in the rates and lump sum prices entered in the priced Bill of Quantities for works which incorporate the requirements of this section of the Technical Specification. These shall include the entire cost of completing the work including materials, labour, equipment, transportation and any other associated costs.