Contractor and the cost shall be deemed to be included in the unit rate for concrete. The cost of capping and testing shall be borne by the Employer.

Subject to approval by the Engineer, the Contractor may arrange for his own convenience to have cylinders tested at other locations provided all such tests are carried out in the presence of the Engineer and provided a current and valid certificate of calibration by a recognized authority is submitted in respect of any testing machine used. All cylinders tested by the Contractor shall be sulphur capped before test and the complete cost of such testing shall be borne by the Contractor.

14.8 Batching and Mixing

14.8.1 Batching

All aggregates for concrete, other than blinding concrete shall be proportioned by weight unless otherwise specified.

The mechanism of delivery of material to the weigh-hopper shall be such that there is the least reasonable time lag between the closing of the material hopper and the entry of the material into the weigh-hopper.

Cement for Grade 25, Grade 30 and Grade 40 concrete shall be batched by weight and shall be weighed separately from the aggregates. Cement for other grades shall be batched by weight or by bag. If it is batched by weight, the cement shall be weighed separately, if it is batched by bag, a minimum of 1 in 20 bags used shall be weighed.

Batches involving the use of fractional bags will not be permitted. Water and admixtures may be batched by weight or volume. If batched by volume, water shall be measured in vessels clearly calibrated in litres or in a manner approved by the Engineer.

All weighing equipment used in batching the materials shall be in accordance with the requirements set out in AS 1379 "Ready Mixed Concrete".

The quantity of water and aggregate added to the mix shall be adjusted to allow for the water content of the aggregates. The Contractor shall keep on site and at the works an approved device for determining the water content of the fine aggregates.

14.8.2 Mixing

Concrete shall be mixed in a batch mixer of approved type and capacity with the drum rotating at the speed recommended by the manufacturer. The capacity of the

mixer shall be such that one or more whole bags of cement can be used per batch of concrete. The mixer shall be set up level and the volume of mixed concrete in a batch shall not exceed the rated capacity of the mixer.

When concrete is to be placed at a rate of 15 or more cubic metres per day, a spare mixer, in serviceable condition, shall be kept on site. All mixers shall be equipped with adequate water storage and a device for accurately measuring and automatically controlling the amount of water used in each batch. The batch shall be charged into the mixer so that some water will enter in advance of any aggregate. Materials shall be so placed in the hopper that at least two-thirds of the sand and gravel comprising the batch will enter the drum before the cement. Mixing shall continue until the concrete is thoroughly mixed.

The minimum mixing time after all materials, including water, have entered the mixer shall be two minutes for drum type mixers. For pan or other type mixers, the minimum time shall be as directed by the Engineer after conducting tests.

Upon cessation of mixing for any period exceeding 30 minutes, the mixer shall be cleaned thoroughly. Upon resumption of mixing, the first batch of concrete materials charged into the mixer shall contain only two thirds of the quantity of coarse aggregate. The entire contents of a batch shall be discharged from the mixer before any materials are placed therein for the succeeding batch.

Hand mixing shall be permitted only in the case of emergency and only then with the approval of the Engineer. Where permitted, the quantity of hand mixed concrete shall be limited to that required to complete a member or reach a construction joint. Hand mixing shall be carried out on a water-tight platform and the batch shall be turned a minimum of three times dry and three times wet. Cement content shall be increased by 20% over that for the approved mix.

14.8.3 Placing Time

Site mixed concrete shall be placed and compacted within 45 minutes of charging the mixer for concrete temperatures up to 30°C and within thirty (30) minutes of charging the mixer for concrete temperatures exceeding 30°C.

14.8.4 Ready Mixed Concrete

Only those manufacturers approved by the Engineer shall supply ready mixed concrete and the Engineer at his sole discretion may withdraw approval from any supplier.

The production, delivery and testing of the ready mixed concrete shall be carried out in accordance with the requirements of AS 1379 "Ready Mixed Concrete", except that Clauses 14.5, 14.6, 14.7 and 14.8.3 of this Specification shall apply. Mixing speeds shall be from 12 to 20 r.p.m. and agitating speeds from 2 to 3 r.p.m. Notwithstanding the provisions of AS 1379, the slump of the concrete immediately prior to placing shall comply with the Clause 14.6.1 of this Specification.

Ready mixed concrete shall be placed and compacted within the time limits specified in the following table.

The temperatures in the table shall be the temperatures at the time of discharge from the mixer.

Concrete Temperature at time of Placing	Maximum Elapsed Time from Time of Charging the Mixer
Less than 24°C	75 minutes
24°C - 27°C	60 minutes
27°C - 30°C	45 minutes
30°C - 33°C	30 minutes
Over 33°C	Not Acceptable

The time of introduction of the cement to the aggregate shall be recorded on the Delivery Note together with the weight of the constituents of each mix.

For truck mixed concrete water shall be added under supervision either at site or at the batch plant as agreed by the Engineer. In no circumstance shall water be added in transit.

14.8.5 Hot Weather Concreting

The Contractor shall take all practical precautions to maintain the concrete at a temperature not exceeding 33°C at the time of placing and to prevent shrinkage, settlement and presetting cracks. Precautions shall include any or all of the following:

(a) Crushed ice (where available) may be added in lieu of mixing water, under the supervision of the Engineer. No ice particle shall be larger than that which will allow complete melting and mixing of the ice prior to discharge from the mixer.
(b) Shading and watering aggregate stockpiles.
(c) Insulating or burying pipelines.
(d) Painting water pipes white.
(e) Cooling formwork by damping with water sprays.

(f) Shading work areas.
(g) Erection of wind breaks.
(h) Placing the concrete at a time when the temperature is at a minimum.
(i) Reducing the time for placing and finishing.

No concrete with a temperature higher than 33°C shall be placed, except that no concrete Grade 40 having a temperature greater than 30°C shall be placed in the forms.

When concrete has been rejected under this Clause, ice shall be added in accordance with (a) above, to subsequent mixings carried out in the same or similar weather conditions.

The temperatures of formwork and steel reinforcement at the time of placing shall be less than 35°C.

14.9 Placing and Compacting

14.9.1 Placing

Except as provided below, all concrete shall be placed in the dry and no concrete shall be placed until the forms and reinforcement have been inspected and approved by the Engineer.

When rain threatens or seepage exists in excavations, the Contractor shall have on site sufficient dewatering equipment and covers as applicable to prevent any additional water entering the concrete.

Concrete shall be placed in a continuous manner. Fresh concrete shall not be placed against in-situ concrete which has been in position for more than 30 minutes unless a construction joint is formed. When in-situ concrete has been placed for more than 4 hours no further concrete shall be placed against it for a further 20 hours.

Any troughs and chutes used as aids in placing concrete shall be metal or metal lined and shall be arranged and used in a manner that does not cause segregation. The use of water to facilitate the movement of concrete along troughs or chutes is expressly prohibited, but all troughs and chutes shall be kept clean and free of coatings of hardened concrete by flushing thoroughly with water, which shall be discharged well clear of concrete in place.

Troughs and chutes shall discharge into vertical downpipes at least 1 metre in length. where steep slopes are required, the chutes shall be equipped with baffles or be in short lengths that reverse the direction of movement so that the concrete slides without segregation.

Pneumatic placers shall be used only if authorized by the Engineer. Concrete pumps may be used subject to the approval by the Engineer of the pump and equipment. Such equipment shall be arranged so that no vibrations will damage freshly placed concrete. The delivery end of the pipe shall terminate in a fitting of approved design which shall prevent segregation of the concrete. After completion of any concreting operations the equipment shall be thoroughly cleaned.

Concrete shall not be dropped from a height, or in such a manner as will cause segregation or loss of material on the steel reinforcement or forms.

When placing operations would involve dropping the concrete more than 2 metres it shall be deposited through a sheet metal or other approved downpipe in such a way that the concrete does not segregate. As far as practicable, the pipes shall be kept full of concrete during placing and their lower ends shall be kept buried in the newly placed concrete. The depositing of a large quantity of concrete at any point with the intention of moving it along the forms will not be permitted.

After initial set of the concrete, the forms shall not be jarred and no strain shall be placed on the ends of reinforcing bars which project.

14.9.2 Placing Concrete under Water

Concrete shall not be placed under water unless specifically approved by the Engineer. The work shall only be carried out under the immediate supervision of the Engineer and as specified hereunder.

The quantity of cement in the concrete shall be increased by 25% above the approved minimum cement quantities for the grades of concrete designated.

Concrete shall not be placed in running water. Any pumping must cease and the water level must be constant where placement commences. The concrete shall be placed carefully in a compact mass in its final position by a tremie, a closed bottom dump bucket or by other approved means. Concrete seals shall be placed in one continuous operation,the concrete shall not be disturbed after being deposited and the placing shall be regulated so as to continually maintain an approximately horizontal surface.

When a tremie is used it shall consist of a watertight tube and at no time shall concrete in the tube come in contact with water when it is being filled. The means of supporting the tremie shall be such as to permit free movement of the discharge end and to permit its being lowered rapidly when necessary to choke off or retard the flow of concrete. No water shall enter the tremie tube.

The discharge end shall be completely submerged in concrete at all times and the tremie tube shall always be filled to a height to overcome the head of water.

When concrete is placed with a bottom-dump bucket, the bucket shall be lowered gradually and carefully until it rests upon the prepared foundation or upon concrete already placed. It shall then be raised slowly during the discharge travel so as to maintain as far as practicable still water at the point of discharge and to avoid agitating the mixture. The concrete so placed shall not be disturbed.

Placing concrete of cast-in-situ bored piles shall conform to the requirements of Clause 10.5.7 of this Specification.

14.9.3 Use of Spalls

Spalls (plums) of solid approved rock not exceeding 12 kg in mass may be used in mass concrete if approved by the Engineer. The spalls shall not be placed closer together, nor nearer the face of the forms than 150 mm. The surface of spalls shall be wetted before placing. They shall be well bedded by hand and the concrete vibrated in place around them.

14.9.4 Compaction of Concrete in the Form

Concrete during and immediately after depositing shall be thoroughly compacted. Concrete other than no-fines concrete shall be compacted with high frequency internal vibrators in the manner described below. Hand compaction in lieu of mechanical vibration will be allowed as an emergency measure when approved by the Engineer.

(a) The vibration shall be internal except as provided in (h) (form vibrators).

(b) Vibrators shall be of an approved type, capable of transmitting vibration to the concrete at frequencies of not less than 8000 impulses per minute at such an intensity to visibly affect a 25 mm slump concrete at a radius of 300 mm. Vibrators for Grade 40, Grade 30 and Grade 25 concretes shall be capable of transmitting vibration to the concrete at frequencies of not less than 12,000 impulses per minute at an intensity to visibly affect a zero slum concrete at a radius of 300 mm.

(c) The Contractor shall provide a sufficient number of vibrators to properly compact each batch immediately after it is placed in the forms. The minimum number of vibrators to be provided will depend on the rate of placing concrete but in no case shall be less than 1 vibrator for each 5 cubic

metres of concrete or part thereof placed per hour with a minimum of 2 vibrators.

Sufficient spare vibrators in a serviceable condition shall be on site at all times during placing and compacting of concrete.

(d) A vibrator shall be inserted into the concrete at successive positions not more than 500 mm apart and vibration shall continue at each position until air bubbles cease to emerge. It shall then be withdrawn slowly.

(e) Vibrators shall be inserted so as to thoroughly compact the concrete around the reinforcement and embedded fixtures and into the corners and angles of the forms.

Vibration shall be applied at the point of deposit and in the area of freshly deposited concrete. Where more than one layer is being placed in a continuous operation, the vibrator shall be inserted through the layer into the layer below.

(f) The vibrators shall be inserted into and withdrawn from the concrete slowly. The vibration shall be of sufficient duration to thoroughly compact the concrete, but shall not be continued so as to cause segregation.

(g) Where vibrators of the immersion type are used, contact with the reinforcement shall be avoided as far as it is practicable. Vibration shall not be applied directly or through reinforcement to sections or layers of concrete which have hardened to a degree that the concrete ceases to be plastic under vibration. Notwithstanding the foregoing, concrete shall not be subject to vibration between 4 hours and 24 hours after placing and compacting. It shall not be used to make concrete flow in the forms over distances so great as to cause segregation and vibrators shall not be used to transport concrete in the forms.

(h) The provisions of this section shall also apply to precast members except that if approved by the Engineer, the manufacturer's method of vibration may be used. For precast slab units internal vibration shall be used in conjunction with external mould vibration.

Except when authorized by the Engineer and in thin web sections concrete shall be placed in horizontal layers not more than 300 mm thick. Each layer shall be placed and compacted before the preceding layer has taken its initial

set, unless an approved construction joint has been approved.

Immediately following the discontinuance of placing concrete all accumulations of mortar splashed upon steel reinforcement and the surfaces of the forms shall be removed.

Special care shall be taken to ensure complete compaction behind prestressing anchorages.

14.9.5 Concreting Deck Slabs

Deck slabs for bridges shall be cast full length without construction joints other than any specifically shown on the Drawings. Concrete in deck slabs shall be placed in strips not more than 2 metres wide running transversely to the girders. The maximum time which shall elapse between the pouring of the first and last concrete in a deck slab shall be 5 hours, unless otherwise permitted by the Engineer.

14.9.6 Construction Joints

Construction joints shall be constructed only where shown on the Drawings or specified hereunder unless otherwise approved by the Engineer. If not detailed on the Drawings, specified hereunder or in the case of emergency, construction joints shall be placed as directed by the Engineer.

Construction joints shown on the Drawings are mandatory unless specifically exempted by the Engineer.

Construction joints shall not be made within 500 mm of the top of any wall or pier unless shown on the Drawings or otherwise approved by the Engineer. Pile caps, headstocks, in-situ diaphragms if any and similar sections shall be cast in one operation without construction joints. Spacing of horizontal construction joints shall be to the approval of the Engineer but shall not in any case be less than one metre.

At horizontal construction joints dressed timber strips approximately 25 mm square shall be placed inside the forms for all exposed surfaces. The surface of the concrete shall be stopped slightly above the lower edge of the strips.

The placing of concrete shall be carried continuously from joint to joint.

Should the Contractor wish to cast a wall or similar section in one continuous pour, he shall submit proposals to the Engineer for achieving compaction of the concrete, particularly near the bottom.

Before depositing new concrete on or against concrete which has hardened, the forms shall be retightened. Wherever possible laitance shall be removed whilst the concrete is still green. Where this is not possible the surface of the hardened concrete shall be roughened as required by the Engineer, in a manner that will not leave loosened particles at the surface. The roughened surface shall be thoroughly cleaned of foreign matter and saturated with water. To ensure an excess of cement at the joint, the surface shall first be thoroughly covered with a coating of cement grout consisting of cement and water with a water/cement ratio of approximately 0.5 by weight, against which the new concrete shall be placed before the grout has attained its initial set.

14.10 Placing of Grout and Mortar

Unless otherwise indicated on the Drawings grout shall normally be placed using a pressure gun. At the Engineer's discretion alternative means may be used provided that the Contractor demonstrates that the proposed method will ensure complete filling of all cavities. Mortar placed under bearing pads and bearings where the surface is levelled before the placing of the items should be placed and levelled by trowel.

14.11 Finishing and Curing

14.11.1 Formed Surface

Refer to Clause 12.3 of this Specification.

14.11.2 Unformed Surface

The following classes of finish are appropriate to unformed surfaces:

(a) Class U1 - When the moisture film has disappeared and the concrete has hardened sufficiently to prevent laitance from being worked to the surface, a Class U3 surface shall be steel-trowelled under firm pressure to produce a dense, smooth and uniform surface free from trowel marks.

(b) Class U2 - After the concrete has hardened sufficiently, the concrete Class U3 surface shall be floated by hand or machine sufficiently only to produce a uniform surface free from screed marks.

(c) Class U3 - The concrete shall be uniformly levelled and screeded to produce a plain or ridged surface as described in the Contract. No further work shall be applied to the surface unless it is used as the first stage for a Class U2 or Class U1 finish.

14.11.3 Finishing to Road Surface of Bridge Decks

Concrete in bridge deck slabs shall be finished by hand screeding followed by power floating. A grid of removable spot levels shall be set up over the top of the girders at the correct level and profile of the top of the deck (allowing for deflection) prior to casting the deck. The grid shall be at not more than 3 metre centres. The concrete shall be placed and compacted by immersion vibrators and screeded to profile with hand screeding boards. The concrete surface shall be finished with power floats. At least five passes shall be made with the power float, each successive pass being in a direction perpendicular to the previous pass. After floating, the surface shall be checked with a 3 metre straight edge. Any deviation in excess of 3 mm shall be made good.

Finally the surface shall be vigorously broomed transversely with a stiff broom when the surface has started to stiffen. Brooming shall continue until a fine but rough surface has been achieved to the satisfaction of the Engineer. A smooth deck surface producing low tyre friction will not be accepted and the Contractor will be required to roughen the surface to the Engineer's satisfaction.

14.11.4 Curing

Concrete surfaces other than slabs shall be cured for a period of not less than 7 days. Slabs shall be kept cured for a period of not less than 14 days.

Horizontal surfaces shall be wet cured by water sprays or wet sand. Other surfaces shall be wet cured or membrane cured.

The surfaces shall be cured 24 hours a day for the full period specified without any breaks at weekends or holidays. Curing shall be commenced immediately on completion of finishing of exposed surfaces or within half an hour of removal of the forms from other surfaces.

Generally, the only membrane curing compound which will be approved is paraffin wax emulsion in water. The compound shall be applied at the rate recommended by the manufacturer. Slabs shall be sprayed with curing

compound as soon as possible after finishing and before plastic cracking occurs, and shall be immediately covered with an approved building paper. Should the building paper be lifted by wind or other action, the area uncovered shall be resprayed and the paper replaced. When wet curing of slabs is to be used it shall commence on completion of finishing of the slab.

14.12 No-Fines Concrete

No-fines concrete shall consist of Portland Cement and coarse aggregate. Portland Cement and coarse aggregate shall comply with Clause 14.5 of this Specification.

Coarse aggregate shall comply with the following grading:

Sieve Size AS 1152	Percent Passing
31.5 mm	100
22.4 mm	95 - 100
9.5 mm	0 - 5

No-fines concrete shall be proportioned as follows:

Aggregate/cement ratio shall be 8 parts of aggregate as specified above to 1 part of Portland Cement by weight.

The water/cement ratio shall be from 0.38 to 0.40 by weight.

No-fines concrete shall be screeded to the required surface levels without tamping, rodding or vibrating. It shall be moist cured for at least 4 days by covering with wet hessian, building paper or other similar material. Sand or other material likely to enter the voids shall not be permitted for curing.

Before normal concrete is poured over no-fines concrete, building paper or other similar material approved by the Engineer shall be placed over the no-fines concrete. Any tears or holes shall be repaired to the satisfaction of the Engineer.

14.13 Miscellaneous Details

The Contractor shall build into the concrete all ducts, unistruts, pipes, water stops and other details shown on the Drawings or specified herein.

Where these items are not shown separately in the Bill of Quantities, the cost of supplying and placing thereof shall be included in the price of concrete or for precast elements.

14.14 Tolerances

Tolerances, being the allowable deviation from plumb or level and from the alignment, profile, grades and dimensions shown on the Drawings, shall be as shown on the Drawings, specified elsewhere in the Contract or shall be not greater than the requirements hereunder. The Contractor shall be responsible for ensuring that the work is completed within the tolerance specified.

(1) Tolerances for reinforced concrete structures:

(a) Variations from plumb in the lines and surfaces of columns, piers, walls and in arises or variations from the level of the grades indicated:

in 3 metres or less - 6 mm
Plus 2 mm per metre up to a maximum of 20 mm.

(b) Variation in the sizes of locations of sleeves or blockouts or the placing of embedded metal work

- 6 mm

(c) Variations in cross sectional dimensions of columns and beams and in the thickness of slabs and walls

- Minus 6 mm
Plus 12 mm

(d) Footings:

Variation in dimensions in plan - Minus 12 mm

Misplacement or eccentricity - 2% of the footing width to a maximum of 50 mm

Reduction in thickness - 5% of specified thickness

(2) Tolerances for reinforcing steel:

Tolerances for cutting, bending and fixing reinforcemnet shall be in accordance with the requirements of AS 1480.

Where, in the opinion of the Engineer the application of the tolerances would adversely affect the appearance or serviceability of the structure, he may at his discretion reduce the magnitude of the tolerances. Where appearance or serviceability of the structure will not be impaired (e.g. in concrete to be subsequently buried below ground level), the Engineer may at his discretion, relax the tolerances.

14.15 Measurement and Payment

Only work completed in accordance with the Contract Documents and accepted by the Engineer will be measured for payment. No measurement will be made for concrete required to fill overbreak in excavation.

The quantity of concrete for structures will be calculated from the dimensions on the Drawings or as revised by the Engineer. Deductions will not be made for the volume occupied by reinforcing steel, drainage facilities or expansion and contraction joint material. No deduction will be made for fillets and chamfers 40 mm or less nor for conduits 100 mm or less encased in the concrete.

Payment shall not be made separately for grout and mortar used in association with holding bolts and bearings but shall be deemed to be included in the items for holding down bolts and bearings.

The work measured as provided above for the various grades of concrete shall be paid for at the scheduled rate according to the particular purpose provided in the Bill of Quantities per cubic metre. The rate shall include full compensation for furnishing all labour, materials, plant, tools, equipment and all miscellaneous items necessary for the finished concrete, including supply and storage of materials, mixing, transporting, placing, finishing, curing and the furnishing of and placing of all other incidental construction items not otherwise covered as a separate scheduled item, all as required by this Specification and as directed by the Engineer.

GROUP 15

STRUCTURAL STEELWORK

GROUP 15

STRUCTURAL STEELWORK

15.1 General

This Specification covers the supply, fabrication, delivery to the Site, erection, testing and inspection of structural steelwork for bridges.

15.1.1 Drawings, Procedures and Programme

At least one month prior to commencement of fabrication of any portion of the Work, the Contractor shall submit three copies of the relevant workshop drawings to the Engineer for review. These drawings shall clearly show all sizes, dimensions, markings and connections including loose packs and shall set out the position, sizes and lengths of all welds, nuts, bolts and washers as are necessary for the complete fabrication, assembly and erection of the steelwork. Splices other than those indicated on the original drawings shall not be included in steel sections without the prior written consent of the Engineer. If such additional splices are consented to, testing will be carried out at the discretion of the Engineer and costs incurred for this testing will be borne by the Contractor.

At least four (4) copies of reviewed drawings of portions of the Work shall be supplied to the Engineer before fabrication on those portions is commenced. The drawings should in general comply with AS 1100. The Contractor shall be responsible for the correctness of the shop drawings and the Engineer's consent to the shop drawings shall not relieve the Contractor of this responsibility. At least fourteen (14) days before the commencement of fabrication, the Contractor shall submit his complete programme of work, including details of procedures entailing weld sequences, distortion control, preheating etc., to the Engineer for his review. Any departure from the agreed programme and procedures as may be found necessary during the progress of the Work shall be subject to the Engineer's review.

Fabrication shall not be commenced until the Engineer has consented to the use of the shop drawings and procedures and the programme of work is agreed.

15.1.2 Facilities for Inspection

The Contractor shall furnish all facilities for the inspection of material and workmanship at the place of fabrication and the Engineer shall be allowed free access to the necessary parts of the premises when requested.

15.1.3 Notice of Intention to Commence Work

The Contractor shall give at least seven (7) days notice of the time and place at which he proposes to commence fabrication of the structural steel.

15.1.4 Sub-Contractors

The Contractor shall not sub-let the fabrication of structural steelwork or any part thereof without prior consent in writing of the Engineer. Only those workshops that have been specifically approved by the Engineer to carry out the Work will be authorized to perform the work on the structural steel.

15.2 Materials

15.2.1 General

Steel shall be ordered at the earliest possible time in consultation with the Suppliers and according to the fabrication priorities. The order shall be submitted to the Suppliers with the name of the project for which the steel is to be used and the nature of the work e.g. "welded steel plate girder".

Prior to the purchase order being made, the Contractor shall furnish the Engineer with a copy of the order. Should delays be experienced in the supply of the steel, no extension of time will be allowed to the Contract, if, in the opinion of the Engineer, such delay could have been reasonably avoided by the earlier placement of the purchase order.

15.2.2 Standards for Materials

(1) Plates, Sections, Bars and Bar Sized Sections

Plates, sections (other than 914 UB343), bars and bar sized sections shall comply with AS 1227 and 1204 and shall be of the grades shown on the Drawings.

914 UB343 shall comply with BS 4.

Structural steel plate shall comply with AS 1184.

Structural steel sections shall comply with AS 1131.

Universal beam sections exceeding the nominal size specified in AS 1131 - 1979 shall conform to JIS G 3106 & G 3192 or equivalent.

Structural steel flats of lesser widths than 450 mm shall be cut from plate of greater width than 450 mm.

The Contractor shall supply test certificates of chemical and physical properties of the steel in accordance with AS 1227, AS 1204 and BS 4360.

(2) Hollow Sections

Structural steel hollow sections shall comply with AS 1163.

(3) High Strength Steel Bolts

High strength steel bolts with associated nuts and end washers shall comply with AS 1252 and shall incorporate load indicating devices acceptable to the Engineer. High strength bolts and washers shall be galvanized and shall also comply with AS 1214 and AS 1650 as appropriate. Load indicating devices shall be applied with a sherardized coating.

(4) Commercial bolts and Screws

Commercial grade bolts and screws shall comply with AS 1111. Nuts shall comply with AS 1112, Grade 5 and washers with AS 1237. If specified to be galvanized, they shall also comply with AS 1214 and AS 1650 as appropriate.

15.2.3 Storage of Materials

All steel, whether fabricated or not shall be stored above the ground on platforms or skids, or other supports, and adequately protected against corrosion.

Excessively rusted, bent or damaged steel will be rejected.

Steel surfaces, having undergone the treatment recommended in Group 16 of this Specification shall not be stored with surfaces in contact, but shall be separated by adequate numbers of spacers.

15.2.4 Identification

Steel shall be marked as it is taken into stock. At all stages of fabrication all pieces shall be identifiable by grade, by an appropriate colour marking or other marking acceptable to the Engineer, or it shall be classed as unidentified steel.

Unidentified steel shall only be used with the prior written consent of the Engineer.

15.2.5 Test Certificates

Test certificates shall be supplied to the Engineer before work on the material commences to prove the steels compliance with the appropriate above Standards.

15.2.6 Defective Materials

Defects arising from the manufacture of the steel which become evident at any stage of fabrication shall be inspected by the Engineer, who will decide whether the material may be repaired by the Contractor or will be rejected. The cost of repairs or replacement will be the Contractor's responsibility.

15.3 Fabrication

15.3.1 Templates

All templates, jigs and other equipment necessary for the accurate fabrication of the Work shall be provided by the Contractor at his own expense.

15.3.2 Cutting of Steel

Edges may be cut by either planing, machining, flame cutting or shearing, but edges to be welded shall nevertheless comply with the welding sub-section of this Specification. Cut edges shall be free of gouges, burrs and other defects which are greater than 5 mm deep, or which would otherwise adversely affect the serviceability of the member. Occasional notches or gouges not more than 5 mm deep on otherwise satisfactory surfaces shall be removed by machining or grinding. Correction to defects shall be faired to the surface with a slope not exceeding 1 in 10.

Oxygen cutting of steel and weld metal shall be permitted provided a smooth and regular surface free from cracks and notches is secured, and provided that an accurate profile is secured by the use of a mechanical guide. Free-hand oxygen cutting shall be done only where approved by the Engineer.

In all oxygen cutting the cutting flame shall be so adjusted and manipulated as to avoid cutting inside the prescribed lines. The surface roughness of oxygen cut surfaces shall be equivalent to or better than the standard classes of replicas of flame cut surfaces as existing on the Australian Welding Research Association (A.W.R.A.) standard samples.

The following classes shall be applicable to all edges unless otherwise specified on the Drawings:

	Part	A.W.R.A Standard Sample	B.S. 1134 Roughness Value (Raum)
(a)	All edge preparations for welds, edges of flanges, and webs of boxes and plate girders.	Class 1 (Good Quality)	5.0
(b)	All other edges, e.g. ends of sections, except where specified in (c) below.	Class 2 (Medium Quality)	10.0
(c)	Edges of material thicker than 50 mm where the edge does not carry calculated stress.	-	50.0

Surface roughness values shall be measured in accordance with B.S. 1134 for the assessment of surface texture.

Roughness exceeding these values and occasional notches or gouges not more than 2 mm deep, on otherwise satisfactory surfaces, shall be removed by machining or grinding. Cut surfaces and edges shall be left free of adhering slag. Corrections of defects shall be faired to the oxygen cut surface with a slope not exceeding 1 in 10. Defects of oxygen cut edges shall not be repaired by welding except with the express approval of the Engineer for occasional notches or gouges less than 5 mm deep. Such weld repair shall be made by suitably preparing the defect, welding with low hydrogen electrodes not exceeding 4 mm in diameter, observing the applicable requirements of the welding sub-section of this Specification, and grinding the completed weld smooth and flush with the adjacent surface to produce a workmanlike finish.

Re-entrant corners, except for the corners of weld access cope holes adjacent to a flange, shall be filleted to a radius of not less than 20 mm. The fillet and its contiguous cuts shall meet without offset or cutting past the point of tangency.

Air carbon arc or oxygen gouging shall be permitted for joint preparation, back gouging, or the removal of defective work or material, provided the following provisions are complied with.

Oxygen cut or air carbon arc gouged edges conforming with the other requirements of this Specification shall be permitted in the fabrication of the steelwork provided:

(a) The hardness in the heat affected region adjacent to the cut edge is less than 350HV5.

(b) The ductility developed in bending with the cut edge in tension is sufficient to accommodate bending around a former of radius equal to twice the plate thickness.

As a guide, compliance with these requirements will generally be achieved by adopting the relevant combination of equipment as listed below:

Thickness	Nozzle Size	Cutting Oxygen Pressure kPa	Preheating Acetylene Pressure kPa	Cutting Speed mm/min
Grade 250 and 250 LO Steel				
12	12	200	70	400
25	15	240	70	260
40	15	300	70	200
50	15	330	70	180
60	15	350	70	165
70	20	370	70	150
Grade 350 LO Steel				
12	12	200	70	260
25	15	240	70	200
40	15	300	70	150
50	15	330	70	125

If the hardness of flame cut edges exceeds the specified value, or the specified ductility is not achieved, the Engineer shall have the right to order machining of the edge until the hardness is less than the specified value, or to direct that the edge be reprepared on a new plate if such machining would result in undersize plates.

15.3.3 Straightening

All material before being assembled, shall be straightened or formed to the specified configuration by methods specified below.

Straightening or bending of either fabricated or unfabricated steel, if necessary, shall be done by means of steady pressure applied by rolls or presses. Straightening and bending shall not be done by hammering or, unless the Engineer's approval has been obtained, by heating. If straightening by heating is allowed, the steel shall in no case be heated to a higher temperature than 600°C as measured by indicating crayons, liquids or bimetal thermometers. After heating the metal shall be cooled slowly in air without any forced cooling.

Following the straightening of a bend or buckle, the surface of the metal shall be carefully inspected for evidence of fracture. Depending on the location in the Works, the Engineer shall have the right to reject the metal or to direct that the defects be repaired in a manner that shall be approved by the Engineer. The cost of replacement or repair shall be borne by the Contractor.

15.3.4 Welding

(1) General

This Sub-Clause covers the electric arc welding by manual shielded metal-arc, submerged arc, gas metal arc, or flux-cored arc of weldable structural grade, low carbon steels not more than 100 mm thick, and the welding of reinforcing steel and stud shear connectors. It does not cover the welding of weldable low and medium alloy steels.

Except where otherwise herein specified, all welding shall conform to American Welding Society Structural Welding Code A.W.S. D1.1-75.

The whole of the metallic arc welding shall be carried out in strict accordance with the Drawings, this Specification and to the entire satisfaction of the Engineer. Any weld not in accordance with the Specification shall be cut out and the work rewelded or otherwise rectified to the satisfaction of the Engineer and at the Contractor's expense.

(2) Equipment

(a) Welding Equipment

Electric arc welding equipment and plant shall conform to AS 1966, "Electric Arc Welding Machines" and shall be maintained at all times in good condition to the satisfaction of the Engineer.

Equipment for welding shall be of an approved type and shall be used in the circumstances and in the manner recommended by the manufacturer, i.e. sizes of electrodes, currents, voltages, speeds of travel, position of welding and fixtures and jigs shall be as laid down for the particular class of work and shall not be varied therefrom without the written approval of the Engineer.

Where a machine or a method is not of a conventional type, adequate demonstration of its use may be called for by the Engineer before approval will be given.

(b) Gas Cutting Equipment

Gas cutting equipment shall be of a type approved by the Engineer and shall be maintained in good working condition. Torches and nozzles shall be of proper size and type for the work in hand. Suitable regulators shall afford the operator complete control over the pressure and rate of flow of each gas.

(3) Electrodes

(a) Electrodes for Manual Shielded Metal Arc Welding

Only covered electrodes shall be used and all electrodes shall conform to AS 1553 and A.W.S. A5.1-69.

The Contractor shall specify with regard to the electrodes which he proposes to use:-

(i) Maker's name and trade mark

(ii) Class of electrode and weldment for which it is intended to be used.

Every package of electrodes used in the Work shall be clearly marked with the information specified in AS 1553. The following electrodes classified in accordance with AS 1552 shall be used to obtain the weld metal mechanical properties specified in AS 1553.

Steel Grade (AS 1204)	Electrode Classification (AS 1552)	Electrode Approval (AS 1553)
250	E4113, E4114, E4813, E4814, E4127, E4824	Grade 2 (min)
250 LO	E4116, E4118, E4816 E4818	4
350 LO	E4816, E4818	4

Reinforcing steel shall not be welded unless authorized in writing by the Engineer, when the electrodes shall comply with AS 1552 classification EXX16 or EXX18.

All electrodes shall be dry when used. Electrodes which have been wet shall not be used. Once the sealed containers have been opened, electrodes other than low hydrogen electrodes, shall be kept in storage ovens held at a temperature of 6°C above the ambient temperature.

All low hydrogen electrodes shall conform with the requirements of Clause 4.9.2 of A.W.S. D1.1-75 in respect of purchase and drying conditions. Notwithstanding that Clause, low hydrogen electrodes that are not used within 2 hours after removal from the hermetically sealed packet or oven, shall be redried before use.

Cartons or other packaging severely damaged during delivery, or electrodes on which the flux has been spalled, shall be rejected.

(b) Electrodes and Flux for Submerged Arc Welding

In all respects, the electrodes and flux shall conform to the A.W.S. D1.1-75 and A.W.S. A5.17-69. The bare electrodes and flux used in combination for submerged arc welding shall be capable of producing weld metal that complies with A.W.S. A5.17-69 when deposited in a multiple pass weld made in accordance with the procedure requirements of this Specification.

The following flux-wire combinations shall be used to obtain the weld metal mechanical properties specified in A.W.S. A5.17-69.

Steel Grade	Flux-Wire Combination
250	F60-EXXX
250 LO	F62-EL12, F72-EL12, F72-EM12K
350 LO	F72-EM12K

Flux used for submerged arc welding shall be dried at 100°C - 200°C for 4 to 6 hours prior to use. It shall be free of contamination from dirt, mill scale or other foreign material. Flux fused in welding shall not be re-used.

If the Contractor desires to repeatedly re-use flux, the flux recovery equipment shall be of a type that removes dirt and dust.

The dust bag of the recovery unit shall be cleaned regularly. Used flux which in the opinion of the Engineer contributes to porosity or other defects in the weld shall be rejected.

The electrode wire shall be stored in warm dry conditions.

(c) Electrodes and Gas for Gas - Metal Arc Welding

The electrodes used for this process shall conform in all respects with A.W.S. D1.1-75 and A.W.S. A5.18-76. The following electrodes shall be used to obtain the weld metal mechanical properties specified in A.W.S. A5.18-76.

Steel Grade	Electrode
250	E70S-X or E70U-1
250 LO	E70S-6
350 LO	E70S-6

In particular, the weld metal shall have Charpy V-notch impact properties exceeding 27J at -15°C, for all grades of steel.

The gas used for shielding shall be of welding grade and shall comply with A.W.S. A5.18-76.

The electrode wire shall be supplied in hermetically sealed cartons and stored under cover.

(d) Electrodes for Flux-Cored Arc Welding

The electrodes used for this process shall conform in all respects with A.W.S. D1.1-75 and A.W.S. A5.20-76.

The following electrodes shall be used to obtain the weld metal mechanical properties specified in A.W.S. A5.20-76.

Steel Grade	Electrode
250	E60T-7 or E70T-5
250 LO	E70T-5
350 LO	E70T-5

In particular the weld metal shall have Charpy V-notch impact properties 27J at -29°C, for all grades of steel. The electrode wire shall be stored in warm dry conditions.

(e) Testing of Electrodes

Test requirements may be fully or partially waived for electrodes that are of a type generally approved and subject to periodic tests by Lloyds Register of Shipping or other approved competent authority. Written application shall be made to the Engineer by the Contractor for such waiving of tests, giving adequate guarantees.

When required by the Engineer, test pieces shall be cut from deposited weld metal for testing for the relevant properties of deposited weld metal and compliance with AS 1552, A.W.S. A5.1, A5.17, A5.18 and A5.20

The Contractor shall provide and deliver the completed test pieces to the laboratory nominated by the Engineer at his expense. Testing shall be at the Employer's expense.

(4) Qualifications of Personnel

(a) Work Supervisor

All welding shall be carried out under the supervision of a person employed by the Contractor, who has had suitable training and experience in the fabrication of welded structures.

The Contractor shall satisfy the Engineer that the Works Supervisor is suitable for the work upon which he will be employed.

Notwithstanding the above, the Works Supervisor shall hold a current Structural Welding Supervisors Certificate issued in conformity with AS CA 60.

(b) Qualifications of Welders and Welding Operators

Welding shall be carried out by welding operators who have had suitable training and practical experience in the execution of this form of construction, under the immediate and continuous supervision of a Works Supervisor qualified as in sub-clause 4(a) above.

The holding of the A Grade Welding Operator's Certificate for Electric Welding of the Australian Welding Institute shall be deemed to be satisfactory proof of a welder's training and experience.

Welding operators not holding the above qualifications will be tested as prescribed in AS 1796 "SAA Welding Certification Code" unless the operator can demonstrate his previous qualification to the satisfaction of the Engineer.

The welding and testing of qualification test specimens shall be carried out in the presence of the Engineer.

Where a method or process of manual welding is not of conventional type, the operator shall be subject to tests as required by the Engineer of generally similar type and standard to those mentioned above, using the process as intended for use in the Work in all the circumstances likely to occur in the Work.

If the Engineer considers the quality of an operator's work is below the required standard, he may require the operator to undergo re-qualification tests.

(c) Cost of Tests for Welding or Welding Operator Qualification

The costs of testing the weld test pieces completed by welders or welding operators to be employed on the Work shall be borne by the Employer.

All other costs including the cost of materials, labour, overhead charges and delivery to the testing laboratory nominated by the Engineer associated with the qualification of welders and welding operators shall be borne by the Contractor and shall be included in the scheduled rate for "Structural Steelwork - Supply, fabrication, shop painting and delivery to Site."

(5) **Welding Procedure Qualification**

Welding on any particular weld type shall not commence until the Engineer has, in writing, consented to the use of the appropriate procedure.

Before consent is given, the Contractor will be required to submit such test assemblies as the Engineer requires for examination and testing. These test assemblies shall duplicate as far as practicable the actual conditions in the Work, particularly with regard to plate thicknesses and geometrical arrangements.

Test assemblies will be required in the case of submerged arc welding and may be required in the case of manual welding.

Welding of test assemblies shall be done in the presence of the Engineer or his representative who will record:-

(1) Operator's name
(2) Type and make of equipment
(3) Weld preparation
(4) Type and size of wire or electrode
(5) Type of flux
(6) Preheat temperature
(7) Welding speed, automatic and semi-automatic
(8) Welding current
(9) Welding voltage
(10) Weld size and number of passes

After the procedure has been examined, it shall not be altered except within the limits consented to by the Engineer.

The cost of supply and welding of test pieces shall be borne by the Contractor. Testing will be carried out at the Employer's expense.

Where a maximum welding residual stress is shown on the Drawings for a particular weld, the Contractor shall show that his proposed welding procedure will not induce a greater residual stress than that shown.

Notwithstanding any procedure approvals which may be given by the Engineer, the Contractor shall be responsible for fabricating the steel work in accordance with the Contract Documents, and within the specified tolerances.

(6) Welding Requirement

(a) Preparation of Material for Welding

Surfaces and edges to be welded shall be smooth, uniform and free from fins, tears, cracks and other defects which would adversely affect the quality or strength of the weld. These surfaces shall also be free from loose scale, slag, rust, grease, moisture or other material that will prevent proper welding. Mill scale that withstands vigorous wire brushing, a light film of drying oil or a thin rust inhibitive coating may remain except that all mill scale shall be removed from the surfaces on which fillet welds are to be made by submerged arc welding or by manual metal-arc welding with low hydrogen electrodes. Surfaces within fifty (50) millimetres of any weld location shall be free from any paint or other material that may prevent proper welding or produce objectionable fumes while welding.

Edges of material thicker than specified in the following list shall be trimmed if and as required to produce a satisfactory welding edge wherever a weld along the edge is to carry calculated stress:

(i) Sheared edges of material thicker than 12 mm.

(ii) Rolled edges of plates (other than Universal Mill plates) thicker than 10 mm.

(iii) Toes of angles or rolled shapes (other than Universal Beam Sections) thicker than 16 mm.

(iv) Universal Mill plates of edges of flanges of Universal Beam Sections thicker than 25 mm.

Preparation of edges shall wherever practicable be done by machine methods. Machine flame cut edges shall be substantially as smooth and regular as those produced by edge planing, and shall be left free of slag. Manual flame cutting will be permitted only where machine gas cutting is not practicable and only with the written approval of the Engineer.

Preparation of edges for butt welding of the flange plates shall be in accordance with Figures 3.1(a) and 3.1(b) in N.A.A.S.R.A. Welding Manual for Highway Bridges and any variation from these details shall be subject to the approval of the Engineer. Where butt welds are required at angled joints, the preparation of edges shall be as shown in A.W.S. D1.1-75 or as approved by the Engineer.

Edges of built-up beam and girder webs shall be cut to the prescribed camber with suitable allowance for shrinkage due to cutting and welding. However, moderate deviation from the specified camber tolerance may be corrected by a carefully supervised application of heat.

(b) Assembly

The parts to be joined by fillet welds shall be brought into as close contact as practicable and in no event shall be separated by more than two (2) millimetres. Where directed by the Engineer, the legs of fillet welds shall be increased by the amount of the separation. The parts to be joined by butt welds shall be carefully aligned. The misalignment of parts to be joined shall not exceed 10 per cent of the thickness of the thinner part joined, nor two (2) millimetres, whichever is the lesser.

In correcting misalignment in such cases, the parts shall not be drawn into a slope greater than 2 degrees (i.e., approximately 1 in 25).

Joints which are not sealed by welds throughout their length shall be sufficiently close fit to exclude water after painting. The use of joint fillers is prohibited except as specified on the Drawings or where directed by the Engineer.

Members to be welded shall be brought into correct alignment and held in position by bolts, clamps, wedges, struts and other suitable devices, or by tack welds, until welding has been completed. The

use of jigs and fixtures, where practicable, is recommended. In the design of holding devices, suitable allowance shall be made for warping and shrinkage.

Tack welds shall be subject to the same quality, procedure (including preheat) and requirements as the final welds. Tack welds shall be cleaned of all slag and shall then be fused thoroughly with the final weld. Defective, cracked or broken tack welds shall be removed before final welding.

(c) Control of Distortion and Shrinkage Stresses

In assembling and joining parts of a structure or built-up members, and in welding reinforcing parts to members, the welding procedures and sequence shall be such that distortion and shrinkage are minimized.

Before the start of welding on a member or structure, the procedures for welding sequence and distortion control shall be approved by the Engineer. The Engineer's approval of the Contractor's proposed methods of distortion control in no way relieves the Contractor of the responsibility for producing a fabrication within the stated tolerances. As far as practicable, all welds shall be deposited in a sequence that will balance the heat applied to the assembly while the welding progresses.

The direction of the general progression in welding on a member shall be from points where the parts are relatively fixed in position with respect to each other toward points where they have a greater relative freedom of movement.

Joints which are expected to have the largest shrinkage shall be welded first with as little restraint as possible.

All shop splices in each component part of a built-up member shall be made before such part is welded to other parts of the member.

Unless otherwise approved by the Engineer, manual fillet welds over one (1) metre in length shall be applied by an intermittent or back step sequence. In this case, welding shall proceed generally from the centre towards the outside edges with the welds in each run applied in the opposite direction to the general progression of the weld.

(d) Weather Conditions

Welding shall not be done when the air temperature is less than 10°C, unless the parts to be welded are preheated to a temperature warm to the hand within a distance of seventy-five (75) millimetres from the point of welding, both laterally and in advance of the welding. Welding shall not be done when the surfaces are moist, during periods of strong wind, or in showery weather unless the work and the welding operators are adequately protected.

(e) Preheating

Refer to Clause 3.9.1 - N.A.A.S.R.A. Welding Manual for Highway Bridges. The preheating requirements for this clause shall also apply to tack welds.

(7) Welding Technique

(a) General

All butt welds in any part of a member shall be completed by the Contractor and approved by the Engineer before that part is welded to any other part. Any welds made contrary to this order of work will be cause for rejection of these parts.

Suitable run-on and run-off tabs shall be used for all butt welds. The tabs shall have the same thickness and preparation as the parts to be joined and shall be to the approval of the Engineer. Each weld pass shall be terminated at least twenty (20) millimetres beyond the edges of the parts to be joined.

Root runs of butt welds shall be back-gouged by flame, grinding or other approved means to expose sound metal. The groove formed by back-gouging shall be filled with weld metal fused completely to the adjacent metal.

Before welding over previously deposited metal, the slag shall be removed and the weld and adjacent parent metal shall be brushed clean. This requirement shall apply not only to successive layers but also to successive beads and to the crater area when welding is resumed after any interruption.

Each time the arc is started, either to begin a weld or to continue a partly completed weld, the arc shall be manipulated to obtain complete fusion of the deposited weld metal with the parent metal, and with any previously deposited weld metal, before any progression of the arc along the joint.

At the completion of a weld pass, the arc shall be manipulated so as to fill the crater with sound metal.

(b) Manual Welding

The welding voltage, amperage and polarity shall be in accordance with the manufacturer's recommendations given on each container of electrodes used, unless previously approved otherwise by the Engineer.

Electrode size, arc length, voltage and amperage shall be suited to the thickness of material, type of preparation and other conditions of the work.

The maximum size of electrode for downhand position welding, excepting root runs of multiple pass welds, shall be six (6) millimetres unless the work is in the flat (natural-vee) position where eight (8) millimetre electrodes may be used. For welds made in all other positions and the root runs of multiple pass welds, the maximum size shall be five (5) millimetres.

The maximum size of fillet weld which may be made in one pass shall be eight (8) millimetres except that ten (10) millimetres fillet welds may be made in the flat (natural-vee) position subject to the approval of the Engineer.

A single layer of weld metal, whether deposited in one pass or made up of several parallel bands, shall not exceed three (3) millimetres in thickness if the position of welding and viscosity of the weld metal is such that it does not overflow on to unfused parent metal.

When welding in the vertical position the direction of welding for all passes shall be upward.

(c) Submerged Arc Welding

All transverse butt welding of flange plates and of web plates shall be carried out with the plates on the flat before flanges and webs are assembled. The positioning for the welds between the webs and the flanges shall be subject to the approval of the Engineer.

Fillet welds may be made in either the flat or horizontal-vertical positions except that single-pass fillet welds made in the horizontal-vertical position shall not exceed eight (8) millimetres.

The electrode and flux combination shall conform to the requirements of sub-clause 15.3.4(3)(b) of this Specification. The maximum size of electrode shall be six (6) millimetres.

The thickness of weld layers, except root and surface layers shall not exceed six (6) millimetres. The split layer technique shall be used in making multiple-pass welds when the width of the layer exceeds sixteen (16) millimetres.

Neither the depth of fusion nor the total width of fusion at any point in a single weld or weld pass shall exceed the width of the face of the weld or weld pass.

The welding current, arc voltage and speed of travel shall be such that each pass will have complete fusion with the adjacent parent metal and weld metal, and there will be no overlap or undercutting.

The limits within which the welding current, arc voltage and speed of travel can vary will be established as part of the procedure tests detailed in sub-clause 15.3.4(5) of this Specification. As a general guide the limits would be:-

Welding Current	+ or - 5 percent
Arc Voltage	+ or - 7 percent
Speed of Travel	+ or - 10 percent

Roots of butt welds may be sealed with a root pass made by manual shielded metal-arc welding with low hydrogen electrodes when such sealing is necessary to prevent burnthrough of the initial submerged arc welding pass.

Where practicable, run-on and run-off tabs shall be used for fillet welds as well as for all butt welds.

(d) Plug and Slot Welds

Plug welds in the downhand position may be welded without interruption if the dimensions of the plug and the conditions of welding are such that the slag covering the weld metal remains molten throughout the process. If the arc is broken, the slag shall be allowed to cool and shall be removed completely before restarting the weld.

Plug welds made in the vertical position shall be built up in layers, commencing at the lower side of the hole. The slag shall be cleaned from the weld between successive layers.

Plug welds made in the overhead position shall be laid down in layers and the slag removed between successive layers.

Slot welds may be made by techniques similar to those specified above for plug welds except that if the length of the slot exceeds three times its diameter, or, if the slot extends to the edge of the plate, the weld shall be made in layers. The slag shall be removed completely between successive layers.

(8) Appearance and Finish of Welds

Exposed faces of welds shall be made reasonably smooth and regular, shall conform as closely as practicable to specified dimensions and shall not at any place be less than the specified dimensions. The acceptance of welds with dimensions in excess of design requirements shall be at the discretion of the Engineer.

Fillet welds shall be of the type depicted as acceptable in Figure 3.3 N.A.A.S.R.A. Welding Manual for Highway Bridges.

The surface of fillet welds shall junction as smoothly as practicable with the parent metal. In no case shall the convexity exceed the values shown on Figure 3.3 N.A.A.S.R.A. Welding Manual for Highway Bridges.

Butt welds shall be of the type and details depicted as acceptable in Figures 3.2 and 3.3 N.A.A.S.R.A. Welding Manual for Highway Bridges.

Run-on and run-off tabs shall be removed after the joint has cooled and the edges of the welds shall be finished smooth and flush with the faces of the abutting parts.

Butt welds shall be finished smooth and flush with abutting surfaces where required for assembly, where specified in the Drawings, where the welds are to be x-rayed and on the exterior faces of exterior girders.

All weld spatter shall be removed from the surface of the weld and the parent metal to the satisfaction of the Engineer.

Welds with defective profiles such as those shown on Figures 4.1 to 4.8 N.A.A.S.R.A. Welding Manual for Highway Bridges will not be acceptable.

(9) Quality of Welds

There shall be thorough fusion between weld metal and base metal and between successive passes in the weld. All craters shall be filled to the full cross-section of the weld.

Welds shall be free from overlap.

Welds transverse to the longitudinal axis of a primary member shall be free from undercut. For all other welds undercut shall not exceed 2.5 millimetres.

The presence of any of the following listed defects in excess of the limits specified below will result in rejection of the weld.

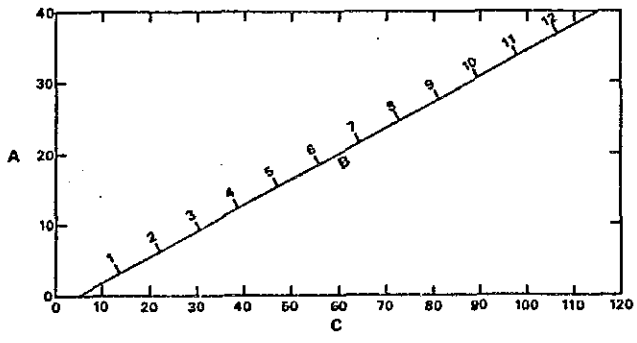
(a) Cracks. No cracking will be allowed regardless of length or location.

(b) Porosity or fusion defects less than two (2) millimetres greatest dimension may be allowed only if dispersed evenly, and provided that the sum of the greatest dimensions does not exceed ten (10) millimetres per linear twenty five (25) millimetres of weld. Porosity includes gas pockets and other similar globular type voids. Fusion defects include slag inclusions, incomplete fusion, inadequate penetration and similar defects.

(c) Porosity or fusion defects (as defined above) two (2) millimetres or larger may be allowed provided such defects are smoothly rounded and do not exceed the limits indicated on Figure No.1 below. Porosity or fusion defects with any dimension greater than twelve (12) millimetres will not be accepted.

Typical weld defects are shown on Figure 4.1 to 4.8 N.A.A.S.R.A. Welding Manual for Highway Bridges.

FIGURE NO. 1 - LIMITATIONS OF POROSITY AND FUSION TYPE DEFECTS



A: Butt weld effective throat thickness or fillet weld size (mm).

B: Dimension of defects (mm).

C: Minimum clearance measured along the longitudinal axis of the weld between edges of porosity or fusion type defects.

1. To determine the maximum size of defect permitted in any joint or weld throat thickness: Project (A) horizontally to (B).

2. To determine the minimum clearance allowed between edges of defects of any size: Project (B) vertically to (C).

Note: For joint thickness greater than forty (40) millimetres, the maximum allowable dimension and minimum spacing of porosity and fusion type defects will be the same as for forty (40) millimetre joints.

For butt welds the joint thickness shall be the lesser of T1 or T2 as shown on Figure 3.2 and 3.3 N.A.A.S.R.A. Welding Manual for Highway Bridges.

For fillet welds the joint thickness shall be the throat thickness.

(10) Corrections

Following the rejection of any defective welds, consideration may be given to corrective measures. Unless otherwise directed by the Engineer, weld defects are to be corrected in accordance with N.A.A.S.R.A. Welding Manual for Highway Bridges.

Where the approval of the Engineer is obtained, defective welds shall be corrected as specified below:

	Defect	Corrective Measure
(a)	Excess convexity	Reduce to specified size by removal of excess weld metal.
(b)	Craters, excessive porosity, slag inclusions, overlapping and lack of fusion	Remove defective portions and deposit additional weld metal.

(c)	Undercut, undersize welds, excessive concavity, removal of adjacent parent metal during welding	Clean and deposit additional weld metal.
(d)	Cracks in parent or weld metal	As directed by the Engineer.

Where the removal of part or all of the weld or a portion of the parent metal is prescribed, such removal shall be effected by gouging with flame or air-arc, grinding or other approved means.

Where corrections require the depositing of additional weld metal, the electrode used shall preferably be smaller than the electrode used in making the weld. The electrode size shall be to the approval of the Engineer.

A weld which is cracked shall be removed throughout its length, unless by the use of approved inspection methods the extent of the crack can be shown to be limited. In this case, sound weld metal fifty (50) millimetres or more beyond each end of the crack need not be removed.

In removing defective parts of a weld, the gouging shall not extend into the parent metal by a substantial amount beyond the depth of the weld penetration unless cracks or other defects exist in the parent metal. The weld or parent metal shall not be nicked or undercut in gouging.

Where work performed after making a defective weld has made the weld inaccessible or has caused new conditions which would make the correction of the deficiency hazardous, detrimental or ineffective, the original conditions shall be restored by removal of welds or members, or both, before making the necessary corrections. Alternatively the deficiency may be remedied by additional work as specified by the Engineer.

Before adding weld metal or re-welding, the surfaces to be welded shall be cleaned thoroughly.

Caulking of welds will not be permitted.

All corrective welding shall be in accordance with the requirements of this Specification.

Improperly fitted and misaligned parts may be cut apart and rewelded subject to the approval of the Engineer.

With the approval of the Engineer, members distorted by the heat of welding may be straightened by mechanical means or by the carefully supervised application of a limited amount of heat. The temperature of such heated areas shall not exceed 650°C.

(11) Inspection

(a) General

All material and workmanship shall be subject to inspection by the Engineer during and after fabrication. To enable the Engineer to arrange inspection, the Contractor shall give seven (7) days notice in writing before beginning work in the shop and no work shall be done before such period has elapsed. The Engineer shall have full liberty at all reasonable times to enter the Contractor's shop for the purpose of inspecting work.

Methods of inspection which may be used include the following:

- Visual inspections, including the use of penetrant dyes, acid etching and photography.
- Magnetic particle inspection
- Radiographic inspection
- Ultrasonic inspection

The Contractor shall lay out and arrange the individual members or units to be inspected so that identification marks on each may be readily distinguished and so that each member or unit is accessible for such inspection as the Engineer may deem necessary. The Contractor shall assist the Engineer by turning the members or parts to permit examination on all sides. The Contractor shall supply free of charge all labour, tools, scaffolding etc., required during inspection.

No work shall be dispatched from the shop until it has been inspected by the Engineer.

(b) Non-Destructive Testing

(i) Radiographic Inspection

Radiographs will be made either by x-ray or gamma ray in accordance with AS B164 and the

A.W.S. D1.1-75. The reinforcement on the weld that is to be radiographed shall be ground smooth and flush.

Details of the extent of radiographic inspection which will be undertaken are as follows:-

Location	Minimum length of weld to be radiographed (% of total length)
Tension flange splices	100%
Compression flange splices	100%
Web splices	25%
Butt welded joints between girder flanges and webs	5% (including at least 750 mm on each side of each pier diaphragm)

Where less than 100% of a weld type is inspected the Engineer will select those portions of welds to be subject to radiographic inspection.

(ii) Ultrasonic inspection shall be carried out in accordance with AS 1710 and the A.W.S. D1.1-75.

Ultrasonic inspection shall be used on Flange/web and Flange/Flange fillet welds and in any other areas directed by the Engineer.

The extent of testing shall be as indicated on Figure No.2.

Defects revealed by non-destructive tests will be compared with the standards for allowable porosity and fusion type defects set out herein. Where weld defects exceed the limits specified the weld will be rejected. If approved by the Engineer the Contractor shall carry out the corrective measure specified herein.

The Contractor shall programme his work to the satisfaction of the Engineer in order to keep visits to a minimum.

The cost of providing welding inspectors, and equipment and operators for non-destructive testing will be borne by the

Employer. Power for operation of equipment shall be supplied by the Contractor at his own expense.

After the repair of any defective weld, further non-destructive tests of the corrected weld will be made at the Contractor's expense. The cost of any further corrective measures and subsequent non-destructive testing of the weld will be borne by the Contractor.

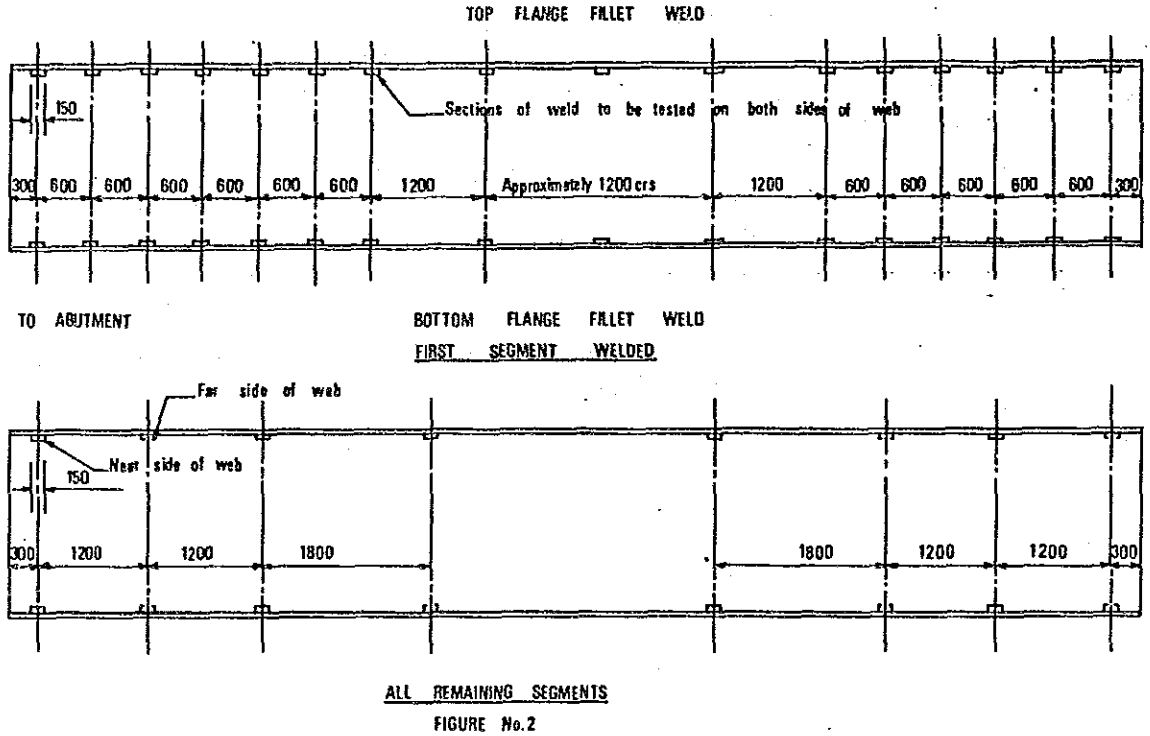


FIGURE No.2

15.3.5 Shear Connector

(1) General

Shear connectors shall be provided and welded in position as specified on the Drawings. The material for shear connectors shall be steel channel conforming to the requirements of AS 1204 Grade 250.

Should the Contractor wish to use a type of connector not shown on the Drawings he is required to seek the Engineer's consent. Full supporting calculations will be required. The Contractor shall not deviate from the Drawings without the Engineer's consent in writing.

(2) Angle, Channel or Hoop Connectors

This type of connector shall be welded in accordance with the requirements of Clause 15.3.4.

(3) Stud Connectors

(a) Definitions

"Stud base" as used herein shall be considered as the stud tip at the welding end, including flux and container, and 3 mm of the body of the stud adjacent to the tip.

The "angle of bend" in testing studs as used herein shall be measured between the original axis of the stud and a line passing through the centres of the two ends of the bent stud.

(b) General Requirements

Studs shall be of a design suitable for arc-welding to steel members with automatically timed stud welding equipment. The type, size or diameter, and length of stud shall be as specified by the Drawings, Specification, or Special Clauses as approved by the Engineer.

An arc shield (ferrule) of heat-resistant ceramic or other suitable material shall be furnished with each stud.

A suitable deoxidizing and arc stabilizing flux for welding shall be furnished with each stud.

Only studs with qualified stud bases shall be used. A stud base to be qualified, shall satisfy sub-clause 15.3.5 (3)(g) herein. The arc shield used in production shall be the same as used in the qualification test.

Finish shall be produced by cold heading, cold rolling, or machining. Finished studs shall be of uniform quality and condition, free of injurious laps, fins, seams, cracks, twists, bends, or other injurious defects. A stud with cracks or bursts deeper than one-half the distance from the periphery of the head to the shank shall be cause for rejection.

When requested by the Engineer, the Contractor shall provide the following information:

(i) A description of the stud and arc shield to be furnished.

(ii) A certification from the manufacturer that the stud base is qualified as specified in the following clause. Qualification test data shall be retained in the files of the manufacturer. Copies of the data shall be furnished on written request of the Engineer.

(c) Mechanical Requirement

Studs shall be made from cold drawn bar stock conforming to the requirements of AS 1480 Supplement No. 1 - 1974.

Tensile requirements of studs as determined by tests of bar stock after drawing, or of full diameter finished studs at the manufacturer's option, shall conform to the following:

Tensile strength (min.)	410 MPa
Elongation (min.)	20% in 50 mm
Reduction of area (min.)	50%

When the above tensile requirements are determined from finished studs, the tensile tests may be made on studs welded to test plates of Grade 250 steel. If fracture occurs outside the middle half of the gauge length, the test shall be repeated.

Upon request, the Contractor shall furnish the manufacturer's certification that the studs as delivered are in accordance with the above requirements. Certified copies of the manufacturer's test reports of the last completed set of in-plant quality control mechanical tests for the above requirements, of studs or material for the studs of the diameters to be provided, shall be furnished to the Engineer upon request. The quality control tests shall have been made not more than 6 months prior to delivery of the studs. If quality test reports are not available, the Contractor shall furnish in lieu thereof, reports of mechanical tests for the above requirements, on studs or bars for the studs of the diameters to be provided, selected form the material to be provided. The number of tests hall be as directed by the Engineer.

The Engineer may, at the Contractor's expense, select studs as necessary for checking the above requirements.

(d) Workmanship

Studs shall be welded to steel members with automatically timed stud welding equipment connected to a suitable power source.

If two or more stud welding guns are to be operated from the same power source, they shall be interlocked so that only one gun can operate at a time, and so that the power source has fully recovered from making one weld before another weld is started.

While in operation, the welding gun shall be held in position without movement until the weld metal has solidified.

At the time of welding, the studs shall be free from rust, rust pits, scale, oil or other deleterious matter that would adversely affect the welding operation.

The stud base shall not be painted, galvanized or cadmium plated prior to welding.

The areas on the member to which the studs are to be welded shall be free of scale, rust or other injurious material to the extent necessary to obtain satisfactory welds.

Welding shall not be done when the base metal temperature is below -15°C, or when the surface is wet or exposed to falling rain or snow. When the temperature of the base metal is below 0°C, one stud in each 100 studs welded shall be tested by the methods specified in sub-clause 15.3.5 (3)(f) herein as applicable in addition to the first two tested as specified in the following sub-clause.

Longitudinal and lateral spacings of studs with respect to each other and to edges of beam or girder flanges may vary a maximum of 25 mm from the location shown on the Drawings provided the adjacent studs are not closer than 65 mm centre to centre. The minimum distance from the edge of a stud base to the edge of a flange shall be the diameter of the stud plus 3 mm, but preferably not less than 40 mm.

Arc shields shall be broken free from shear connectors after welding.

The studs, after welding, shall be free from any defect or substance that would interfere with their intended function.

(e) Quality Control

The first two studs welded on each member, after being allowed to cool, shall be tested by bending to an angle of 45° by striking the stud with a hammer. If failure occurs in the weld zone of either stud, the procedure shall be corrected and two more studs shall be welded to the member and tested.

If either of the second two studs fail, additional welding shall be continued on separate material until two consecutive studs are tested and found to be satisfactory. Two consecutive studs shall then be welded to the member, tested and found to be satisfactory before any more production studs are welded to the member.

The foregoing testing shall be performed after any change in the welding procedure. If failure occurs in the stud shank, an investigation shall be made to ascertain and correct the cause before further welds are made.

Studs on which a full 360° weld fillet is not obtained may, at the option of the Contractor, be repaired by adding a 5 mm fillet weld in place of the missing weld fillet, using the shielded metal-arc process with low-hydrogen welding electrodes in accordance with the requirements of this Specification.

If the reduction in the length of studs as they are welded becomes less than normal, i.e. the length of stud is more than 1.5 mm greater than specified, welding shall be stopped immediately and not resumed until the cause has been corrected.

The areas of all components subjected to tensile stresses where a defective stud has been removed shall be made smooth and flush. Where in such areas base metal has been pulled out in the course of stud removal, a shielded metal arc welding process with low-hydrogen electrodes, in accordance with the requirements of this Specification, shall be used to fill the pockets and the weld surface ground flush. In compression areas of members where stud failures are confined to shanks of studs or fusion zones of studs, a new stud may be welded adjacent to the defective area in lieu of repair and replacement on existing weld area. If metal is pulled from the base metal of such areas, the repair provisions shall be the same as for tensile areas except that, when the depth of the defect is not more than the lesser of 3 mm or 7% of the base metal thickness, the defect may be faired by grinding in lieu of filling the defective area with weld metal. Where a replacement stud is to be placed in the defective area, the above repair shall be made prior to welding the replacement stud. Replacement studs shall be tested by bending to an angle of 15°. The areas of components exposed to view in completed structures shall be made smooth and flush where a stud has been removed.

(f) Inspection Requirement

If visual inspection reveals any stud that does not show a full 360° weld fillet, any stud that has been repaired by welding, or any stud in which the reduction in length due to welding is less than normal, such stud shall be struck with a hammer and bent to an angle of 15°. For studs showing less

than 360° weld fillet, the direction of bending shall be opposite to the missing weld fillet.

Studs that crack either in the weld, the base metal, or the shank under inspection or subsequent straightening shall be replaced.

The Engineer, where conditions warrant, may select a reasonable number of additional studs to be subjected to the tests specified above.

The bent stud shear connectors that show no sign of failure shall be left in the bent position if no portion of the stud is less than 25 mm from a proposed concrete surface. All required bending and straightening shall be done without heating before completion of the stud welding operation on the job, except as otherwise provided.

If during the progress of the work, inspection and testing indicates in the judgement of the Engineer that the stud welds being produced are not in accordance with this Specification, the Contractor will be required at his expense to make changes (such as welding procedure, welding equipment and stud base) necessary to secure satisfactory results on studs to be subsequently welded.

At the option and the expense of the Employer, the Contractor may be required at any time to submit studs of the types used under the Contract for check qualification in accordance with the procedures of the following clause.

(g) Stud Base Qualification Procedure

(i) General

The purpose of these requirements is to prescribe tests for manufacturer's certification of a stud base for welding under shop or field conditions.

The manufacturer shall be responsible for the performance of the qualification tests. These tests shall be performed by a registered N.A.T.A. laboratory or other laboratory approved by the Engineer, who shall submit a certified report to the manufacturer of the stud, listing procedures and results for all tests.

Qualification of a stud base shall constitute qualification of stud bases with the same geometry, material, flux and arc shield, of the same diameter and down to, but not including 3 mm smaller nominal diameters.

A size of stud base with arc shield, once qualified, is considered qualified until the manufacturer makes any change in the stud base geometry, material, flux, or arc shield which affects the welding characteristics.

Test specimens shall be prepared by welding representative studs to suitable specimen plates of Grade 250 steel. The studs shall be welded with power source, welding gun, and automatically controlled equipment as recommended by the manufacturer. Welding voltage, current and time shall be measured for each specimen. Lift and plunge shall be at the optimum setting as recommended by the manufacturer.

Thirty test specimens shall be welded consecutively with constant optimum time but with current 10% below optimum.

Qualification of stud bases shall be at the Contractor's expense.

(ii) Tensile Test

Ten of the specimens from each set as defined above shall be subjected to a tensile test. A stud base shall be considered as qualified if all test specimens have a tensile strength equal to or greater than the minimum specified herein.

(iii) Bend Test

The remaining twenty specimens from each set shall be bend tested by being bent alternatively 30° in opposite directions until failure occurs. A stud base shall be considered as qualified if, on all test specimens, fracture occurs in the shank of the stud or plate material, and not in the weld or heat affected zone.

If failure occurs in a weld or heat affected zone in any of the bend test groups, or at less than the specified

minimum tensile strength of the stud in any of the tensile test groups, a new test group as specified above, as applicable shall be made up and retested. If such failure repeats, the stud base shall fail to qualify.

(iv) Acceptance

For a manufacturer's stud base and arc shield combination to be qualified, each stud of each group of thirty studs shall, by test or retest, meet the requirements prescribed above. Qualification of a given diameter of stud base shall be considered qualification for stud bases of the same nominal diameter, stud base geometry, material, flux and arc shield.

(v) Manufacturer's Qualification Test Data

The data shall include the followings:

Drawings that show shapes and dimensions with tolerances of studs, arc shields, and, where used, of sheet flux.

A complete description of materials used in the studs, including the quantity and analysis of the flux, and a description of the arc shields. Certified results of laboratory tests required by this section.

15.3.6 Holes for Bolts

(1) General

All holes shall be drilled. Punching of holes shall not be permitted. Reamed and fitted holes shall be sub-drilled 3 mm less in diameter than that of the finished holes and reamed to size.

Reamed and fitted holes and drilled holes shall be made through steel templates or after assembly or by other approved means, to ensure complete matching between the plys of the joints.

All steel templates shall have hardened steel bushings in holes accurately dimensioned from the centre lines of the connection. The centre lines

shall be used to accurately locate the template.

Reaming or drilling full-size holes for field connections through templates shall be done after the templates have been located with the utmost care as to position and angle, and firmly bolted. Templates used for the reaming of holes in matching members, or of opposite faces of one member, shall be exact duplicates. Templates for connections which duplicate shall be so accurately located that like members are duplicates.

All finished holes shall be cylindrical and perpendicular to the member unless otherwise specified. All burrs and other defects shall be removed.

(2) Sizes

The diameter of the completed hole shall be 2 mm larger than the nominal diameter of the bolt unless otherwise specified except that for the inner plies of a structural connection fastened by high-strength bolts the diameter of the hole shall not be larger than 3 mm larger than the nominal diameter of the bolt.

(3) Alignment

All matching holes shall register with each other so that a gauge or drift 2 mm less in diameter than the holes shall pass freely through the assembled contact faces at right angles to them.

(4) Finishing

Burrs, fins and other defects shall be removed. Drifting to align holes shall be done in a manner that will not distort the metal or enlarge the hole.

15.3.7 Marking for Final Assembly

Each part shall be carefully marked to facilitate final erection. Such marking shall be durable but shall not injure the material. Such marks shall not be injured, defaced or removed by any person. The marking of components shall be in accordance with that shown on the workshop drawings submitted.

15.4 Trial Assembly

15.4.1 General

All the Work shall be trial assembled at the shop or other location approved by the Engineer prior to dispatch to the Site. The components shall be assembled

together into such parts of the whole at any one time as the Engineer shall order. In general minimum assemblies shall be as follows:

Simply supported beams	:	A complete beam.
Continuous beams	:	Not less than 1½ spans of beam at any one time.
Cross girders	:	Each complete cross girder together with connecting parts of main beams.
Trusses	:	Complete trusses.
Floor system bracing and other parts and other parts	:	As the Engineer shall direct.

However, nothing in the above schedule shall imply that the whole of the steelwork shall not be shop assembled in consecutive stages and that all joints shall not be trial assembled.

All components shall be match marked prior to dispatch so that they may be reassembled in the same position. The parts shall not be interchanged. Diagrams showing such match marks shall be furnished to the Engineer prior to dispatch.

All bolts used in the trial assembly shall be of the same size as those to be used in the final assembly.

All trial assemblies shall be fitted in the presence of the Engineer.

15.4.2 Acceptance

Notwithstanding any prior inspection and approval of the work, any material or finished work found to be defective shall be rejected.

Rejected material or work shall be promptly replaced or made good by the Contractor at his own expense, to the satisfaction of the Engineer.

Acceptance of a trial assembly by the Engineer in no way relieves the Contractor of the responsibility to ensure that the final assembly is within tolerance and true to line, level and position.

15.5 Tolerances

All fabrication shall be executed accurately to the shapes and dimensions shown on the Drawings, and, unless otherwise indicated on the Drawings, shall be within the tolerances listed below. Where, in the opinion of the Engineer, there is evidence that the application of the following tolerances would adversely affect the serviceability of the structure, the Engineer shall have the right to reduce the tolerances.

Unless otherwise specified, the following tolerances shall apply:-

(1) General

The tolerance on all structural dimensions shall be plus 2 mm, minus 2 mm.

(2) Straightening

A structural member before erection shall not deviate from straightness or the specified configuration by more than the following:

Struts	:	1/1000 of the length
Tubes	:	1/600 of the length
Plates	:	1/200 of the lesser dimension of the plate panel
Other members	:	1/500 of the length

(3) The length of member shall not deviate from the specified length by more than the followings:

For lengths 9 metres and under	:	+ 0 -3 mm
For lengths over 9 metres	:	+ 0 -5 mm

(4) Twist

The twist of a member shall not be greater than the following:

Box girders and heavy columns	:	1/1500 of the length
Other members	:	1/1000 of the length

(5) Camber

The camber of a member shall not deviate from that specified by more than plus 3 mm minus 3 mm when measured fully supported and unloaded.

(6) Squareness of Ends

The deviation from squareness of ends (other than butt joints in compression) shall not exceed the following:

Members 800 mm deep and less	:	1 mm
Members over 800 mm deep	:	1 mm per 800 mm of depth to a maximum of 2 mm

(7) Butt Joint in Compression

Over at least 60 per cent of the bearing surfaces, the clearance between the surfaces shall not exceed 0.25 mm.

Over the remainder of the surface, the measurable gap between the surfaces shall not exceed 0.50 mm.

Web Stiffeners in bearing with flanges shall have positive contact over not less than half their bearing area. The remainder of the contact face shall not have a gap exceeding 0.25 mm.

The deviation from squareness of ends of members in compression shall not exceed 1 mm.

The abutting ends of two members in compression shall be aligned to within 1/1000 of their combined length.

(8) Deviation of Web from Flange Centreline

The maximum deviation of the centreline of the web from the flange centreline in built up members shall not exceed 6 mm.

(9) Depth of Built up Members

The tolerance on the overall depth of a built up members shall not exceed the following:

Depth 900 mmm and less	:	± 3 mm
Depth over 900 mm up to 1800 mm	:	± 5 mm
Depths over 1800	:	+ 8 mm - 5 mm

(10) Flatness of Web Plate

The deviation from flatness of girder web plates shall not exceed 1/200 of the lesser dimension of the web panel.

(11) Tilt and Warp of Flange Plate

The maximum combined warpage and tilt on the flanges of built up members shall not exceed 1/200 of the total width of the flange or 3 mm whichever is the greater.

Tolerances shall be measured and applied in accordance with Standards Association of Australia MA1.8 Section 8.4.

15.6 Inspection and Testing

The Contractor shall advise the Department of Works with his tender whether work specified under this Clause is to be carried out in Papua New Guinea or beyond.

If the work is to be carried out beyond Papua New Guinea, the Employer will engage an approved Testing and/or Inspecting Authority to carry out the supervision on behalf of the Engineer.

If the work specified is to be carried out in Papua New Guinea, the Contractor will be advised whether the supervision shall be carried out by the Engineer or by a Testing and/or Inspecting Authority appointed by the Engineer.

The Contractor shall allow the Engineer access to all areas in which work on the Contract is being carried out, and to all materials, plant and fabrications connected with the work, at all reasonable times.

The Contractor shall programme his work to the satisfaction of the Engineer in order to keep visits to a minimum.

The Contractor shall lay out and arrange the individual members or units to be inspected so that each member or unit is accessible for such inspection as the Engineer may deem necessary.

The Contractor shall assist the Engineer by turning the members of parts to permit examination on all sides. The Contractor shall supply free of charge all labour and tools required during inspection.

15.7 Delivery to Site

All materials shall be delivered to the Site at such time or times as they are required for incorporation in the Works. Bolts and small or loose pieces shall be bagged and close crated. Bolts, nuts and washers shall be separately bundled for each size and each bundle clearly marked with the size and purpose of the bolts. The batch number of each bag of bolts shall be clearly marked to facilitate reference to the test certificates.

During delivery all component materials shall be adequately protected from damage and the Contractor shall be responsible for any damage which may occur. In particular, the Contractor shall adequately strut the bottom flange of plate girders.

All straps and chains used in lifting shall be adequately padded to prevent damage to the steelwork and its protective coating.

No fabricated steel shall leave the Contractor's works without being inspected and passed by the Engineer at the place of fabrication or be placed in the Work without being inspected and passed by the Engineer after delivery.

15.8 Erection of Structural Steelwork

15.8.1 Erection Procedures

(1) General

The Contractor's attention is drawn to the requirements of Clause 1.19 of this Specification regarding the requirement for the Engineer's consent to the use of Contractor's erection proposals.

Prior to girder installation and tightening of splice bolts to the required tension, the Contractor shall assemble the girder to the camber shown on the Drawings for the approval of the Engineer. This shall be accomplished by tightening all splice bolts to an equal tension just sufficient to permit the girder to support its own weight for the full girder span length. After the camber introduced in the girder has been accepted by the Engineer, the Contractor shall immediately tighten all splice bolts to their required tension.

(2) Launching of Superstructure

Outline details of a suggested lauching procedure for Bridges No. 6 and No. 7 are shown on the Drawings. The Contractor shall however design the Temporary Works for the lauching of Bridges No. 6 and No. 7 based on his proposed method of working. Pursuant to Clause 8.2 of the Conditions of Contract, the design of these Temporary Works is the Contractor's responsibility, and the outline details shown on the Drawings are not "Temporary Works prepared by the Engineer".

At least ten (10) weeks before he intends to launch the superstructure the Contractor shall provide full calculation and detailed drawings for his

intended procedure. The calculation for stability and member stresses shall be in accordance with N.A.A.S.R.A Bridge Design Specification.

The drawings shall show all temporary works necessary for the launching including bearings, supports and incidentals, and include full method statements for each stage of the launch.

Launching shall not commence until the Engineer has indicated that he has no further comments on the Contractor's proposals.

15.8.2 Additional Members

Additional members and attachments used to facilitate erection shall be accepted by the Engineer and affixed in a manner which does not weaken permanent steelwork. Welded outstands and attachments to assist the erection will be permitted providing that in the opinion of the Engineer such attachments neither adversely affect the serviceability nor mar the final appearance of the structure. In general, such attachments will not be permitted on the outside face of the structure or in parts of high stress. They shall be removed from the structure after erection and any holes sealed against corrosion to the Engineer's satisfaction.

Tack welds will not be permitted across members or parts which will carry tension in the structure's working conditions.

Any tack welds used in the erection of the structure shall be ground flush after removal of the affixed parts.

15.8.3 Storing of Steelwork

Steelwork shall be stored on timber bearers, clear of the ground and in such a way as to permit checking and to avoid excessive handling and damage to the steelwork or its protective coating.

15.8.4 Straightening of Bent Members

Any member bent out of the fabricated shape, shall be straightened by methods which will not cause fractures, injury or excessive residual stresses. The steelwork shall not be heated unless otherwise approved by the Engineer and if so approved the Contractor shall make good at his own expense any damage caused to the steelwork or its protective coating by such heating. The temperature of such heated areas shall not exceed 650°C.

The Engineer's approval shall be obtained prior to commencing straightening of any bent members.

15.8.5 Preparation of Contact Surface

Unless otherwise directed by the Engineer, all surfaces to be brought together to form a joint or splice shall be free of paint or any other applied finish, oil, dirt, loose rust, loose scale, burrs and other defects which would prevent solid seating of the parts or would interfere with the development of friction between them.

15.8.6 Assembly

Steelwork shall be placed and assembled in accordance with the Drawings and the approved method; all match marks shall be followed.

Each joint shall be bolted up with service bolts and parallel drifts so that the various sections and plates are in close contact throughout. Service bolts shall not remain in the completed structure.

Drifts shall be parallel barrel drifts. The barrels shall be drawn or machined to a diameter equal to the full diameter of the hole subject to a tolerance of + 0 to - 0.13 mm. The length of the barrels shall not be less than the combined thickness of the material, plus one diameter. The ends of the drift, for a length of 1.5 barrel diameters, shall be tapered down to an end diameter equal to half the barrel diameter. Heavy drifting that would distort the holes shall not be carried out.

High tensile bolts shall be assembled with one hardened washer under the turned element (nut or bolt head). The washer shall be assembled with any convexity outwards. The inserting and tensioning of the high tensile bolts shall be so arranged that the close contact established by the service bolts is maintained at all times. The tensioning of high tensile bolts shall not commence until the joint has been inspected by the Engineer.

The slope of surfaces of bolted parts in contact with the bolt head and nut shall not exceed 1:20 (2°51') with respect to a plane normal to the bolt axis; in cases where the shape of the member is such that this slope is exceeded, taper washers shall be used.

15.8.7 High Strength Friction Grip Bolts

(1) Supply

High Strength Friction Grip (H.S.F.G.) bolts shall comply with the requirements of AS 1252. The Contractor shall supply test certificates for each batch of bolts at least one month before they are to be used.

(2) Tightening

(a) H.S.F.G bolts shall be brought to the required tension by the "Torque-control Method" as described in AS 1511. The "Part-turn" method shall not be used.

(b) H.S.F.G bolts may be tightened using hand or mechanically operated wrenches. Hand wrenches shall be of an approved type, which will indicate when the specified torque is reached. Mechanical wrenches shall be of an approved type which will stall or slip when the tension or specified torque is attained. Wrenches shall be calibrated in the presence of the Engineer before the work of tightening bolts commences and recalibrated at least once every five working days for the duration of such work. The Engineer may also direct that any wrench be recalibrated during the course of the work, to ensure correct tension at all times.

(c) The appropriate torque for each size and batch of bolts shall be determined by the Contractor using a load cell as directed by AS 1511. The Contractor shall supply the Engineer with six bolts from each batch for testing. The supply of these bolts will be deemed to be included in the item for "Supply, fabrication, shop painting and delivery to site" of structural steelwork.

(d) Bolts shall protrude beyond the nuts by not less than two (2) millimetres and not more than ten (10) millimetres.

(3) Air Impact Wrenches

(a) General

Where air impact wrenches are used, they shall be of a suitable size. Where the use of an extension bar is necessary, it must be a part manufactured specifically for the wrench. The wrench shall be supplied with compressed air from a compressor capable of developing seven hundred kilopascals (700 kPa) line pressure, and of maintaining six hundred and fifty kilopascals (650 kPa) under all loading conditions. The layout and sizes of supply lines, shall be determined to give a suitable air pressure to each wrench; where the work is far distant from the compressor, extra receiver tanks may be needed to cut down surge, moisture, etc.

An air regulator reducing valve shall be inserted within ten (10) metres of the air wrench, in the hose connecting the wrench to the supply line. The regulator, connecting hose and wrench shall be tested and calibrated as a unit.

(b) Tightening with Impact Wrenches

The wrench shall be held in a position normal to the plane of the washer wherever possible and the operator shall assume a suitable position to apply normal operation pressure. Adequate staging shall be provided for this purpose. Where it is impossible to hold the wrench in a position normal to the washer and "gooseneck" or other extensions are employed, the unit shall be recalibrated to test the effect of the extension.

(c) Calibration of Wrenches

Each wrench shall be calibrated at intervals not exceeding five (5) working days to ensure that it applies the correct tension to the bolt size for which it shall be reserved. The contractor shall be responsible for this calibration, and shall appoint a competent person to see that wrenches are properly calibrated at all times by the following procedure:

The impact wrench shall be supplied with air at six hundred and twenty kilopascals (620 kPa) through its own hose and reducing valve and applied in the correct manner to the nut of a bolt, with washers inserted in a hydraulic load measuring capsule. The reducing valve shall be gradually opened until the wrench "stalls" with the hydraulic capsule carrying the load specified for calibration. The wrench shall now be considered to be calibrated and the date of calibration shall be recorded. The air regulating valve handle shall be removed, or the spindle secured by a lock nut or other means to ensure that the setting is not altered by any person or by any accident.

The Contractor shall remain responsible for the accuracy of all wrenches. If at any time the length of the connecting hose is changed, or a different size of bolt has to be tightened, or the wrench itself is changed, a fresh calibration shall be made before the wrench is used for tightening.

Hand or mechanically operated torque wrenches, having inbuilt torque registering devices shall be checked against the hydraulic load measuring capsule and shall achieve the calibration load at the required torque reading.

15.8.8 Erection of Steel Handrailing

Hand rails shall be packed up on level packs and all adjustments necessary to the leveling bolts made before mortaring up.

Posts shall be vertical and the rails shall form a straight line between their ends. End panels shall be set first and used as a datum for the erection of the remainder of the handrails. Rails shall be set to a tolerance of ± 3 mm vertically and horizontally.

15.8.9 Site Welding

Unless shown on the Drawings, site welding will not normally be permitted except for butt welding of piles. If the Engineer permits site welding, it will be restricted to minor joints and the requirements of Clause 15.3.4 shall apply.

Welding procedure trials and operator qualification trials shall be carried out under site conditions using the plant to be used on the Site.

15.8.10 Accuracy of Assembly

Steelwork shall be assembled on blocks and wedges accurately to line, level and camber as shown on the Drawings.

15.8.11 Misfits

Misfits of holes shall be corrected by means of parallel barrel drifts and parallel shank reamers having diameters equal to the full diameters of the bolts.

If any errors in fabrication are found, which cannot be corrected by light reaming, the circumstances shall be reported to the Engineer and his approval shall be sought for the proposed method of correction. Heavy drifting which would distort the metal around the bolt holes is prohibited.

15.9 Measurement and Payment

The items for "Structural Steelwork, supply, fabrication, shop painting and delivery to the Site" and "Erection" shall be measured for payment as the weight of steel permanently remaining in the structure. The unit will normally be the tonne. This item shall include all bolts, nuts and washers other than holding down bolts where they are measured separately, but exclude bearings which shall be measured separately.

The scheduled rate shall include full compensation for all materials, tools, labour, equipment and incidentals necessary to satisfactorily complete the steelwork, including launching, erection and removal of all falsework; all sealing operations; protective coatings; mastic fillers where necessary; and all other incidental

construction items not otherwise covered as a separate scheduled item, all as specified in the Contract Documents and as directed by the Engineer.

GROUP 16

PROTECTION OF STEELWORK

GROUP 16

PROTECTION OF STEELWORK

16.1 Shop Painting

16.1.1 Surface Preparation

After dismantling subsequent to satisfactory trial assembly, all grease, oil and foreign matter shall be removed from the surfaces of all steelwork by washing with solvent in conformity with the requirements of AS 1627 Part 1. The surface of steelwork, excepting as otherwise provided, shall be prepared as specified for Class 3 surface preparation in accordance with AS 1627 Part 4. Other methods of surface preparation may be approved by the Engineer, however, if so approved they shall be carried out in accordance with the relevant Australian Standard.

16.1.2 Prime Coat

A prime coat as specified in Clause 16.9 shall be applied to all bridge steelwork surfaces, except those specified in Clause 16.1.3, within three hours of abrasive blast cleaning. Should any steelwork surface become contaminated by oil, grease, dirt, dust or water prior to application of the prime coat, it shall be re-prepared in accordance with Clause 16.1.1. The prime coat shall be applied in an enclosed workshop.

16.1.3 Surfaces not to be Painted

(a) Unless a primer with approved friction grip properties is used, surfaces to be brought into contact in friction grip joints shall not be prime coated. However, where the interfaces of High Strength Friction Grip (HSFG) bolted joints are bare steel, the prime coat shall be applied 20 mm inside the perimeter of the joint area. HSFG bolted joint interfaces shall not receive further top coats of paint.

(b) Surfaces of steel to be in contact with, or embedded in concrete shall not be painted;

(c) Surfaces to which bearings are to be bonded shall not be painted;

(d) Such surfaces as described in (a), (b), (c) above shall be treated by an approved process in order that they may be protected from excessive

deterioration during transport and/or storage before erection. Prior to or during erection these surfaces shall be prepared in the manner prescribed in the appropriate section of the Specification.

(e) Galvanized surfaces of handrails, impact angles, movement joint cover plates and tee sections shall not be painted.

16.2 Galvanizing

Steelwork to be galvanized as indicated on the Drawings or in the Specification shall be prepared in accordance with Clause 16.1.1, except that blast cleaning shall be Class 2.1/2 and hot dip galvanized in accordance with AS 1650.

The Engineer may order any test of the coating to be carried out in accordance with AS K53.

Where galvanized bolts or fasteners are indicated on the Drawings, they shall conform to AS 1214.

16.3 Site Painting of Steelwork

16.3.1 Preparation

Site painting of steelwork shall not be commenced until concreting of the deck has been completed and the formwork stripped and removed clear of the area to be painted.

Surfaces that will be in contact with concrete shall not be painted. Existing concrete work shall be protected from paint splashes and drips during painting of adjacent steelwork. Any paint on concrete shall be cleaned off to the satisfaction of the Engineer.

All field joints and any damage occurring to the shop coat(s) during construction shall be made good prior to site painting being commenced.

Bolts, nuts and washers which have not been previously prime coated or protected by a metal coating shall be treated as specified in Clause 16.1.1 except Class 3 surface preparation in accordance with AS 1627.2 may be substituted for AS 1627.4

Surfaces prior to painting shall be prepared strictly in accordance with the paint manufacturer's instructions.

16.3.2 Painting

The protective system to be applied to all exposed surfaces shall be as specified in Clause 16.9 All products shall be applied strictly in accordance with the manufacturer's instructions and recommendations.

16.3.3 Application of Paint

Surfaces to be painted shall be thoroughly dry and free from oil, grease and dust or other deleterious substances.

Paint shall not be applied in wet, or dusty weather or in other unsuitable weather conditions unless precautions, approved by the Engineer, are taken to exclude the effects of such weather from the work.

The paint (including sprayed paint if directed by the Engineer) shall be vigorously brushed into the surface around rivet and bolt heads, nuts and washers, and into all corners, joints of plates etc., and crevices, and then lightly and evenly smoothed out. Any recesses which could contain or entrap water or debris, or through which water might be able to percolate, shall be filled with thick paint or, if so directed by the Engineer, with a waterproofing compound before completion of the final coating.

As soon as the first coat has dried an extra stripe of paint, in a contrasting shade, shall be applied by brush to all edges, corners, crevices, exposed parts of bolts and welds.

16.4 Transport and Storage of Paint

Paint shall be stored in sealed containers at a temperature between 4°C and 33°C. Any special transport and storage conditions recommended by the paint manufacturer shall be observed.

Paint which has not been used within its "shelf life" or within 12 months from the date of maufacture, whichever is the lesser, shall be replaced. At the end of each working day paint from painter's kettles and the like shall be returned to the store and kept in sealed containers which shall have not more than 10 per cent ullage.

16.5 Storage of Steel and Fabricated Steelwork

The Contractor shall take all necessary precautions to minimise exposure of steel awaiting fabrication, to chemical pollution.

Fabricated steelwork stored awaiting delivery to site or erection shall be kept clear of the ground and shall be laid or stacked so as to prevent water or dirt accumulating on or against the surfaces.

Packing shall be placed between layers of stacked steelwork. Where a cover is provided it shall be sufficiently ventilated to keep condensation to a minimum.

16.6 Repairs to Damaged Surfaces

Areas of paint which have been damaged shall be cleaned back to bare metal and the edges of the undamaged paint bevelled. The damaged areas and the existing paint within 50 mm of the affected part shall be coated with Epoxy Polyamine Paint or similar quality paint acceptable to the Engineer, to achieve a dry film thickness of 60 microns. First and second coats of the painting system shall then be applied to the damaged areas as required to provide the same protective coating as applied to the adjacent undamaged sections. Each coating of paint shall overlap the existing paint by at least 50 mm.

16.7 Welded Joints

Unless otherwise described on the Drawings or in the Specification, the weld and surfaces affected by welding shall receive the same protection which is applied to the parent surfaces.

16.8 Surface Preparation and Painting of Completed Joints

Where the interfaces of HSFG bolted joints are bare steel the surfaces of the parent and joint material shall be prepared, together with exposed parts of bolts, nuts, washers, load indicating devices and welds, and painted as specified within 10 days of the joints having been made and accepted by the Engineer.

16.9 Protective System

The protective paint system to steelwork for bridge beams, cross beams, bracing, seismic restraint and connection bracket shall be as follows or similar quality paint acceptable to the Engineer:

(i) Prime coat

Pretreatment: "Inorganic Zinc Rich Paint" applied to achieve a total minimum dry film thickness of 75 microns.

Prime coat: "Epoxy Polyamine Paint" applied to achieve a total minimum dry film thickness of 60 microns.

(ii) 1st Coat: "Micaceous Iron Oxide Epoxy Polyamine Paint" applied to a total minimum dry film thickness of 50 microns.

(iii) 2nd Coat: "Epoxy Polyamine Paint" applied to a total minimum dry film thickness of 30 microns.

(iv) 3rd Coat: "Polyurethan Paint" applied to a total minimum dry film thickness of 30 microns.

16.10 Measurement and Payment

The rate for "Supply, fabrication, shop painting and delivery to the Site" of Group 15, structural steelwork in the Bill of Quantities, will be deemed to include shop painting.

The unit for measurement of site painting of Clause 16.3 shall be in square meter of the actual painted area as shown on the Drawings or as directed by the Engineer.

Payment shall be made at the scheduled rate per square meter in the Bill of Quantities, which the rate of site painting shall constitute full compensation for the cost of all labour, tools, equipment and materials including furnishing, transporting, coating the paint, temporary access for the painter and other items necessary to complete the work.

GROUP 17

MISCELLANEOUS BRIDGEWORK ITEM

GROUP 17

MISCELLANEOUS BRIDGEWORK ITEM

17.1 Proprietary Products

Where proprietary products are specified by name on the Drawings it implies a standard and is in no way intended to preclude the use of an alternative approved by the Engineer. The product shall be used in accordance with the manufacturer's instructions. Where such instructions are in conflict with the Drawings or Specification the Contractor shall draw the Engineer's attention to the inconsistency and await the Engineer's directions.

17.2 Bearings

Bearings of steel girders shall be a pot bearing conforming to the requirements of Japan Bridge Bearing Association and shall be specified on the Drawings.

The Contractor shall inform the Engineer at least four weeks in advance of the manufacture of the bearings and shall submit the specification and test certificates.

The Contractor shall submit the detailed installation method and procedure of bearings and concrete works around bearings for the Engineer's approval. The bearings shall be a fixed type bearing and a movable type bearing as shown on the Drawings. The types, dimensions, design conditions and materials shall be specified in the Drawings.

The Contractor shall supply and fit all bearings in the positions as shown on the Drawings. Bearings shall be set when the ambient temperature is approximately equal to the mean temperature of 26.1°C in the Project area.

Bearings shall be accurately aligned, levelled in approved non-shrinkage cement sand grout and anchored to the abutments and/or piers with holding down bolts as shown on the Drawings and to the satisfaction of the Engineer.

Painting for these bearing surfaces shall be carried out in accordance with Group 16 of this Specification. The protective system shall conform to Specification Clause 16.9.

17.3 Impact Angles

Trafficked concrete edges at deck level shall be protected by steel angel sections as specified on the Drawings.

Care shall be taken in placing concrete adjacent to the impact angles to ensure that it is sound, without air pockets and is properly worked into corners and/or below the legs of the angles.

Angle sections of the impact angles shall be Grade 250 conforming to the requirements of AS 1204.

Impact angles excluding anchors shall be hot dip galvanized in accordance with Clause 16.2 of this Specification with a minimum coating of 600 grams per square metre. Galvanizing shall satisfy any test ordered in accordance with AS K53.

17.4 Seismic Restraints

Seismic restraints shall include plates, plate stiffners, anchor bolts, anchor plates, bolts with cotter pins, ancillary steelwork and the like as specified on the Drawings. Steel plates shall be Grade 250 conforming to the requirement of AS 1204. Seismic restraints shall be hot dip galvanized in accordance with Clause 16.2 of this Specification with a minimum coating of 600 grams per square metre.

Anchor plates and anchor bolts shall be installed and fixed in position as shown on the Drawings. The restraints shall not be cast in until after the superstructure has been landed on its permanent support.

17.5 Scuppers

Scuppers shall be constructed in the positions and in intervals and to the details shown on the Drawings. The scupper pipes of 80 mm diameter shall be unplasticised polyvinyl chloride conforming to the requirements of AS 1260. Outlets shall be arranged so as not to stain exposed surface with water discharged.

17.6 Handrails

Handrails shall include unequal angles, rectangular hollow sections, bolts, steel plates and holding down bolts which are Grade 250 conforming to the requirements of AS 1204.

Handrails shall be hot dip galvanized in accordance with Clause 16.2 of this Specification with a minimum coating of 600 grams per square metre. Galvanizing shall satisfy any test ordered in accordance with AS K53.

Posts shall be installed vertically in position by fixing the bottom plate with the holding down bolts and the

unequal angels shall be bolted with the post as shown on the Drawings. The erection of hand rails shall be made in accordance with Clause 15.8.8 of this Specification.

17.7 Measurement and Payment

(1) The measurement and payment for bearings shall be by number. Payment shall include full compensation for the supply of all materials, testing, painting, labour, equipment and incidentals necessary to install and fix the bearings. Separate payment will not be made for forming pockets, installation of holding down bolts and subsequent grouting.

(2) Impact angles shall be measured in linear metres. Payment shall include full compensation for supply of all materials, labour, equipment and other incidentals to complete the work. The cost of anchors, and drilling of holes and grout shall be included in the scheduled rate per metre.

(3) Seismic restraints shall be measured by number installed at the abutments and the piers respectively, stated in the Bill of Quantities. Payment shall include full compensation for the supply of all materials, testing, labour, equipment and incidentals necessary to install the items in accordance with the Specification. Separate payment will not be made for forming pockets and subsequent grouting.

(4) Scuppers shall be measured in linear metres. Payment shall include full compensation of material, labour, tools and other incidentals to complete the work.

(5) The measurement and payment for handrails shall be made in linear metres. Payment shall include full compensation for the supply of all materials, labour, equipment, tools and other incidentals to complete the work.

GROUP 18

RIVER TRAINING, BANK PROTECTION, GABIONS AND RENO MATTRESSES

GROUP 18

RIVER TRAINING, BANK PROTECTION, GABIONS AND RENO MATTRESSES

18.1 Gabions and Reno Mattresses

18.1.1 General

The requirements as set out below for Gabions shall also apply to Reno Mattresses.

The gabions shall be flexible galvanized wire boxes of the sizes stated in the Drawings and in this Specification fabricated of wire mesh of the type and size, and selvedged as specified below. Each gabion shall be divided by diaphragms into cells whose length shall not be greater than the width of the gabion plus 100 millimetres, except in the case of 1.5 metres long by 1 metre wide gabions which have no diaphragm, 2.5 metres long by 1 metre wide gabions which shall have one central diaphragm, and reno mattresses where the diaphragms shall have a maximum spacing of 600 mm.

18.1.2 Wire

All wire used in fabrication of the gabions and in the wiring operation during construction shall conform to B.S. 1052-1942, having a tensile strength of not less than 350 MPa.

18.1.3 Galvanizing

All wire used in the fabrication of the gabions and in the wiring operations during construction shall be galvanized to B.S. 443-1969, and the minimum weight of the zinc coating shall be according to the figures shown in the table below:

Diameter of Wire Millimetres	Weight of Coating grams per sq. metre
3.90	290
3.40	270
3.00	270
2.70	260
2.40	260
2.20	240
2.00	240

The adhesion of the zinc coating to the wire shall be such that when the wire is wrapped six turns around a mandrel of 4 times the diameter of the wire, it shall not flake nor crack to such an extent that any zinc can be removed by rubbing with the bare fingers.

18.1.4 Mesh

The mesh shall be hexagonal woven mesh wherein the joints are formed by twisting each pair of wires through three half turns. The diameter of the wire shall be as specified.

The undisturbed size of the mesh shall be 80 millimetres by 100 millimetres, the shorter dimension being taken from centre to centre of the twisted joins and the longer dimension, which is normal, being to the ends of the twisted joins. The tightness of the twisted joins shall be such that a force of not less than 1.75 kN pulling on one wire is required to separate it from the other wire when each wire is prevented from turning and the wires and the applied force are all in the same plane.

The wire mesh shall have elastic properties sufficient to permit elongation of the mesh equivalent to a minimum of 10% of the length of the section of mesh under test without reducing the gauge or tensile strength of individual wire strands to values less than those for a similar wire one gauge smaller in diameter.

18.1.5 Selvedges

All edges of the gabions, diaphragms and end-panels except as stated in Clause 18.1.6 shall be selvedged with a wire of which the diameter is 25% greater than that of the wire used to form the mesh. Where the selvedge is not woven integrally with the mesh but has to be fastened to the cut ends of the mesh, it shall be attached by binding the cut ends of the mesh about it so that a force of not less than 8.5 kN applied in the same plane as the mesh, at a point on the selvedge of a mesh sample of length one (1) metre is required to separate it from the mesh.

18.1.6 Diaphragms and End-Panels

The diaphragms and end-panels shall be selvedged on the top and vertical sides only. The end panels shall be attached by twisting the cut ends of the mesh wires at the bottom of the panel about the selvedge on the base of the gabions. Similarly, the diaphragms shall be attached by twisting the cut ends of the mesh to the twisted joins of the mesh of the gabions. In each case the force required to separate the panels from the base shall not be less than that required to break the mesh over the same length.

18.1.7 Binding and Connecting Wire

Sufficient binding and connecting wire shall be supplied with the gabions to perform all the wiring operations to be carried out in the construction of the gabion work as stated in Clauses 18.1.10 to 18.1.13 below. The diameter of wire shall be 2.20 millimetres.

18.1.8 Filling Material

Filling material shall consist of hard, durable stone of minimum dimension 100 millimetres and maximum dimension 250 millimetres and shall be tightly packed to give a minimum of voids. The top layer of material shall consist of selected smaller stone of not less than 100 millimetres minimum dimension.

18.1.9 Tolerances

A tolerance on the diameters of all wire of ± 2.5 per cent shall be permitted. The length of the gabions is subject to a tolerance of ± 3 per cent and the width of gabions to a tolerance of ± 25 millimetres. All other gabion dimensions are subject to a tolerance of ± 3 per cent of the sizes stated in this Specification or on the Drawings.

18.1.10 Fabrication

The gabions shall be unfolded on the ground and stretched to the maximum extent possible while ensuring that all creases are in the correct positions for forming the box. Any cutting required shall be carried out so that the cut ends of wire are a minimum of 50 millimetres from the twisted joins. After stretching and cutting as required the side and end panels shall be lifted so that the tops of all sides are level. Any loose ends of wire protruding above a level plane at the top or from the corners shall be bent down into the box. Corners shall be fastened securely and the box shaped prior to commencing any binding.

The binding wire shall be securely fastened to the top of a corner by lacing between two meshes at the corner and twisting the binding wire through three half turns. The wire shall then be laced around the two vertical selvedges, when applicable, and through each mesh in turn in a continuous lacing action and shall be pulled tight before securing to the bottom corner by the three half turns to an adjacent wire.

The diaphragm panels shall then be placed in position and secured to the gabion sides in the same manner as

the corners. The empty box shall then be firmly seated on a prepared area in its required final position and laced to the adjoining corners or sides of gabions previously placed along all adjoining corners and tops. If additional binding of the gabions is required this shall be shown on the Drawings or specified.

18.1.11 Placement

The placement of the gabion boxes shall be carried out in an orderly manner so that a face of uncompleted work is maintained.

At least two rows of empty boxes shall be wired together at the face of uncompleted work prior to filling the box closest to the completed work. Prior to filling any box one end or side of the box shall be secured to completed works or to stakes driven into the ground at the corners or in any other approved manner and the opposite end, side or corner shall be stretched with crowbars and secured top and bottom in an approved manner.

18.1.12 Filling

When boxes used are one (1) metre high or more they shall be cross tensioned in each compartment at third points in the height by wires of the same diameter as the binding wire securely tied by two turns around the mesh or selvedge wire and three half turns around itself. The boxes shall be filled to between 25 and 50 millimetres above their tops. The lids shall be stretched tight over the filling with a crow-bar or similar and wired down in a continuous lacing process in the same manner as that specified for corners. Each edge may be laced with a separate length of binding.

18.1.13 Measurement and Payment

Measurement of the quantity of gabions and reno mattresses shall be in cubic metres and shall be based on the nominal external dimensions of the gabions and reno mattresses completed and accepted by the Engineer. Payment shall be made at the scheduled rate for gabion and reno mattresses protection works, and shall include full compensation for the supply of materials, erection, wiring, bracing and cutting; and the supply and placement of filling material, and for all labour, materials, equipment, tools and incidentals necessary to complete the work herein specified.

18.2 Bank Protection

Bank protection works will unless otherwise shown on the Drawings be carried out with gabions and reno mattresses as detailed in Clause 18.1. The gabions and reno

mattresses shall not be placed until the bank has been trimmed and compacted to the satisfaction of the Engineer.

The Contractor is to note that the works shown on the Drawings are simply an indication of type of construction and extent of works. The actual detailed layout will be decided on site by the Engineer.

18.3 River Training

River training works shall be constructed as shown on the Drawings except that the detailed layout will be decided on site by the Engineer.

The front line of gabion works is intended to break the force of the river and cause deposition. Unless otherwise directed by the Engineer they shall be placed at a level with their tops approximately 600 mm above the river's normal flow level.

The chain mesh fences shall be placed generally to the lines shown on the Drawings or as directed by the Engineer. They are intended to act as a debris trap. Adequate numbers of cuttings shall be planted to provide long term protection. These shall be placed to the direction of the Engineer. The cuttings shall be of a type known to grow strongly, with heavy root growth, in moist ground conditions, in the area in which the works are being carried out.

18.4 Construction of Levees, Bank Protection, River Training Works and Realignment of Channels

Levees, bank protection and river training works shall be constructed as shown on the Drawings or as directed by the Engineer. Before work commences, and periodically thereafter as directed by the Engineer, surveys shall be carried out to permit measurement. Realignment of channels and reshaping of river channels adjacent to bridges shall be carried out as shown on the Drawings or as directed by the Engineer.

18.5 Clearing and Grubbing for Bank Protection, River Training Works and Realignment of Channels

(i) Clearing and grubbing for bank protection, river training works and realignment of channels shall be carried out, measured and paid for in accordance with the provisions of Group 3 of this Specification.

(ii) Payment shall be at the scheduled rate entered in the Bill of Quantities of Group 3.

18.6 **Excavation for Bank Protection Works**

(i) Excavation for bank protection works shall be carried out in accordance with the provisions of Group 4 Clauses 4.13.1, 4.13.2 and 4.13.3 of this Specification.

(ii) Measurement of the quantities of excavation shall be in cubic metres which shall be calculated from the projected area of the gabion footings or, parts thereof, onto a horizontal plane multiplied by the average vertical depth shall be measured at 10 m intervals or such lesser interval as may be directed by the Engineer and shall be measured from which ever is the lowest of the following.

(a) where the existing ground level is not lowered the depth shall be measured from the ground line as it exists after clearing and grubbing operations have been completed.

(b) where the existing ground level is lowered by excavation for river training works the depth shall be measured from the ground line after excavation, as shown on the Drawings or as directed by the Engineer.

Where the projected area of gabion footings increases in steps, the projected area shall be measured at each step.

(iii) Payment shall be made at the scheduled rate in the Bill of Quantities and shall be full compensation for all battering, shoring, dewatering, labour, equipment, materials and incidentals necessary to complete the excavation, and shall include for any costs in keeping the excavation open and dewatered as necessary until the completion of the construction of the gabion footings.

18.7 **Excavation for River Training Works and Realignment of Channels**

(i) Excavation for river training works and realignment of channels shall be carried out and measured in accordance with the provisions of Group 4 of this Specification in respect of road excavation.

(ii) Payment shall be made at the scheduled rate in the Bill of Quantities and shall be full compensation for loosening, blasting, breaking up, removal, loading, haulage, and satisfactory disposal of all excavated materials, and for furnishing all labour, equipment, materials and incidentals necessary to complete the excavation and shall include for working in and dealing with the existing flow of water.

18.8 Backfilling to Gabion Protection Works

(i) Backfilling to gabion protection works shall be advanced as each layer of gabions is completed and shall be finished to the top of each layer before the next layer of gabions commences. Backfill shall be placed in 300 mm thick uncompacted layers and compacted to at least 90% of the maximum dry density determined in accordance with AS 1289 Test E1.1.

(ii) Backfill material shall be subbase material in accordance with Group 5 of this Specification.

(iii) Measurement shall be in cubic metres and shall be based upon the cross-section dimensions shown on the Drawings multiplied by the length of gabion protection works completed and accepted by the Engineer.

(iv) Payment shall be at the scheduled rate in the Bill of Quantities and shall be full compensation for the supply, haulage, placement, spreading, compaction, finishing and all labour, equipment, materials and incidentals necessary to complete the backfilling.

18.9 Concrete Protection to Gabion

(i) Concrete protection to gabions shall be constructed as shown on the Drawings or as directed by the Engineer.

(ii) The concrete shall have a maximum aggregate size of 10 mm and shall be Grade 15 concrete produced and placed in accordance with Group 14 of this Specification, except that the concrete shall be placed as a screed.

(iii) Measurement shall be made in cubic metres and shall be based upon the thickness shown on the Drawings multiplied by the surface area of the finished screed completed and accepted by the Engineer.

(iv) Payment shall be at the scheduled rate in the Bill of Quantities and shall be full compensation for furnishing all labour, materials, equipment, tools, and all miscellaneous items necessary for the finished concrete including supply and storage of materials, mixing, transporting, placing, finishing, curing, and the furnishing of and placing of all other incidental construction items not otherwise covered as a separate scheduled item, all as required by this Specification and as directed by the Engineer.

18.10 Weepholes

(i) Weepholes through concrete protection to gabions shall be installed at the locations shown on the Drawings or as directed by the Engineer.

(ii) The weepholes shall be 75 mm diameter UPVC pipe of sufficient length to project 75 mm beyond the concrete protection into the gabion fill.

(iii) Measurement shall be by length in metres of weepholes completed and accepted by the Engineer.

(iv) Payment shall be at the scheduled rate in the Bill of Quantities and shall be full compensation for supply, transportation, placement and fixing.

GROUP 19

DAYWORKS

Clause No.	Item
19.1	Labour
19.2	Materials
19.3	Plant Hire

GROUP 19

DAYWORKS

19.1 Labour

19.1.1 The item in the Bill of Quantities for the provision of labour employed on Dayworks shall include for the costs of the actual hours worked by leading hands and workmen at the direction of the Engineer. The leading hands and workmen shall be paid at the basic rates of pay, together with such plus rates for skill only as specified in the Registered Award as set out by the Industrial Relations Act of Papua New Guinea, or other appropriate wage-fixing body, current at the time the work is carried out. The basic rates shall be increased for overtime, where applicable, in accordance with Registered Award. Overtime shall only be worked with the prior agreement of the Engineer.

19.1.2 The percentage added by the Contractor to the costs as detailed in Clause 19.1.1 for overheads and profit shall include for:

(i) All charge of every description in accordance with the Registered Award of the Industrial Relations Act;

(ii) Annual and Public Holidays with pay;

(iii) Long service leave;

(iv) Use and maintenance of all small tools, plant and appliances not provided for under Clause 19.1;

(v) Protective clothing;

(vi) Profit;

(vii) Incentive and bonus payments;

(viii) Supervision.

19.2 Materials

19.2.1 The item in the Bill of Quantities for the provision of materials expended on Dayworks shall include for the net price paid by the Contractor for materials delivered to the Site. These net costs must be substantiated by suppliers invoices.

19.2.2 The percentage added by the Contractor to the costs as detailed in the Clause 19.2.1 for overheads and profit shall include for:

(i) The cost of unloading at Site;

(ii) Taking into store;

(iii) Storing as may be required;

(iv) Profit;

(v) The cost of transporting materials paid for by Dayworks to Site, when it is not possible for the supplier to do so;

(vi) Supervision.

19.3 Plant Hire

19.3.1 General

The Contractor shall furnish and deliver Constructional Plant for hire, together with all supplies and repairs incidental to and necessary for the operation thereof in accordance with the provisions of the Contract.

19.3.2 Inspection Prior to Acceptance

All Constructional Plant offered for hire shall be made available for inspection by the Engineer when required. All items offered shall be subject to approval by the Engineer prior to acceptance.

If the Engineer requires that various alterations or repairs be carried out on the items prior to their commencing work on the Site, any acceptance subsequently issued shall be subject to these alterations and repairs being satisfactorily completed.

If the Contractor proposes to use new plant, he shall furnish to the Engineer full details of the plant to be purchased, and the plant shall be approved for use subject to it conforming with details submitted.

19.3.3 Operators

The Contractor at his own cost and expense shall provide an approved operator for all plant items to be furnished. Such operator shall be the servant of the Contractor, paid and accommodated by the Contractor,

and under his supervision and control and may be removed or replaced by the Contractor at his discretion and the Contractor shall be solely responsible for any damage, loss or injury caused by any act or omission of such operator.

The actions and control of the operator shall also be subject to any provisions stated in the Preliminary Clauses or the General Conditions of Contact.

19.3.4 **Maintenance of Plant**

The Constructional Plant to be furnished under this Contract shall be in first class mechanical condition so as to produce satisfactory results. The Contractor shall keep all plant in good and substantial repair and shall carry out at his own cost all repairs and maintenance required. Damage to the plant from whatever cause, shall be the sole responsibility of the Contractor.

Whenever the proper or possible output of any plant item which is being hired is reduced due to need for repairs and adjustments, such repairs or adjustments shall be made at the first available interval between working days or shifts; provided however that if such need for repairs or adjustments results in unsatisfactory output and therefore, in the opinion of the Engineer, further operation of the plant will cause increased costs of the work, the Engineer shall have the right to suspend operations of the plant until the necessary repairs and adjustments are made.

The Contractor shall, at his own cost and expense, have available at all times a serviceman or mechanic together with the necessary wrenches, tools, etc. to maintain the plant in proper working order. The Contractor shall also have available on the Site or within reasonable proximity, sufficient spare parts to enable normal maintenance repairs to be carried out.

The Contractor shall provide the workshop and tool facilities, labour and supplies necessary to satisfactorily carry out maintenance and repairs to the plant.

19.3.5 **Fuel, Oil and Grease**

The Contractor shall, at his own cost and expense, furnish all fuel, oil, grease and supplies necessary for the operation, servicing and maintenance of the Constructional Plant and shall be responsible for the storage of such items.

19.3.6 **Safety of the Plant**

The Contractor shall be responsible for the safety of the plant and of any accessories or tools or temporary works provided for the maintenance, servicing or operation of the plant.

19.3.7 **Use of the Plant**

Subject to the provisions of the Contract, the Engineer shall have the right to decide what plant, in what locality and on what days and for what hours during the continuance of the Contract, the Contractor's Plant will be required. During the Contract period the Constructional Plant shall be made available for inspection by the Engineer as and when required.

19.3.8 **Transport of Plant to and from the Site**

In the event of plant brought to the Site on written instructions of the Engineer and used only for Dayworks, the cost of transport to and from the Site will be paid to the Contractor net. The Contractor will not be paid for the hire of the plant during the time it is being transported to and from the Site.

19.3.9 **Assessment of Hours of Hire**

The Contractor shall be paid for the actual hours worked by each item of plant in accordance with the Contract, valued at the scheduled rates and subject to the following:-

(i) Payment shall not be made, in respect of any one item of plant for more than eight hours in any one day unless the Engineer has requested in writing that such additional hours be worked.

(ii) Payment shall not be made for hours worked which have not been directed by the Engineer to be worked.

(iii) Payment shall not be made for time when the plant was unserviceable or broken down or when the Engineer has suspended the hire of the plant as provided for in Clause 19.3.4 above. In this respect, when one item of plant which forms a group for a construction task, becomes unserviceable or is suspended, and the task cannot efficiently be carried out in the absence of this item of plant, the Engineer shall have the right to suspend the hire on the remaining items in the unit until all necessary items are reinstated to a satisfactory condition.

(iv) Payment shall be made for the time consumed in making emergency minor repairs and adjustments necessary to keep the plant items properly operating provided however, that such accumulated delay time in any one day does not exceed one tenth of the established working time for that calendar day and provided also that the Contractor has complied with all other requirements of the Specification with regard to the maintenance of plant.

(v) The Engineer shall have the right to deduct from the number of hours to be certified for payment, such hours as he determines that the plant was not gainfully employed in carrying out the Works due to failure of the operator to maintain normal production. The Engineer shall provide the Contractor with details of the number of hours so deducted in respect of each item of plant and the reason why the hours have been deducted.

(vi) Payment shall not be made for time during which the plant is not able to work due to adverse weather conditions.

(vii) The Contractor will be paid for time spent by plant travelling within the Site provided that the Contractor's transport proposals are approved by the Engineer and provided also that Clause 19.3.9 (viii) does not apply.

(viii) Payment shall not be made for time during which plant, which is not able to be self-propelled to its working location, is being loaded onto or carried by a truck or float, however the cost of such transport as is provided shall be paid for at the rate tendered for the number of hours which the transport item actually spent loading, hauling and unloading the plant but not including time spent in positioning and returning the transport item.

19.3.10 Evidence Hours Worked

Further to the requirement of Clause 52(4) of the Conditions of Contract, the Contractor shall prepare dockets showing the number of hours worked by each plant item in accordance with the Contract. These dockets shall be signed at the end of each day's work by the Contractor and the Engineer and such signature shall indicate that the dockets are a true record of the number of hours worked during that day. Should the Engineer dispute any figures shown on the dockets, he shall, prior to signing, note the figures that are in

dispute and advise the Contractor, in writing, of the hours he considers are correct and such dispute shall be dealt with as provided for in the Contract.

The Engineer reserves the right to inspect time sheets of the Contractor's employees to verify dayworks labour rates.

APPENDIX A

APPENDIX A

Publications

For the convenience of the Contractor, the following lists those Australian Standards, British Standards and other publications referred to in the Specification. No responsibility is accepted by the Papua New Guinea Government nor Department of Works nor the Engineer for this information and the Contractor is deemed to have satisfied himself that it is correct in providing AS, B.S. and other publications required by Clause 1.3. of this Specification.

Australian Standard	Title	Specification Group
AS 1012	Methods of testing concrete	14
AS 1111	ISO metric hexagon commercial bolts and screws	8
AS 1112	ISO metric hexagon nuts, including thin nuts, slotted nuts and castle nuts	8
AS 1131	Dimensions of hot-rolled structural steel sections	10
AS 1141	Methods of sampling and testing aggregates	5,6
AS 1152	Test sieves	14
AS 1160	Bituminous emulsions for construction and maintenance of pavements	6
AS 1163	Structural steel hollow sections	15
AS 1204	Structural steels- Ordinary weldable grades	13,17
AS 1214	Hot-dip galvanized coatings on threaded fasteners	8,14,1,6
AS 1227	General requirements for the supply of hot-rolled steel plates, sections, piling and bars for structural purposes	13

Australian Standard	Title	Specification Group
AS 1237	Flat Metal washers for general engineering purposes	8
AS 1252	High strength steel bolts with associated nuts and washers for structural engineering	15
AS 1260	UPVC pipes and fittings	17
AS 1289	Methods of testing soils for engineering purposes	4,5,7
AS 1302	Steel reinforcing bars for concrete	13
AS 1303	Hard-drawn steel reinforcing wire for concrete	13
AS 1304	Hard-drawn steel wire reinforcing fabric for concrete	13
AS 1315	Specification and methods of test for portland cement	14
AS 1317	Blended cements	14
AS 1342	Precast concrete drainage pipes	7
AS 1379	Ready-mixed concrete	14
AS 1465	Dense natural aggregates for concrete	14
AS 1478	Chemical admixtures for use in concrete	14
AS 1479	Code of practice for the use of chemical admixtures in concrete	14
AS 1480	The use of reinforced concrete in structures	14
AS 1509	Rules for design and construction of formwork	12

Australian Standard	Title	Specification Group
AS 1510	Code of practice for control of concrete surfaces	12
AS 1511	Rules for the use of high strength bolts in steel structures	15
AS 1627	Code of practice for preparation and pretreatment of metal surfaces prior to protective coating	16
AS 1640	Rules for brickwork in buildings	14
AS 1650	Galvanized coatings on ferrous articles	8,14,16
AS 1743	Road signs	8
AS 1906	Retroreflective materials and devices for road traffic control purposes	8
AS 2008	Residual bitumen for pavements	6
AS 2041	Corrugated steel pipes, pipe arches and arches	7
AS 2042	Codes of practice for design and installation of corrugated steel pipes, pipe arches and arches	7
AS 2157	Cutback bitumen	6
AS 2341	Methods of testing bitumen and related roadmaking products	6
AS CA23	Rules for the storage and handling of explosives	4
AS K146	Road marking paints	8

	Publications	Specification Group
American Society for Testing Materials (ASTM)	Designation 1250-56 ASTM-IP Petroleum Measurement Tables	6
National Association of Australian State Road Authorities	N.A.A.S.R.A Principles and Practice of Bituminous Surfacing Volumes 1 and 2	6
National Association of Australian State Road Authorities	N.A.A.S.R.A Bridge Design Specification 1976	10 to 16
Forest Products Research Centre Department of Forests Papua New Guinea	Properties and Uses of Papua New Guinea Timbers	8
National Association of Australian State Road Authorities	N.A.A.S.R.A Welding Manual	15
American Welding Society	Welding Codes D1.1-75 A5 1-69 A5 17-69 A5 18-76 A5 20-76	15

British Standard	Title	Specification Group
B.S. 4	Specification for structural sections	15
B.S. 443	Galvanized coatings on wire	18
B.S. 812	Testing aggregates	6
B.S.1052	Mild steel wire for general engineering purposes	18
B.S.1134	Method for assessment of surface texture	15

Japanese Industrial Standards	Title	Specification Group
JIS A5525	Steel pipe piles	10
JIS G3106	Rolled steels for welded structures	15
JIS G3192	Dimensions, weight and permissible variations of hot rolled steel sections	15

	Publications	Specification Group
Japan Road Association	List of Main Dimensions Weights and Painting Areas of Standard Design of Bearings for Bridges	17

APPENDIX B

APPENDIX B

Schedule of Contract Drawings

Title of Drawings	Drawing No.
GENERAL DRAWINGS	
Site and Locality Plan	A1/88051
Abbreviation and Legend	A1/87761
Plans Layout, Co-ordinates of Control Point and Intersection Point	A1/88052
STANDARD DRAWINGS	
Tipical Cross Section (Cut and Fill Section)	A1/88053
Tipical Cross Section (Sand Mat t= 0.5 m and Alika Swamp)	A1/88054
Tipical Cross Section (Sand Mat t= 1.0 m)	A1/88055
Tipical Cross Section (Sand Mat t= 1.0 m t=0.5 m)	A1/88056
Tipical Pavement Section for Road CH 33+500 to CH 80+596	A1/88057
Superelevation	A1/87766
ROAD FURNITURE	
Standard Guard Rail	A1/87772
Guard Rail and Fender Post Details (Approach for Single Lane Bride)	A1/88058
Road Edge Guide Post and Road Edge Markers	A1/87774
Schedule of Road Edge Guide Post, CH 33+500 - CH 80+596 - 1/3	A1/88059
Schedule of Road Edge Guide Post, CH 33+500 - CH 80+596 - 2/3	A1/88060
Schedule of road Edge Guide Post, CH 33+500 - CH 80+596 - 3/3	A1/88061
Pavement Markings	A1/87777
Schedule of Pavement Marking CH 33+500 - CH 80+596	A1/88062
Road Signs	A1/87779
Road Sign for Bridge Approach and Intersection	A1/87780
Schedule of Road Signs,	

Title of Drawings	Drawing No.
CH 33+500 - CH 80+596	A1/88063
DRAINAGE	
Standard Culvert Headwalls	A1/87782
Culvert Headwalls in Alika Swamp	A1/88064
Culvert Bedding, Subsoil Drain and Standard Inlet Pit	A1/87783
Culvert Schedule, CH 33+530 - CH 41+015	A1/88065
Culvert Schedule CH 41+150 - CH 53+350	A1/88066
Culvert Schedule CH 53+845 - CH 60+450	A1/88067
Culvert Schedule CH 60+500 - CH 64+270	A1/88068
Culvert Schedule CH 65+260 - CH 79+140 and on Side Ditch	A1/88069
OTHERS	
Earthworks Schedule CH 33+500 - CH 80+596	A1/88070
Settlement Plate and Displacement Peg	A1/88071
Reno Mattress and Gabion	A1/88072
Borrow Pit No. 1	A1/88073
Borrow Pit No. 2-1 & 2-2	A1/88074
Borrow Pit No. 3-1 & 3-2	A1/88075
Borrow Pit No. 4 and Sand Borrow Pit No. 2	A1/88076
Borrow Pit No. 5, Base Borrow Pit No. 1, Subbase Borrow Pit No. 3 and Spoil Bank No. 4	A1/88077
Sand Borrow Pit No. 1 and No. 2 and River Deposit No. 2	A1/88078
Spoil Bank No. 1,2 and 3 for Lot I/Stockpile For Lot II	A1/87788
Project Notice Board	A1/87791
Engineer's Office Accommodation Plan, Elevation, Sections and Details	A1/87792
Door and Window Schedule, Stair Details, Section and Joinery Elevations	A1/87793
Plans, Elevations, Electrical Legend and Wiring Diagram	A1/87794
Sections Details	A1/87795
	A1/87796

Title of Drawings	Drawing No.
LIST OF PLAN AND LONGITUDINAL SECTIONS	
Plan and Longitudinal Section	A1/88079 - A1/88147
LIST OF CROSS SECTIONS	
Cross Section	A1/88148 - A1/88248
BRIDGES	
Bridge No. 4 - Miaru Bridge	A1/88249 - A1/88261
Bridge No. 5 - Kapuri Bridge	A1/88262 - A1/88274
Bridge No. 6 - Lakekamu Bridge	A1/88275 - A1/88292
Bridge No. 7 - Tauri Bridge	A1/88293 - A1/88310
Bridge No. 8 - Makara Bridge	A1/88311 - A1/88323
Bridge No. 9 - Sappaharo Bridge	A1/88324 - A1/88337