5.3.7 Bituminous Prime Coat

The bituminous prime coat where applicable shall be applied as soon as practical after but not before the levels, surface compaction, quality and finish of the base course have been approved by the Engineer. Should the pavement due to any reason or cause lose the required quality, stability, density or finish before surfacing is complete it shall be made good at the sole expense of the Contractor.

5.3.8 Measurement of Base Course

Base course shall be measured as:-

(a) The volume of base course material compacted in place and accepted by the Engineer shall be measured as the product of the average end area based on the nominal thickness and the length measured horizontally along the road centreline.

(b) The area of existing pavement required to be scarified and shaped in accordance with Clause 5.3.4 herein which shall be the product of the plan width of existing pavement required to be scarified and shaped and the length measured horizontally along the road centreline.

5.3.9 Payment for Measured Work

This work measured as provided above shall be paid for at the scheduled rate for the appropriate items listed above. The payment shall be full compensation for opening up borrow pits, sampling, procuring materials, processing, hauling, scarifying, placing, compacting and finishing and for all labour, equipment, tools and other incidentals necessary to complete the work specified in Clause 5.3. In addition, the rate for base course shall include the removal of overburden and its disposal, maintenance of borrow pit and the construction of access roads where required at the borrow pit.

Interim payment may be made on the loose volume in cubic metres of base course material satisfactorily stockpiled on site at the rate of 40% of the scheduled rate for base course providing the Contractor's intention to use the material in the Works is clear.

Payment for cement treated base course shall be made in accordance with Clause 5.4 of this Specification.

5.4 Cement Treated Material

5.4.1 Scope

This Clause deals with the addition and mixing in of

cement hereinafter described as the "stabilizer" to the natural materials as described in Clauses 5.2.1 and 5.3.1 of this Specification.

Following the addition and mixing in of the stabilizer the material is referred to as "treated material". Treated material shall be the cement stabilized material.

This Clause also deals with the compaction and curing of the treated material.

Treated materials shall be used in the upper subbase and base course.

5.4.2 Source of Materials

In accordance with Clauses 5.2.1 and 5.3.1 of this Specification.

5.4.3 Material Requirements

(a) Natural Materials

In accordance with Clauses 5.2.1 and 5.3.1 of this Specification.

(b) Cement

(i) Cement

Unless otherwise specified cement shall be Ordinary Portland Cement complying with the requirements of Clause 14.5. (1) of this Specification.

(ii) Storage

The requirements of Clause 14.5 (6) of this Specification shall apply to cement.

5.4.4 Amount of Stabilizer to be Added

The amount of cement to be added shall be 1.5 percent by weight for upper subbase and 4.5 percent by weight for base course. The Engineer may change and direct the cement content following laboratory trials, and site trials carried out by the Contractor. The laboratory test shall be made by the Engineer and the cement content shall be determined by the Engineer.

5.4.5 Stabilizing Method

The Contractor shall submit a construction method and selection of plant and equipment to the Engineer prior to the commencement of subbase and base course works. The

site trials shall be made by the acceptable construction method. No cement treated material shall be placed until the Engineer has indicated that he has no further comment on the Contractor's programme.

Stationary plant method of mixing in of stabilizer shall apply the base course, unless otherwise accepted by the Engineer.

(1) **Mix-in-Place Method of Construction**

The mix-in-place method may be used for the addition and mixing in of stabilizer.

(a) The equipment for pulverizing the material and mixing in the stabilizer shall be purpose-built equipment, capable of pulverizing the materials and mixing in the stabilizer to the full depth of the loose layer necessary to give the specified thickness of compacted material mixed and compacted in accordance with this Clause of this Specification.

The equipment may be either single or multipass machines and shall only be acceptable if, during the site trials carried out in accordance with Clause 5.4.4 of this Specification, it can produce material to the specified requirements.

The mixers shall be equipped with a device for controlling the depth of processing and mixing blades shall be maintained or reset periodically so that the correct depth of mixing is obtained at all times.

Mixing by grader will not be permitted.

(b) Before the stabiliser is applied, the material to be treated shall be spread and broken down and oversize material removed so that the maximum size of the particles is not more than specified. If multi-pass processing is employed, the material shall first be pulverized to the required tilth by successive passes. The material shall then be shaped true to line, grade and cross-section and, if required, lightly compacted. The loose thickness shall be such as to give the specified thickness after full compaction has been carried out.

The moisture content of the layer before the addition of the stabiliser shall be adjusted to within the range directed by the Engineer.

(c) Spreading the Stabilizer

After the layer to be treated has been prepared to the satisfaction of the Engineer, the stabilizer shall be uniformly spread over the width to be worked at the specified rate. If a spreader is used to spread the stabilizer ahead of the mixer, it shall be fitted with a device to ensure a uniform and controllable rate of spread both transversely and longitudinally.

Only sufficient stabilizer for immediate use shall be spread ahead of the mixing operation and any which, in the opinion of the Engineer, becomes defective, shall be replaced at the Contractor's expense.

Only equipment actually used in the spreading or mixing operation shall be allowed to pass over the stabilizer, when so spread, before it has been mixed into the material to be treated.

(d) Mixing

Immediately after the stabilizer has been spread, it shall be thoroughly and intimately mixed into the material for the full depth of the layer. Mixing shall continue until the resulting mixture forms a fine and homogeneous tilth. The mixing machine shall be set so that it cuts at least 100mm into the edge of any adjoining lane processed previously so as to ensure that all the material forming the layer has been properly processed.

Care shall be taken both during this and during subsequent watering operations that the underlying layer is not disturbed and that no material from the underlying layer is mixed with that being processed.

If watering is necessary to bring the mixture to the required moisture content, then this shall be done after spreading and mixing in the stabilizer. Water shall be added in a uniform and controllable manner and, where necessary, in successive increments. Each increment shall be mixed

in as a separate mixing operation. Care shall be taken to avoid a concentration of water at any point or a flow of water over the surface.

Any part of the mixture which becomes too wet after the stabilizer has been added and before the mixture is compacted will be rejected and any such part shall be allowed to dry out until its moisture content is satisfactory and shall be retreated with fresh stabilizer and finished off in accordance with this Clause.

Throughout the process of mixing in the stabilizer and water, a uniform thickness of the mixture shall be maintained and, if necessary, the mixture shall be graded to maintain the correct uncompacted thickness and shape. Any part of the mixture that becomes segregated shall be removed and replaced.

(2) Stationary Plant

(a) Mixing Equipment

Stationary mixing plant shall be of the power driven paddle or pan type and may be of the batch or continuous type.

If batch mixers are used, the appropriate measured amounts of material and stabilizer shall first be placed in the mixer, water being then added as necessary to bring the moisture content of the resulting mixture within the range determined in the laboratory and site trials. Special care shall be taken with batch type paddle mixers to ensure that the stabilizer is spread uniformly in the loading skip so that it is fed evenly along the mixing trough and that with both paddle and pan mixers the stabilizer is proportioned accurately by a separate weighing or proportioning device from that used for the material being stabilized. Mixing shall be continued until the mixture has the required uniformity and for not less than 1 minute unless a shorter minimum period is permitted by the Engineer after satisfactory trials.

If continuous mixing is used, the paddles, baffles and rate of feed of materials shall be adjusted to give uniformly mixed material.

If a spray is used for distributing water into the mixer, it shall be adjusted to give uniformity in moisture content throughout the mix.

(b) Transporting

Mixed material shall be transported to the road in suitable vehicles. Material that becomes segregated or is affected by weather shall be removed and replaced at the Contractor's expense.

(c) Laying

The mixed material shall be spread either mechanically by means of pavers, spreaders or motor graders, or manually to the required width and such thickness that the tolerance requirements as specified in Clause 5.3.6 of this Specification are obtained after final compaction. Segregation shall be avoided and the layer shall be free from pockets of coarse or fine material.

(d) Compaction and Finishing

For cement treated materials final compaction and finishing shall be completed within 2 hours after the cement comes into contact with the material to be treated.

(i) Thickness Limitations

The compacted thickness of any treated layer laid, processed and compacted at one time shall not exceed 150mm. The material shall be laid in one layer as shown in the Drawings.

(ii) Compaction Requirement

The minimum density for all cement treated materials shall be 95% dry density as determined by AS1289 Test No. E2.1. The moisture content at the time of compaction shall not vary more than ± 5% from the optimum moisture content.

(iii) Finishing

The surface finish after compaction of any treated layer shall be free from ridges, compaction planes, laminations, loose and segregated material and other surface irregularities and shall be to line and level and within the tolerances specified in Clause 5.3.6 of this Specification. If the surface fails to meet the requirements of this Specification the Contractor shall take the action set out in the appropriate part of Clause 5.4 of this Specification or such other action as the Engineer may instruct or agree.

(iv) Joints between New and Existing Work

The forming of construction joints and the protection of previously treated or other work shall be carried out so as to produce a uniformly compacted and homogeneous layer free from ridges or other irregularities.

Full width working, without longitudinal joints, will generally be required. Half-width working may be instructed by the Engineer to pass traffic. When forming longitudinal joints, with the mix-in-place method at least 100mm of the first laid half-width layer shall be retreated and mixed in with the second half-width layer.

When forming transverse joints, with the mix-in-place method, at least 1.0m length of the previously laid treated work shall be incorporated into the new treated layer and the Engineer may instruct that the percentage of stabilizer be increased at these places.

When forming longitudinal or transverse joints with the stationary plant method of construction, previous work shall be cut back to expose fully treated and compacted material.

5.4.6 Protection and Curing

Treated layers shall be kept continuously damp by lightly spraying with water, from completion of compaction until the curing specified below is completed.

The compacted cement treated subbase and base course shall be cured with bituminous curing seal. Bituminous prime coat specified in Clause 6.1 of this Specification shall be applied. Treated layers shall be protected, within 4 hours of completion of compaction in the case of cement treated material.

Plant used for dumping and spreading material, and the application of water or emulsion shall be approved by the Engineer. During construction of Works, care shall be taken to avoid damage to cement treated subbase and base course by the passage of heavy construction equipment, and the Contractor shall be wholly responsible for any damage occurring from such operations.

Immediately prior to the application of prime coat the surface of the treated layer shall be made thoroughly damp by lightly spraying with water as directed by the Engineer.

The curing shall be kept in place and intact for a minimum of 7 days after completion of compaction although small areas may be temporarily removed for the purposes of carrying out control testing but only for the minimum amount of time required for the testing.

5.4.7 Traffic

Traffic or equipment, other than that actually engaged in the various treatment or protection processes, shall not run over the layer being processed or compacted.

On completion of curing no traffic or equipment shall be allowed on the treated layer with the exception of that required for proofrolling, priming or construction of the subsequent layer.

5.4.8 Tolerance

(a) Geometric Tolerances

The treated subbase and base course shall be constructed within the tolerances specified in Clause 5.3.6 of this Specification.

(b) Amount of Stabilizer

(i) Mix-in-place Method of Construction

The average amount of stabilizer, measured before mixing, over a length of 100m, shall not be less than the amount ordered.

The average amount of stabilizer in the treated material, measured at five points over a length of 100m, shall not be less than the amount ordered.

The amount of stabilizer, measured after mixing, shall at no point be less than 90% or more than 110% of the amount ordered.

(ii) Stationary Plant Method of Construction

The average amount of stabilizer in the treated material measured at five points over a length of 100m shall not be less than the amount ordered.

The amount of stabilizer measured after mixing shall at no point be less than 90% or more than 110% of the amount ordered.

(iii) Determination of Stabilizer Content

The cement content in mixed materials shall be determined according to Test 14 of BS 1924 or to AASHTO T211-65 (1982).

5.4.9 Construction Limitations

No cement stabilizing work will be permitted in adverse weather conditions or whenever so instructed by the Engineer. No mixing, laying and compacting shall be carried out on a wet surface due to rainfall nor when rain appears imminent nor during high winds.

5.4.10 Measurement

(a) The volume of subbase and base course materials compacted in place and accepted by the Engineer shall be measured as the product of the average end area based on the nominal thickness and the length measured horizontally along the road centreline excluding the existing pavement remaining in place.

(b) Measurement of prime coat for curing treated material shall be in litres of combined cutback material. The quantity of prime coat shall be calculated as the authorized rate of application multiplied by the approved area of subbase and base course or shall be the actual quantity used and accepted whichever is lesser.

(c) Measurement of variation increase or decrease of cement content shall be in tonnes of cement.

5.4.11 Payment for Measured Work

This work measured as provided above shall be paid at the scheduled rate for the appropriate items listed above.

For the purpose of measurement and payment no distinction shall be made between the mix-in-place and stationary plant methods of construction.

The payment shall be full compensation for opening up borrow pits, sampling, procuring material, processing, site trials, hauling, placing, mixing, watering, shaping, compacting and all labour, equipment, tools and other incidentals necessary to complete the work specified in Clause 5.4. In addition, the rate of cement treated work shall include the removal of overburden and its disposal, maintenance of borrow pits and the construction of access roads where required at the borrow pits.

Payment of prime coat for curing treated material shall be made in accordance with Clause 6.1 of this Specification. This payment shall be made in Group 6 of the Bill of Quantities.

The increase or decrease of cement content shall be adjusted as directed by the Engineer.

GROUP 6

BITUMINOUS SURFACING

Clause No.	Title
6.1	Bituminous Prime Coat
6.2	Bituminous Surface Treatment

GROUP 6

BITUMINOUS SURFACING

6.1 Bituminous Prime Coat

6.1.1 General

This work shall consist of the furnishing and application of a cutback bitumen, and blotter material where necessary, to an area of the prepared surfaces of the base course and subbase in accordance with this Specification and as directed by the Engineer.

6.1.2 Cutback Bitumen

The cutback bitumen shall be Grade AMC 0, conforming to the requirements of Australian Standard AS 2157. The cutback bitumen may be prepared on Site by mixing approximately 78 parts aviation kerosene or power kerosene as commercially available in Papua New Guinea with 100 parts of Class 170 bitumen conforming to AS 2008. The kerosene, without being previously heated, shall be pumped into the distributor through the bitumen which has been heated to a temperature within the range 165°C - 175°C (325°F - 350°F) and the mixture shall then be circulated for at least 20 minutes before application.

The Contractor shall supply test certificates confirming that cutback bitumen meets the specified requirements of AS 2157. Tests shall be in accordance with AS 2341.

6.1.3 Blotter Material

Blotter material shall be acceptable, clean, dry sand or stone screening free from any adhesive material. Beach sand is not an acceptable substitute. It shall contain no organic matter. The application rate will likely lie within the range of 0.002 to 0.004 cubic metres per square metre.

6.1.4 Measuring Road Temperature

Unless the Engineer gives directions to the contrary, the Contractor shall measure and record road temperatures at 1 hour intervals during the course of the work. For this purpose a spirit or mercury-glass thermometer, having its bulb coated black with paint or cutback bitumen, shall be placed in direct contact with the pavement and allowed to remain in position until the reading becomes steady. If the pavement is partly in the sun and partly in shade, the temperature for both conditions shall be taken and recorded.

6.1.5 Base Course Surface and Upper Subbase Surface

The surface of the crushed stone or crushed gravel base course shall be swept free of loose stones, dust, dirt and foreign matter so as to uncover, but not dislodge, the coarse aggregate. Immediately before spraying, sweeping shall extend 300 millimetres beyond the area to be primed. A mechanically operated rotary broom may be used for the sweeping provided it does not disturb the surface stones but if a satisfactory clean surface is not obtained thereby, additional sweeping shall be done by hand using stiff bass or similar approved brooms. Adherent patches of foreign material shall be removed from the surface of the road by the use of a steel scraper or other approved method. No spraying shall be undertaken until the pavement has been prepared to the satisfaction of the Engineer.

The cement treated surface for base course and upper subbase shall be finished in accordance with Clause 5.4.5 of this Specification.

6.1.6 Mechanical Distributor

The application of prime coat shall be made by means of a mechanical distributor acceptable to the Engineer which shall have pneumatic tyres of such width and number that the load produced on the road surface shall not exceed 120 kilograms per centimetre of tyre width and shall be so designed, equipped, maintained and operated that the prime coat may be applied at even heat uniformly over variable widths of surface up to 4 metres at readily determined and controlled rates of from 0.2 to 3.0 litres per square metre with uniform pressure and with an allowable variation from any specified rate not to exceed 0.1 litre per square metre. The distributor shall be fitted with instruments for measuring the speed of travel accurately at low speeds, the rate of flow of bituminous material through the nozzles, the temperature of the contents of the tank, and the pressure of the material in spray bars.

These instruments shall be so located that the operator can easily read them whilst operating the distributor. A spare maximum recording mercury thermometer and strainer shall also be available. The tank of the distributor shall be fitted with accurately calibrated dipsticks or content gauges. The distributor shall be equipped with a separate power unit for the pump and full circulation spray bars. The spray bar on the distributor shall be controlled by a man riding at the rear of the distributor in such a position that operation of all sprays is in his full view.

6.1.7 Measuring Equipment

Measuring equipment on the distributor shall have been recently calibrated and an accurate and satisfactory

record of such calibration shall be supplied to the Engineer. If at any time the distribution of bituminous material is found to be in error, the distributor shall be withdrawn from the work and recalibrated in a manner satisfactory to the Engineer before continuing with the work.

6.1.8 Performance of Distributor

The Engineer may require such tests as he considers necessary to check the performance of the distributor. As and when directed by the Engineer, the Contractor, at his own expense, shall make the distributor and its equipment available for field testing and shall supply any assistance required for this purpose. Any distributor which does not operate satisfactorily or conform to the requirements of the Specification in all respects may be rejected by the Engineer for further use on the road.

6.1.9 Hand Spray Equipment

Where the use of the mechanical distributor is not advisable for the application to small areas and areas not satisfactorily sprayed during a run of the distributor, the spraying of such areas as the Engineer may agree to may be done by means of the hand spray equipment of the distributor.

6.1.10 Length to be Sprayed

The length of the surface to be sprayed by each run of the distributor shall be measured and marked on the ground. The application shall commence and finish on a protective strip of paper laid across the surface beforehand, unless the Engineer approves the omission of the protective strip at the finish. The protective strip shall be of paper of quality not less than 50 Kraft, or such other material as the Engineer may accept. The width of the protective strip shall be not less than that endorsed on the distributor certificate or such additional width as the Engineer may direct.

6.1.11 Prime Coat Rate

The prime coat shall be applied at the rate or rates determined by the Contractor following trial runs performed by the Contractor. The application rate will likely lie within the range of 0.4 to 0.8 litres per square metre depending on the texture and density of the surface being primed. A table shall be prepared by the Contractor and amended from time to time as may be necessary, to show distributor road speeds and adjustments for the full ranges of rates of application. The table shall be available on the work at all times and shall enable the appropriate road speed to be determined and the distributor adjusted for the rate of application required prior to the commencement of any run of the distributor.

6.1.12 Width of Prime Surface

The width of primed surface shall be one hundred and fifty (150) millimetres wider on each side than the sealed surface specified on the Drawings or as directed by the Engineer. The edges of the area primed shall not vary by more than ±75 millimetres from the lines specified or as directed by the Engineer.

6.1.13 Optimum Temperature

The optimum temperature of the cutback at the time of application will depend on climatic conditions and the equipment used but shall be in the range 35°C - 55°C for AMC O. Heating quantities in excess of requirements or prolonged heating at high temperatures are to be avoided. Any material which, in the opinion of the Engineer, has been damaged by overheating shall be rejected and shall be replaced at the Contractor's expense.

6.1.14 Application of Prime Coat

Any prescribed application shall be divided into two applications when necessary to prevent bitumen flowing off the surface, and additional material shall be applied where surface conditions indicate it to be necessary, if the Engineer so directs. No further courses shall be applied until the prime coat has set and the solvent evaporated.

When so directed, the prime coat shall be applied in lanes of approximately one half of the width of the completed surface. A lane of prime coat shall be applied, allowed to penetrate not less than 4 hours, unless otherwise permitted by the Engineer. In covering the first treated lane, a strip at least 200 millimetres wide shall be left uncovered where the two lanes join to permit a slight overlap of the prime material.

If the construction equipment has to move in the working area in which the prime coat has been sprayed, the blotter material shall be spread in a thin and uniform layer to prevent damage to the prime coat surface.

6.1.15 Adjacent Trees and Structures

The surfaces of structures and trees adjacent to the area being treated shall be protected in such a manner as to prevent their being spattered or marred. No bituminous material shall be discharged into a borrow pit or gutter.

6.1.16 Construction Limitations

Unless otherwise authorized by the Engineer, prime coat shall be applied only when the weather is dry and when the road temperature is at or above 18°C. Road temperature

shall be measured as set out in Clause 6.1.4. At the time of spraying the road surface shall be clean and slightly damp and the weather is dry. Spraying shall not proceed if rain threatens.

6.1.17 Traffic Restriction

Traffic shall not be permitted on the primed surface until the bituminous material has penetrated and dried and, in the opinion of the Engineer, will not be picked up by the traffic. Where the Engineer deems it impractical to reroute traffic, the Contractor shall spread the minimum quantity, as accepted by the Engineer, of blotter material necessary to avoid picking up, and traffic shall be allowed to use areas so treated. Any areas containing an excess or deficiency of priming material shall be corrected by the addition of sand or prime as directed by the Engineer. Should any break occur in the surface the area affected shall be cut out and made good as directed by the Engineer. All repairs and corrections of faulty work shall be carried out at the expense of the Contractor.

6.1.18 Measurement of Prime Coat

Measurement of bituminous prime coat shall be in litres of combined cutback material. The measured volume shall be determined at the temperature of application and converted to litres at 15.6°C (60°F) in accordance with the requirements of ASTM Designation 1250-56, ASTM - IP Petroleum Measurement Tables. Volumetric measurements shall be taken when the bituminous material is at a uniform temperature throughout its volume and free from air bubbles. The quantity of prime coat applied to any section shall be calculated as the authorized rate of application multiplied by the approved area of seal or shall be the actual quantity used and accepted whichever is lesser.

6.1.19 Measurement of Blotter Material

The quantity of blotter material measured for payment shall be the area in square metres of material spread as agreed to by the Engineer.

6.1.20 Payment

This work measured as provided above shall be paid for at the scheduled rate for each of the items listed above. The rates and payment shall be full compensation for preparation of the surface and for furnishing and placing the materials including all labour, equipment, tools and incidentals necessary to complete the work prescribed in Clause 6.1.

6.2 Bituminous Surface Treatment

6.2.1 General

This work shall consist of the furnishing of one or more applications of bituminous material and cover aggregate to a previously constructed bituminous surface in accordance with this Specification and as directed by the Engineer.

6.2.2 Bituminous Material

The bituminous material shall consist of residual bitumen Class 170 conforming to the requirements of AS 2008, 1980 and cutback bitumen prepared in field, or refinery prepared cutback bitumen. The Contractor shall test the cutback bitumen prepared in the field for conformity with the specified requirements of AS 2157. Tests shall be in accordance with AS 2341 and results made available to the Engineer.

Where refinery prepared cutback bitumen is used the sealing grade selected shall be appropriate to the road surface temperature at the time of spraying.

6.2.3 Percentage of Cutter

If it is necessary for the bitumen to be cut back, the percentage of cutter to be added to the bitumen at any time during the course of the work shall be determined by the Engineer. Mixing shall be carried out on the site, except as may be otherwise authorized by the Engineer. The cutter, without being previously heated, shall be pumped into the distributor through the bitumen when heated to a temperature within the range 165°C - 175°C (325°F - 350°F) and the mixture shall then be circulated for at least 15 minutes before application.

6.2.4 Adhesion Agents

To improve the adhesion of cover aggregates to the binder, an acceptable adhesion agent shall be added to the binder in accordance with the manufacturer's recommendations. The Contractor shall submit his proposals, together with written evidence of the successful use of such additives, to the Engineer for his acceptance prior to purchasing.

6.2.5 Aggregate

Aggregates shall consist of clean, hard, dry, tough, sound, crushed stone or crushed gravel of uniform quality, free from dust, clay, dirt or other deleterious matter and from excess of flat or laminated pieces and shall be of such a nature than when thoroughly coated with the bituminous material proposed for the work, the coating will not peel off upon contact with water.

They shall comply with the following requirements:-

(a) The percentage of wear as determined by AS 1141 Sec. 23, 1974 shall not exceed 30.

(b) Soft particles shall not exceed 2.5% by weight.

(c) The flakiness index of the aggregate retained on the sieve stated in sub-paragraph (f) for the particular nominal size of aggregate shall not exceed 30% when tested in accordance with BS 812.

(d) The portion retained on a 9.5mm sieve shall not contain more than 10% by weight of particles in which the ratio of maximum to minimum dimensions exceeds 5:1.

(e) When crushed gravel is used, not less than 60% by weight of the particles retained on a 4.75mm sieve shall have at least two fractured faces.

(f) The grading of the aggregates shall fall within the limits for the appropriate nominal size shown in the following table:-

AS Sieve Size	Percentage by Weight Passing Sieve Size	
	Aggregate Nominal Size	
	19mm	9.5mm
26.5 mm	100	
19.0 mm	95-100	
13.2 mm	0- 20	100
9.5 mm	0- 5	95-100
6.7 mm	-	0- 40
4.75 mm	-	0- 5
2.36 mm	0- 2	0- 2
Test for Flakiness Index	13.2 mm	6.7 mm

The Contractor shall determine the Average Least Dimension (ALD) of the aggregate by the methods set out in Road Note 3 - "A Guide to Surface Dressing in Tropical and Sub-Tropical Countries", published by the Transport and Road Research Laboratory, United Kingdom.

(g) The Aggregate Crushing Value as determined by As 1141 Sec 21 shall not exceed 20.

(h) The loss of weight of aggregate shall not exceed 12% when tested in accordance with AS 1141 Sec 24.

6.2.6 Aggregate Size

For a double application of bituminous material and cover aggregate, the aggregate for the first application shall be 19mm nominal size, and for the second 9.5mm nominal size. The grading shall comply with Clause 6.2.5 (f).

6.2.7 Aggregate Stockpiles

Aggregates shall be stockpiled clear of traffic, drains and services and other property on well-drained ground acceptable to the Engineer. A separate stockpile shall be made for each nominal size of aggregate at each location and each shall be at least 15 metres from the adjoining stockpile. The site of the stockpile shall be cleared of all vegetation and debris, graded and drained for an area extending 5 metres outside the limits of the stockpile and, where the Engineer deems it necessary, the area shall be surfaced with a 100 millimetres layer of approved stone or rock. Unless otherwise agreed to the Engineer each stockpile shall be built 1 metre high over the whole area of the stockpile and with side slopes of 1 vertical to 1/2 horizontal. The Contractor shall supply any planking or other material required in connection with movement of vehicles over and about the stockpiles. The bottom 50 millimetres layer of aggregate or any contaminated aggregate shall not be used in the work.

6.2.8 Precoating of Aggregate

Particles of aggregate must be completely but thinly coated by means of a fine pressure spray on a moving stream of aggregate or by means acceptable to the Engineer. The quantity of precoating material needed will vary with the nature of the stone but will be within the range of 5.95 to 11.9 litres per cubic metre. Precoating material shall be a distillate with 10% bitumen and 1% megamine BA or equivalent, unless otherwise agreed to the Engineer.

6.2.9 Plant and Equipment

The Contractor shall supply details of the make, model, capacity, weight and such other details of the plant and equipment as may be required by the Engineer. Such equipment shall include a power broom or a power blower or both, a drag broom, a self-propelled pneumatic tyred roller, aggregate spreading equipment, an adequate number of trucks and, when necessary equipment for heating bituminous material. A steel wheeled roller may be used only when so authorized by the Engineer. The plant and equipment shall comply with the following requirements:-

(a) The bituminous material distributor shall conform to the requirements for the mechanical distributor described in Clause 6.1.6.

(b) The power broom shall be a rotary broom, towed or self-propelled, specifically designed for sweeping road surfaces.

(c) The drag broom shall be capable of distributing unevenly spread aggregate without disturbing the particles freshly bedded in the binder.

(d) The pneumatic tyred roller shall be of an approved type having not less than seven wheels mounting smooth tread compactor tyres of equal size and construction capable of operating at inflation pressures up to 8500 grams per square centimetre. Wheels shall be equally spaced along both axle lines and arranged so that tyres on one axle line track midway between those on the other with an overlap. Each tyre shall be kept inflated to the specified pressure such that the pressure difference between any two tyres shall not exceed 350 grams per square centimetre. Means shall be provided for checking and adjusting the tyre pressure on the job at all times. For each size and type of tyre used the Contractor shall supply to the Engineer charts or tabulations showing the relationship between wheel load, inflation pressure and tyre contact pressure, width and area.

Each roller shall be equipped with a means of adjusting its total weight by ballasting so that the load per wheel can be varied from 1,500 to 2,500 kilograms. In operating, the tyre inflation pressure and the wheel load shall be adjusted, as approved by the Engineer, so that contact pressure is as high as the material will support.

(e) The steel wheeled roller, where its use is permitted, shall have a load of between 25 to 45 kilograms per centimetre width of roll.

(f) The aggregate spreader shall be acceptable mechanical equipment capable of spreading a uniform layer of cover aggregate of the specified sizes.

(g) Heating equipment shall be capable of producing uniform heating to the required temperature without damage to the bituminous material. An approved instrument for temperature measurement with an accuracy of plus or minus 3% shall be provided.

Means shall be provided to drain completely the heating tank or tanks. Three or more approved fully charged chemical fire extinguishers and a

stockpile of approved loose sandy material, and shovel, shall be provided and shall be placed adjacent to the heaters while heating is in progress.

6.2.10 Surface Preparation

Prior to the application of binder, loose stones and dirt and other objectionable material shall be removed from the surface by means of the power broom or blower or both but without dislodging the stones embedded in the pavement. If this does not produce a uniformly clean surface, additional sweeping shall be done by hand, using stiff bass or similar brooms. Sweeping shall extend at least 200 millimetres beyond each edge of the area to be sprayed. Adherent patches of objectionable material shall be removed from the surface by steel scraper or other approved method and where the Engineer so directs the scraped area shall be washed down with water and hand brooms. No application of bituminous material shall be undertaken until the pavement has been cleaned and patching of the surface of the road has been completed to the approval of the Engineer. Any area in which the prime coat has been insufficiently applied or is defective in any way shall be reprimed as directed by the Engineer. A period of at least 24 hours or such longer period may be necessary for the prime coat to become completely dry shall elapse before any further bituminous material is applied.

6.2.11 Application Rate

The application rate of bituminous binder material and cover aggregate shall be determined by the Engineer by the methods set out in Road Note 3 - A Guide to Surface Dressing in Tropical and Sub-Tropical Countries, published by the Transport and Road Research Laboratory, United Kingdom. The application rates shall be subject to the acceptance of the Engineer, which acceptance will not relieve the Contractor of his responsibilities under the Contract

The application rate of bituminous binder material may lie within the range of 1.25 - 1.65 litres per square metre for 19mm cover aggregate and 0.60 - 1.00 litre per square metre for 9.5mm cover aggregate. The application rate of cover aggregate may lie within the range of 65 - 80 square metres per cubic metre for 19mm and 100 - 135 square metres per cubic metre for 9.5mm.

A period not less than six weeks shall be allowed between the first coat of seal and the second coat of seal unless the Engineer authorises otherwise.

The Engineer reserves the right to withdraw acceptance of the application rates during th course of the work if the workmanship is found to be unsatisfactory and may require the Contractor to carry out further calculations and testing. The application of bituminous binder material shall be made by means of a mechanical distributor except that where the use of distributor is not practicable for the application to small areas, the application to such areas, as the Engineer may accept, may be done by means of hand held spray equipment attached to the distributor.

6.2.12 Spraying Temperature

The temperature at the time of spraying the bituminous material shall be within the range of 163°C to 185°C.

At no time during the heating shall the upper limit be exceeded. Quantities of bituminous materials in excess of requirements shall not be heated, nor shall such materials be held at temperatures within the spraying range for periods in excess of ten hours. Any bituminous material which has been heated for an excessive period of time or which has been overheated shall be rejected.

6.2.13 Area to be Sprayed

The area to be sprayed with bituminous material at any time shall be limited to that which can be covered with aggregate at the specified rate within 15 minutes of the time of spraying or such smaller period of time as the Engineer shall direct. When so directed the bituminous material shall be applied in lanes of approximately one half of the width of the completed surface and when so applied there shall be an overlap of 75 millimetres of bituminous material along the adjoining edges. The width of the area sprayed shall not vary by more than + 50 millimetres from the width specified in the Contract. The area to be sprayed shall be marked prior to spraying operations commencing for that area.

6.2.14 Construction Limitations

No spraying shall be carried out on a wet pavement nor when rain appears imminent nor during high winds nor when the ambient temperature is below 18°C. The Engineer may order work to cease temporarily on account of adverse weather, unsatisfactory condition of materials equipment, pavement or any condition which he considers may affect the work adversely.

6.2.15 Spraying

Spraying shall commence and finish on a protective strip of paper or other approved material laid across the surface for at least the full width to be sprayed. Paper or other material so used shall be immediately removed and

disposed of in a manner satisfactory to the Engineer. The distributor shall commence moving at a sufficient distance in advance of the start of the application to ensure that the correct road speed for the required application is attained before the spray nozzles are opened and shall maintain this speed until past the finishing point of the application. Spraying shall cease immediately if any defect develops in the spraying equipment and it shall not recommence until the fault has been rectified.

Provision shall be made for 10 percent, or such other percentage as may be determined by the Engineer, of the rated capacity of the distributor tank to be retained in the tank at the completion of each run, so as to avoid air entrainment within the delivery system and provide for any minor excess in the rate of application.

After each application, the quantity of material sprayed shall be checked against the area covered, and any necessary adjustment shall be made to ensure that the specified rate of application is maintained in subsequent runs.

6.2.16 Cover Aggregate Supply

Before the bituminous material is applied, sufficient cover aggregate shall be in trucks at the site of the work to provide the full cover for the area to be sprayed. The application of the aggregate shall proceed immediately after application of bituminous material commences and shall be completed within 15 minutes of the completion of spraying or such shorter period of time as the Engineer shall direct. The aggregate shall be spread uniformly over the bituminous material by means of an aggregate spreader acceptable to the Engineer. Any bare or insufficiently covered areas shall be re-run by the mechanical spreader or covered by hand as necessary to give uniform and complete coverage. Any excess aggregate shall be removed and stockpiled as directed by the Engineer.

6.2.17 Compacting and Finishing

Immediately after spreading to the satisfaction of the Engineer, the aggregate shall be rolled with one or more pneumatic tyred rollers or, if permitted by the Engineer, by approved steel wheeled rollers, until the aggregate is firmly embedded in the bituminous material. Where required to ensure an even distribution of aggregate the surface shall be drag broomed after the initial rolling, except that if the drag broom has any tendency to dislodge aggregate particles bedded in the binder the Engineer may direct that drag brooming be deferred or eliminated and that light hand brooming be substituted. Rolling shall be

continued, as directed by the Engineer, for as long as necessary to ensure thorough incorporation of the aggregate into the binder. Immediately after the binder has hardened to the stage at which, in the opinion of the Engineer, no more aggregate can be pressed into it by rolling, any remaining loose particles shall be removed from the pavement and shoulders.

6.2.18 Traffic Restrictions

No traffic shall be permitted to pass the working area during the application of bituminous material nor shall traffic be permitted to encroach upon the edge of bituminous material until such time as it is covered with aggregate. The Contractor shall take all reasonable precautions to protect traffic against damage or disfigurement by construction equipment, tools and materials, splashes and smirches of bitumen or other construction materials and shall be responsible for any claims arising from such damage or disfigurement.

Traffic shall not be allowed on the new work until sufficient rolling has taken place to minimise the risk of disturbing the aggregate. Traffic shall then be allowed to run on the work at a controlled speed. Approved signs bearing the words "Wet Tar" and "20 km/h" shall be erected at appropriate locations not more than 300 metres apart and shall remain in position during and for 24 hours after each day's work. Other signs, signals, barriers and lamps for warning and guidance of traffic shall be provided at all times during the course of the work in accordance with Group 1, General.

6.2.19 Monitoring of Completed Work

After completion of this work and until the end of the Maintenance Period, the treated surface shall be constantly checked for any tendency to softening or bleeding and these should be attended to by addition of small quantities of aggregate evenly spread. All loose aggregate shall be kept evenly distributed over the surface by drag brooming or light sweeping to the satisfaction of the Engineer. Should any break occur in the surface the area affected shall be thoroughly cleaned and treated with binder and aggregate as directed by the Engineer.

6.2.20 Measurement

Measurement of bituminous surface treatment shall be:-

(a) The volume of bituminous binder material specified or ordered for any section calculated from the sprayed area of the section and the authorised rate

of application or shall be the actual volume sprayed and accepted, whichever is lesser. The measured quantity shall be for the residual bitumen Class 170 excluding cutter oil for which separate measurement will be made as indicated in sub-paragraph (b) below.

(b) The volume of cutter required to be mixed with the volume of residual bitumen measured as specified herein or, where refinery prepared cutback bitumen is used, the volume of cutter in the mixture which shall be taken as follows:

Cutback Bitumen Sealing Grade	A M C5	A M C6	A M C7
No. of parts by volume Residual Bitumen Class 170	100	100	100
No. of parts by volume of Cutter	12	7	3
Equivalent percentage of Cutter in mixture	11	7	3

(c) The quantity of adhesive agent in litres actually used as directed.

(d) The quantity of precoating material in litres actually used as directed.

(e) The quantity of cover aggregate in cubic metres calculated from the specified or directed surface areas of the work and the authorized rate of application or the actual volume spread and accepted whichever is the lesser.

The volume of bituminous binder material shall be determined at the temperature of application and converted to litres at 15°C in accordance with the requirements of ASTM Designation 1250 - 80, ASTM - IP Petroleum Measurements Tables. Volumetric measurements shall be taken when the material is at a uniform temperature throughout its volume and free from air bubbles. The volume shall be divided into the percentage of Class 170

bitumen and the percentage of cutter directed by the Engineer's Representative or where refinery prepared cutback bitumen is used, the percentage of cutter shown in the table above sub-paragraph (b).

6.2.21 Payment

This work, measured above, as specified in Clause 6.2 shall be paid for at the scheduled rate respectively, for each of the items listed above. The rates shall be full compensation for furnishing, mixing and placing all materials, including all labour, equipment, tools and incidentals necessary to complete the work including the rectification of any defective work. The rate for covering aggregate shall also include for the producing aggregate, including crushing and screening, and clearing, removal of overburden and the construction of access roads where required at the river deposit area. Interim payments may be made on the quantity of cover aggregate satisfactorily stockpiled on site at the rate of 40% of the scheduled rate for the respective size of cover aggregate providing that the Contractor's intention to use the material in the Works is clear. Sections of seal in which the workmanship is not strictly in accordance with the requirements of this Specification or the direction of the Engineer, may be deleted by the Engineer, at his sole discretion, from certification for payment for such sections until the Contractor has submitted proposals, approved by the Engineer, for the rectification of the works for those sections where the Contractor's (or his sub-contractor's) workmanship was not in strict accordance with the Specification or the requirements of the Engineer.

GROUP 7

DRAINAGE

GROUP 7

DRAINAGE

7.1 General

The work covered in this Specification shall be the construction of corrugated steel pipe culverts and associated activities.

The details of the location, sizes, lengths, skew angle, invert levels and types of culvert required are provided on the Drawings and this, together with other necessary information, shall be verified by the Engineer in every instance prior to work being commenced.

The Contractor shall submit details of his proposals for installation of corrugated steel pipes in the common swamp area and the Alika Swamp to the Engineer prior to the commencement of Works. Works shall not commence until the Engineer has indicated that he has no further comment on the Contractor's proposals.

7.2 Materials

7.2.1 Corrugated Steel Pipes

Corrugated steel pipe sections shall comply with the requirements of the current Australian Standards 2041 and 2042 for both Riveted, Nestable and Bolted pipes so defined therein. Unless otherwise shown or permitted by the Engineer, all Bolted pipes to be incorporated in the Works shall have had their load carrying capacity increased by shop rolling of the plates at the place of manufacture so that there is a 5 percent increase in the dimension of their vertical axis.

No variation greater than plus or minus 25 percent of the specified elongation (5%) will be accepted. All pipes shall be hot dip galvanized unless otherwise directed.

The gauge and length of the pipe shall be as shown on the Drawings or as directed by the Engineer after analysis of the soil type to be used as backfill.

7.3 Excavation and Bedding

(1) The Contractor shall carry out all necessary excavation associated with the laying of the culvert including excavation for the specified foundation or bedding material and shall dispose of surplus material as directed by the Engineer.

Culvert beddings shall be carried out in accordance with this Specification and in accordance with the Drawings. Where selected material is not ordered below the bedding layer the top 150mm of the foundation area shall be thoroughly compacted to the relative dry density of the equivalent adjacent embankment material as specified in Clause 4.15. The Contractor shall trim the foundation to the correct line and level specified on the Drawings or as directed by the Engineer.

(2) The Engineer may require the culverts to be laid in a trench excavated in the embankment after this has been constructed to the level of the top of the culvert. The width of the trench shall be just sufficient to permit satisfactory jointing of the culvert and thorough compaction of bedding and backfill material under and around the pipe.

(3) Where rock is encountered at or above the proposed invert level of the culvert, it shall be excavated to a depth at least 150mm below the underside of the pipe and the area backfilled with selected material as defined in Clause 7.5 and compacted to a density required by this Clause. Uneven surfaces shall be corrected with a mass concrete bedding so as to provide a uniform surface at least 50mm above the highest points of rock.

(4) Where the foundation material is soft and spongy or otherwise consists of unsuitable material it shall be removed as directed by the Engineer, and backfilled with material as defined in Clause 7.5.

(5) All culverts shall be bedded on sand or other approved fine granular material at least 150mm thick. Beddings on all pipe culverts shall be shaped to fit the underside of the culvert for a depth of one tenth the pipe diameter and graded to provide uniform bearing throughout the length.

7.4 Placing

7.4.1 Corrugated Steel Pipe - Riveted and Nestable

Unless otherwise allowed by the Engineer assembly of riveted and nestable culverts shall commence at the inlet and progress to the outlet end. The full circle shall be assembled and fastened with the bottom plates one sheet ahead at all times and circumferential joints staggered. As additional sections are added to the pipe, they shall always be placed outside the section already placed and fastened. The pipe shall be assembled and placed with the longitudinal joints in the same horizontal plane. A pipe may be wholly or partially assembled adjacent to its final

location and lifted into position. Proper facilities shall be provided for careful handling without excessive deflection. Any pipe which shows any undue settlement after laying or is in any way damaged shall be taken up and relaid or replaced at the Contractor's expense. Where more than one barrel forms the culvert, adjacent sides shall be spaced as shown on the Drawings.

7.4.2 Corrugated Steel Pipe - Bolted

Unless otherwise allowed by the Engineer, the assembly of Bolted culverts shall commence by laying all the bottom plates first from the outlet end. Side and top plates shall then be added generally completing the circle in sections but commencing at the inlet end. Side plates shall be added only so far ahead as is necessary support the plates above. Only sufficient bolts shall be inserted during this stage to hold the plates in position with the nuts screwed up but not tightened. When all the plates are in place all bolts shall be inserted and the nuts thoroughly tightened. When all the bolts in the complete assembly have been inserted and tightened they are to be checked again and retightened where any slackness has occurred. Where more than one barrel forms the culvert, adjacent sides shall be spaced as shown on the Drawings.

7.4.3 Concrete Invert In Corrugated Steel Culverts

Where directed by the Engineer, concrete Grade 20 shall be placed along the invert of corrugated steel pipe culverts to a width equal to half the diameter of the pipe. The concrete shall be placed symmetrically about the invert of the culvert and be 35mm above the crest of the corrugations. The pipe shall be cleaned before placing the concrete. The concrete shall be thoroughly worked into the corrugations and shall be screened and floated off to provide a uniform surface free of depressions. The edge of the concrete paving shall be struck off so that no water will lodge in the corrugations. Water shall not be permitted to flow through the culvert for at least 2 days after placing. Concrete shall be measured and paid for according to the Specification Group 14.

7.5 Backfilling

Backfill shall not be placed until the culvert has been inspected and approved for backfill. The backfill material shall be selected granular material free from lumps and vegetable matter and boulders or stone of greater size than 75mm and having at least 50% retained on 2.36mm sieve. The plasticity index of this material shall not exceed 12% when tested in accordance with AS 1289.

Backfill material shall be placed in uniform horizontal

layers not exceeding 150mm thickness and shall be thoroughly compacted to 95% of the maximum dry density determined by AS 1289 Test No. E1.1 except that any backfill within 300mm of the underside of the subbase level shall be compacted to 100% of the laboratory maximum dry density. The density of the material shall be determined by AS 1289 Test No. E3.1. Material under the haunches of the pipes and those near the sides of the culverts shall be compacted with hand held equipment. The backfill on both sides of the culvert shall be placed concurrently, the levels of each side differing by no more than 150mm at any stage. Special care shall be exercised to prevent distortion of the corrugated metal pipe during the backfilling. Backfilling material shall be placed around the culverts to a depth of 300mm above the top of the culverts unless in a trench, and for a minimum distance of one diameter from the centreline of the pipe. Where the culvert is laid in a trench the backfill shall be placed for the full width and depth of the trench.

During construction of the Works, care shall be taken to avoid damage to culverts by the passage of heavy construction equipment, and the Contractor shall be wholly responsible for any damage occurring from such operations.

7.6 End Treatments

Where indicated on the Drawings or as directed by the Engineer end treatments shall be constructed in accordance with the Standard Drawings as amended by the Engineer. The construction of these treatments at both inlet and outlet may be reinforced concrete Grade 20 when the requirements of Group 9 and Group 14 shall apply or in cement mortar stone pitching when the requirements of Group 9 shall apply.

7.7 Inlets and Outlets to Culverts

Inlet and outlet ditches to culverts shall be constructed for such length, width and depth and fall as will ensure correct functioning of the culvert as directed by the Engineer.

Where additional stone pitching or scour protection are ordered the work necessary shall be paid at the corresponding rates entered in the Bill of Quantities.

7.8 Taking Up and Stacking Culverts

Where shown in the Drawings or ordered in writing by the Engineer culverts shall be carefully taken up and stacked neatly in lines in an accessible position acceptable to the Engineer at least 1 m clear of all earthworks,

watercourses, drains, fences or timber.

7.9 Measurement and Payment

Culverts shall be measured as the length of each separate barrel, nominal size, type, class and plate thickness, complete in place and accepted, as shown on the Drawings or as directed by the Engineer. The length of the culvert shown on the Drawings or directed by the Engineer shall refer in the case of a vertical ended culvert (square or skew) to the length along the invert of one barrel and in the case of a bevel ended culvert (square or skew) to the mean of the invert and obvert lengths. Payment shall be made at the rates entered in the Bill of Quantities per metre for each culvert depending on size, type, class or plate thickness. These prices shall include full compensation for supply, transport, laying, assembling or jointing, compaction of foundation and bedding, and for all labour, materials, plant and equipment, tools and incidentals necessary to complete the work herein specified.

Such incidentals shall include the necessary work for excavation and backfilling required for all culverts.

In case of culvert pipes installed at the Alika Swamp, such incidentals shall include the necessary work for excavation and backfilling, coffering and dewatering.

End treatment works including end wall, reinforced concrete or stone pitched, aprons, riprap shall be measured and paid for at the respective scheduled rate in the Bill of Quantities, Group 7.

Excavation for inlets and outlets shall be measured and paid for as provided in Clause 4.17.

7.10 Subsoil Drains

Subsoil drainage shall consist of perforated unplasticised polyvinyl chloride (UPVC) pipes, conforming to AS 1260 of nominal internal diameter 100mm, installed in a trench, as shown in the Drawings. The trench shall be backfilled with hard, clean, crushed rock or naturally occurring gravel filter material graded as shown below.

Range of Grading Filter Material

Sieve	% Passing by Mass
63 mm	100
37.5 mm	85 - 100
20 mm	0 - 25
10 mm	0 - 5

Subsoil drains shall be measured as the length complete in place inclusive of filter material and pipe as shown on the Drawings and as directed by the Engineer. Payment shall be made at the scheduled rate entered in the Bill of Quantities per metre, and the rate shall include full compensation for furnishing and placing all material, including all labour, equipment, tools and incidentals necessary to complete the work.

GROUP 8

ROAD FURNITURE AND MARKINGS

GROUP 8

ROAD FURNITURE AND MARKINGS

8.1 Road Signs

8.1.1 General

Permanent road signs shall be supplied and installed at specific locations in accordance with this Specification and as indicated on the Drawings.

8.1.2 Standard

Signs shown on the Drawings shall be manufactured and erected in accordance with the Australian Standard Specification for Road Signs AS 1743 - 1975.

Sign faces shall be reflectorised using heavy duty reflectorised paint conforming to AS 1906,Retroreflective Materials and Devices for Road Traffic Control Purposes.

8.1.3 Measurement and Payment

This work shall be measured as the actual number of traffic signs complete with plates and posts erected and accepted, and shall be paid for at the scheduled rate for the item in the Bill of Quantities. This rate shall include full compensation for furnishing, treating, labour, tools and incidentals necessary to complete the work as directed by the Engineer.

8.2 Guard Rails and Road Edge Guide Posts

8.2.1 General

Guard rails, posts and road edge guide posts shall be constructed and erected in accordance with the Drawings or as directed by the Engineer.

8.2.2 Timber Post for Guard Rails and Road Edge Guide Posts

Timber posts for guard rails and road edge guide posts shall be made from sound, fully seasoned approved Papua New Guinea hardwood of straight grain and free from shakes, knots and other defects and have a strength not less than Department of Forestry Designation Strength Group 3. Posts shall be sawn square and straight on all sides and shaped to the required dimensions. The posts shall be chamfered on the top as shown on the Drawings.

The timber shall be pressure treated with copper chrome arsenic solution to a retention of not less than 0.032 gram per cubic centimetre or as recommended by the Department of Forests for the type of timber used.

8.2.3 Steel Beam Guard Rails and Posts

The steel beam guard rails and posts shall be fabricated in a shop from a single steel plate of approved type, thickness and design as shown in the Standard Drawings or as directed by the Engineer. No punching, cutting or welding shall be done in the field except that holes for special details may in exceptional circumstances be drilled in the field when approved by the Engineer.

Bolts, nuts and washers shall comply with Australian Standards 1111, 1112 and 1237 and shall be galvanized to comply with Australian Standards 1214 and 1650 as appropriate. Bolts shall be sufficiently long to extend at least 6mm beyond the nuts but except where required for adjustment shall not extend more than 12mm beyond the nuts.

8.2.4 Erection of Steel Beam Guard Rails

The posts shall be set to line, grade and spacing consistent with erection of the rail in a manner that will result in a smooth continuous taut guard rail closely conforming to the line and grade of the roadway. After setting the posts, the holes shall be backfilled with approved material and thoroughly tamped. When the end of a section of guard rail is to be splayed out as shown on the Drawings, the posts shall be set to accommodate the splaying.

The laps in the rail shall be such that the ends of the rails do not face oncoming traffic in the adjacent lane.

The rail shall be erected so that the bolts at expansion joints shall be located at the centres of the slotted holes. All bolts except where otherwise required at expansion joints shall be drawn tight. Bolts through expansion joints shall be drawn up as tight as possible without being so tight as to prevent rail elements from sliding past one another longitudinally.

Painting and treatment of the rail and posts is to conform with the requirements of the Drawings or as directed by the Engineer. Where galvanized rail is to be painted the surface is to be treated first with a weak solution of copper sulphate.

8.2.5 Erection of Road Edge Guide Posts

Road edge guide posts shall be set to the appropriate position as shown on the Drawings and shall be spaced as

directed by the Engineer. The posts shall be set truly vertical and the tops of the posts shall exhibit a uniform grade.

Painting and treatment of the posts is to conform with the requirements of the Drawings or as directed by the Engineer.

Delineators 50mm square shall be affixed to the posts after painting in an approved manner in accordance with the Drawings.

8.2.6 Measurement and Payment

Road edge guide posts, timber or steel posts for guard rails, and standard terminal sections for guard rails, installed, completed and accepted by the Engineer shall be measured for payment on a number basis.

Steel beam guard rail installed, completed and accepted by the Engineer shall be measured by length in metres from centre to centre of end posts.

Payment shall be made at the scheduled rate entered in the Bill of Quantities and shall be full compensation for excavation, backfill, concreting, furnishing all materials, labour, tools and equipment and for all expenses necessary for placement, erection and installation.

8.3 Pavement Marking Paint

8.3.1 General

This Specification applies to paints suitable for application by spray to road surfaces consisting of asphaltic concrete and bitumen seal coats.

8.3.2 Paint for Road Marking

Paint shall be in accordance with AS K146-1967 Road Marking Paints. The colour shall be white, type 2 and of the class appropriate to the method of application. The paint shall be supplied fresh and ready for use in sealed containers which shall be stored in accordance with the manufacturer's instructions.

8.3.3 Pavement Marking Type

All pavement marking types will be indicated in the Drawings and shall be in accordance with Standard Drawing No. S1, Pavement Markings.

8.3.4 Pavement Condition

All pavement marking shall be painted only on a surface which is clean and dry and in the opinion of the Engineer in suitable condition for application of paint.

8.3.5 Measurement and Payment

The work shall be measured as the actual length of painted line in metres accepted by the Engineer. The scheduled rate shall include the preparation of the surface to be painted, the supply of paint, all labour, equipment, tools and incidentals necessary to complete the work. The rate of application of the paint shall be 2.0 square metres per litre, with a tolerance of +0% - 10%.

8.4 Road Edge Markers

Road edge markers shall be set to the appropriate position as shown on the Drawings or as directed by the Engineer. The markers shall be a reflectorized concrete block and shall conform with the requirements of the Drawings.

Payment shall be made at the scheduled rate entered in the Bill of Quantities and shall be full compensation for excavation, concreting, furnishing all materials, labour, tools, equipment and incidentals to complete the work.

GROUP 9

MASONRY FOR STRUCTURES

Clause No.	Title
9.1	Stone Pitching
9.2	Rockwalling

GROUP 9

MASONRY FOR STRUCTURES

9.1 Stone Pitching

9.1.1 General

Stone pitching shall be laid where specified on the Drawings or ordered by the Engineer as slope protection, aprons, etc. at the inlets and outlets to culverts and other erodable areas where protection is required. The stone shall be roughly dressed naturally occurring sound rock with a general minimum dimension of 150mm and maximum dimension of 450mm and of such shape as can allow close laying.

9.1.2 Mortar for Grouting

Mortar for the cement grouting of stone pitching shall consist of one part of Portland Cement to two parts of clean well graded fine sand mixed with just sufficient water to be of workable consistency. Mortar shall be used within 30 minutes of adding water.

9.1.3 Laying

The stones shall be well bedded in mortar, trowelled to a depth of 60 percent of the maximum thickness of the stones, onto the underlying formation. They shall fit closely and present an even top surface. The large stones shall be used as toe stones at edges or in aprons. Stone pitching shall be placed on freshly excavated and stable surface and when on any embankment or backfill, this shall be compacted well in advance of the pitching to avoid settlement. Where a foundation for stone pitching is not rock or other hard non-erodable strata, it shall be founded and sealed on the bottom with a cut-off wall at least 450mm thick or as shown on the Drawings. The trench for the cut-off wall after dewatering shall be filled with mortar to a depth of 60 percent of the maximum dimension of the stones and immediately thereafter place stones in the unset mortar so as to make a solid dense wall. The process shall be repeated until the trench is filled. Only such length of trench is to be worked upon at a time as to ensure that all stones can be inserted in the fresh mortar. Stone pitching shall be placed in tight contact with a cut-off wall or other foundation and laid from the bottom towards the top. Weepholes shall be constructed as shown on the Drawings or as directed by the Engineer.

9.1.4 Cement Grouting of Stone Pitching

The mortar shall be applied by means of a trowel and shall be well rodded between the stones so that the interstices

are completely filled as far down as practicable but to a depth of at least 75mm. The grouted stone shall be kept damp for at least 48 hours after the mortar is set.

9.1.5 Measurement and Payment

Payment will be made at the scheduled rate per cubic metre for stone pitching to culvert structures and cut-off walls, or at the rate per linear metre for stone pitching to table drains as itemised in the Bill of Quantities for Cement Grouted Stone Pitching. The volume shall be measured by multiplying the surface area by the average depth perpendicular to the surface. The length in linear metres shall be measured along the longitudinal centreline of the drain. This rate shall be accepted as full compensation for all material, excavation, dressing, curing, handling, transporting, backfill, mortar, weepholes, labour, equipment, tools and incidentals necessary to complete the work.

9.2 Rockwalling

9.2.1 General

Where shown on the Drawings or otherwise directed by the Engineer, rockwalling shall be constructed in accordance with Standard Drawing No. S26 to the lines and levels shown or directed. It shall consist of sound durable stones, of not less than 0.016 cubic metres in volume, at least 150 millimetres in vertical dimension and 300 millimetres in both horizontal dimensions. Stones shall be roughly dressed and coursed and all vertical joints shall be broken. The base of the wall shall be bedded in a trench at least 300 millimetres deep unless it is founded on rock, in which case the wall shall be securely bedded on the rock by keying or interlocking.

The wall shall be built up simultaneously with the filling of the bank. When it is found necessary to use stones smaller than those specified above for wedging, such stones shall be adequately bonded to the adjacent courses with cement mortar. However, under no circumstances shall more than two wedging stones be bonded to any stone of volume 0.016 cubic metre or more. The cost of any cement mortar bonding required, excavation and backfilling shall be deemed to be included in the scheduled rate.

9.2.2 Cement Grouted Rockwalling

Cement grouted rockwalling shall be constructed to the details given in Clause 9.2.1 above except that:-

(i) Stones used shall be minimum volume 0.016 cubic metre and least dimension 200 millimetres.

However, for each stone of this minimum size placed up to two stones of some lesser dimension may be used for wedging.

(ii) Each stone shall be firmly bedded in cement mortar prepared as specified elsewhere for cement grouting of stone.

(iii) Weepholes shall be provided as shown on the Drawings or otherwise directed by the Engineer.

9.2.3 Masonry Rockwalling

Masonry rockwalling shall be constructed to the details given in Clause 9.2.1 above except that:-

(i) Stones used shall be a minimum of 0.016 cubic metre with a least dimension of 200 millimetres.

(ii) Each stone shall be properly bedded with a gap of not more than 25 millimetres between stone faces.

(iii) Each stone shall be firmly bonded in cement mortar prepared as specified elsewhere.

(iv) Weepholes shall be provided as shown on the Drawings or otherwise directed by the Engineer.

9.2.4 Weathering

Grouted and masonry rockwalling shall be weathered on the top with a twenty five millimetres thick layer of cement mortar splayed one in three and neatly trowelled to an even surface with clean sharp ridges and angles.

9.2.5 Measurement

The scheduled rate for rockwalling in each of the three categories stated above shall include for all work specified for the complete construction of the rockwall. Measurement of the volume in cubic metres for which payment will be made shall be based on the dimensions shown on the Drawings for the extent of rockwalling constructed in accordance with the Contract.

GROUP 10

PILING FOR STRUCTURES

GROUP 10

PILING FOR STRUCTURES

10.1 General

The Contractor shall supply all labour, materials, equipment and incidentals as necessary to furnish, install, drive and test piling for structures. Piling for structures shall include steel pipe piles, timber piles, cast-in-situ bored piles and driftwood prevention piles as shown on the Drawings.

Prior to commencing the work, the Contractor shall submit to the Engineer for approval full details of the proposed schedule and method of working including the procedures and sequence of pile installation, the specification of all equipment to be used and any other information requested by the Engineer. Approval of the Engineer shall be obtained in writing prior to commencing any piling, which approval shall not relieve the Contractor of any of his responsibility.

During the installation of steel pipe piles and cast-in-situ bored piles, the Contractor shall provide an engineer (experienced in such work) full time on Site.

10.2 Materials

Piles used on the Works shall be in accordance with the Drawings unless otherwise directed by the Engineer.

(1) Steel Pipe Piles

Steel pipe piles shall conform to JIS A 5525 (SKK 41) or equivalent.

Concrete and reinforcement placed in the steel pipe piles shall conform to the requirements of cast-in-situ bored piles.

(2) Timber Piles

Timber piles shall be made from native hardwoods recommended as suitable for such usage in the Department of Forest Booklet, "Papua New Guinea Timbers, Properties and Uses" and "A guide to Specifying PNG Timber for Structural and Non Structural Purposes" as published and printed by the Forest Industries Council of Papua New Guinea or as approved by the Engineer.

The timber piles shall be free from defects deleterious to their strength and durability. Knots shall not exceed 5% of pile diameter in size.

Piles shall meet straightness criteria such that the centroid of any cross section shall not deviate by more than 40 mm from the straight line connecting the centroids of the end faces of the pile.

(3) Cast-in-situ Bored Piles

Concrete quality shall be Grade 30. Cement, fine and coarse aggregates, water and additives shall conform to the requirements of Group 14 of this Specification. Steel reinforcement shown on the Drawings shall conform to the requirements of Group 13 of this Specification.

(4) Driftwood Prevention Piles

Driftwood prevention piles shall be provided at Bridges No 4, No 6 and No 7 and conform to Sub-Clause 10.2(1) and 10.2(3) of this Clause.

10.3 Accuracy

The piles shall be set out in the position shown on the Drawings. The head of completed pile shall be within 75 mm of the correct position in any direction. The maximum deviation from the plumb of the specified batter shall not exceed 1 in 100 to the vertical or to the line of the batter respectively.

Where a pile has not been positioned and driven within the above limits such piles shall not be forcibly corrected for line or position. The Engineer shall decide what corrective measures are appropriate. Such measures may include the construction of additional piles at the Contractor's cost.

10.4 Driven Piles

10.4.1 Programming

The work shall be programmed to allow ample time for procurement of additional lengths of piling, should the piles act, under actual driving, in a manner outside the range of that allowed for in the design.

Any delay in the delivery of piling materials to the Site shall be at the Contractor's expense and shall not qualify for an extra to the Contract.

10.4.2 Handling and Storing of Piles

Handling, transporting, storing and pitching shall be carried out in such a manner as will ensure that the piles are not damaged in any way. Piles damaged by improper handling, transportation or storage shall be

rejected and replaced by the Contractor at his own expense.

All piles shall be properly stored, kept clean, under cover until they are required to be used in the Works.

Piles shall be stored on firm ground in a manner which shall facilitate easy identification and lifting and shall be stacked such that bending and over-stressing of the sections caused by unequal settlement of supports is prevented.

10.4.3 **Preparation for Driving**

Unless otherwise directed by the Engineer, pile toes on steel pipe piles shall be cut square to the axis and treated as shown on the Drawings. The pile toes treated at the open and the closed end shall be approved on Site by the Engineer prior to driving.

Pile toes of timber piles shall be sawed in a cone and the toe angle shall be varied according to the ground conditions or as directed by the Engineer.

All location and survey stakes shall be checked on a regular basis to ensure that pile driving operations have not caused movement of the stakes.

The Contractor shall pitch the pile and position and set the rake of the pile as required. Any surface boulders or other obstructions affecting the position or rake shall be removed.

In general, piles shall not be driven until after the excavation is completed. Any material forced up between the piles shall be removed to correct elevation at the Contractor's expense. The heads of all steel pipe piles shall be cut squarely and a driving helmet shall be provided to hold the axis of the pile in line with the axis of the hammer.

The timber pile heads shall be cut at a right angle to the centre line of pile. The pile heads shall have a circular finish so that a steel ring can be set to prevent damages to the pile heads during pile driving.

Individual pile lengths, except timber piles, shall not be more than 10 metres. Unless otherwise approved or directed by the Engineer, when additional lengths of pile are required to be pitched and spliced, 10 metre lengths shall be used.

Steel pile piles shall be spliced and welded as shown on the Drawings or as approved by the Engineer. The end of the lower pile shall have a backing ring and stopper for the jointing operation as shown on the Drawings or

approved by the Engineer. All welding shall be carried out in accordance with clauses 15.8.9 and 15.3.4 of this Specification or a manufacturer's specification approved by the Engineer. The Contractor shall supply the Engineer with full details of his proposed method of welding and shall, if required, arrange for a demonstration.

10.4.4 Method of Driving

(1) General

The Contractor shall submit to the Engineer details of the driving equipment and driving methods he proposes to use prior to commencing work. The Contractor shall provide adequate pile driving equipment to complete the whole of the work.

No piling work shall commence until the Engineer has given his consent to the Contractor's proposals. Such consent shall not in any way relieve the Contractor of his responsibilities under the Contract.

Piles shall only be driven in the presence of the Engineer and the Contractor shall give the Engineer at least forty-eight (48) hours notice of his intention to commence driving.

Cast-in-situ bored piles shall be constructed in accordance with Clause 10.5 of this Specification.

Piles may be driven with a gravity hammer, a steam (or air) hammer, a diesel hammer or by a combination of any of these. Water jetting will not be permitted with steel pipe piles. A steam or diesel hammer is to be preferred. Preforming or preboring, jetting and shooting will not be permitted for driven piles.

(2) Hammers

The mass of any gravity hammer used for driving steel pipe piles shall be not less than 1.5 tonnes and in no case less than the combined mass of driving head and pile. The fall shall be so regulated as to avoid damage to the piles and in no case shall exceed 3 metres. When a gravity hammer is used the energy developed by the hammer at test shall be not less than 40 kilojoules per blow.

Pile hammers, except gravity hammers, shall be steam, air or diesel hammers subject to the approval of the Engineer. These pile hammers shall develop sufficient energy to drive the piles at a penetration rate of not less than 2 mm per blow at

the required bearing value. When a steam, air, or diesel hammer are used, the total energy developed by the hammer at test shall be not less than 30 kilojoules per blow.

Pile hammers for timber pile shall be of a type, weight and energy suitable for and compatible with the proposed piles and shall match the helmet used.

(3) Additional Equipment

In case the required penetration is not obtained by the use of a hammer complying with the minimum requirements, the Contractor shall provide a heavier hammer at his own expense.

(4) Leads

Piles shall be supported in line and positioned with leads while being driven. Pile driver leads shall be constructed in such a manner as to afford freedom of movement of the hammer, and they shall be held in position by guys or steel braces to ensure rigid lateral support to the pile during driving. Except where piles are driven through water, the leads, preferably, shall be of sufficient length to make the use of a follower unnecessary. Inclined leads shall be used in driving battered piles.

(5) Driving helmets and Followers

Driving helmets and followers shall be capable of protecting the head of the pile and providing a uniform distribution of hammer energy to the pile head, and shall be designed to reduce the absorption of the energy of the hammer blow to a minimum.

Driving helmets shall be of an approved design, having a suitable cushion next to the pile head and fitting into a casting which in turn supports a timber shock block. Driving helmets shall not restrain the rotation of the piles during driving.

Followers of the approved design may be used to drive the tops of piles below the level of the ground surface at the time of driving to the cut-off grade. Followers shall consist of a cylindrical steel mandrel or wide flange section with cap plates at each end welded perpendicular to the axis of the follower.

10.4.5 Penetration

Piles shall be driven to depths or to set as directed by

the Engineer. Set shall be measured as the average penetration over the last ten blows. Where the Drawings shown the load/settlement characteristics assumed in design, the piles shall regardless of all other requirements, be driven such that these, at least, will be achieved.

The Contract Toe Level is the level at which the design has determined the pile should be capable of carrying the maximum ultimate load. The Contractor should allow in his tender to drive all piles to this level. The maximum toe level is the level to which the pile must be driven.

Where driving conditions at the maximum toe level are encountered such that, in the opinion of the Engineer, driving could not satisfactorily continue to the Contract Toe Level, driving operations and all other operations on the bridge, for which the foundations are being piled, shall be suspended, and the Contractor shall request instructions from the Engineer as to any alterations required to the Drawings. Immediately the work is suspended, the Contractor may remove the pile driving frame and equipment from the head of the pile. Provided that details sufficient to permit the Contractor to recommence and thereafter complete the work on the bridge are supplied by the Engineer within one (1) month of the Contractor so requesting, no claim shall be considered for additional costs occasioned by the suspension, other than the cost of moving the plant back to the pile. However, all alterations ordered shall be paid for as a variation.

Where a set is specified, piles shall be driven until the set is obtained which when substituted into the Hiley formula will give capacities not less than the minimum ultimate capacity as indicated on the Drawings. Values of the temporary pile set for use in the Hiley formula shall be determined by measurement in piles while they are being driven.

Piles shall be driven so that the ultimate capacity calculated as above does not vary between piles of the same group by more than 25%.

If the specified penetration per blow is achieved at a depth appreciably above the Contract Toe Level shown on the Drawings, the Engineer will ascertain the reason at the Employer's cost, or if the Engineer so elects, the Contractor shall ascertain the reason at a cost to the Employer to be agreed by the Engineer before commencement of the investigation.

If the specified penetration per blow has been caused by the presence of a hard stratum of rock or compact cemented gravel of sufficient thickness, the Engineer

may authorize that driving be terminated at the depth, provided the specified maximum toe level has been reached.

If the specified penetration per blow has been caused by strata of insufficient thickness, driving shall continue with a heavier hammer until a satisfactory stratum is reached.

10.4.6 Pile Driving Records

Each pile, after being prepared for driving and prior to being driven, shall have its identifying number and overall length marked on it near the head by stamping into the metal, or other means directed by the Engineer. Each pile shall also be marked legibly by painting at intervals of two hundred and fifty (250) millimetres with marks to indicate the distance from the pile toe. This interval shall be reduced to 125 mm for the top 5 metre of the pile. Such marks shall not be injured, defaced or removed by any person.

The records shall be written by the Contractor on forms to be approved by the Engineer and submitted to the Engineer for each day's piling within 24 hours. On completion of the piling for each pile group, the Contractor shall submit to the Engineer a copy of the complete driving records together with an as built location plan recording the exact location, inclination, cut off level and toe level for each pile.

Pile records shall indicate but shall not be limited to:

(a) Serial number and position of piles;
(b) Type and dimensions;
(c) Date of driving;
(d) Group level before and immediately after pile installation;
(e) Total penetration;
(f) Penetration under self weight, self weight plus helmet and hammer;
(g) Type and size of hammer;
(h) Number of blows for each 250 mm of penetration and height of fall or stroke of hammer;
(i) Times of starting, stopping, delays, etc;
(j) Details of all splicing or jointing operations including depth of pile at time of splicing, time taken for splicing;
(k) Top level of pile immediately after termination of driving or completion of installation;
(l) Details of redriving, if any;
(m) Errors in position and inclination;
(n) Toe level;

All pile records and test records shall be deemed confidential and shall not be disclosed by the

Contractor to any third party without the expressed permission in writing of the Engineer.

10.4.7 Pile Heads

After the driving has been satisfactorily completed and approved by the Engineer, the piles shall be cut off at the levels indicated on the Drawings. Flame cutting tools may be used on steel pipe piles but the cut shall be free of any significant protrusion. When required by the Drawings, a pile cap of the type shown shall be provided and preparation of the surface and welding shall be carried out as specified elsewhere.

10.4.8 Filling Concrete in Steel Pipe Piles

Reinforcement cage and concrete shall not be installed and poured until the inside of the steel pipe pile has been inspected by the Engineer and his approval is obtained. This work shall be done in accordance with Clause 10.5 of this Specification.

10.5 Cast-in-situ Bored Piles

10.5.1 General

Cast-in-situ bored piles shall be of a steel pipe pile section above hard stratum of rock and bored section socketed into sound rock as shown on the Drawings. Piles shall be formed from cast-in-situ reinforced concrete. The diameter of bored piles is defined as the exterior diameter of the steel pipe pile.

Steel pipe pile shall be pitched, positioned, driven and installed at the pile toe level indicated on the Drawings or as directed by the Engineer. Boring and excavation through and within the steel pipe piles shall be carefully carried out to avoid damage to the installed steel pipe piles. Pile bottoms shall be drilled and excavated at the specified depths into sound rock as shown on the Drawings or as directed by the Engineer.

The Contractor shall supply the Engineer with complete details of the system of piling, which he proposed to use (including equipment and method of construction).

10.5.2 Equipment

The equipment which the Contractor intends to use, shall require to be to the approval of the Engineer and shall be selected to ensure satisfactory performance for the boring and excavation of the works. The equipment shall provide the best possible performance for the following criteria: precision of pile driving and perforation (maximum variations of 10 mm per meter of pile length

from the vertical shown on the plans), minimum disturbance of the adjoining ground, continuity of the piles, quality of concrete. The drilling installation shall be designed and equipped to prevent seepage (piping) failure.

10.5.3 Casings

The casing shall be of a steel pipe pile and completely even. The steel pipe pile shall conform to Clause 10.2 of this Specification. The steel pipe pile shall be driven to the level which will obtain the specified penetration per blow as directed by the Engineer. After installing the steel pipe pile, the borehole shall be excavated into sound rock without casing. The steel pipe shall remain in position as a permanent liner as shown on the Drawings.

10.5.4 Reinforcement

The reinforcement steel shall be fabricated into a cage and lowered into position prior to the commencement of concreting. The concrete cover over the spiral reinforcement shall be measured from the interior face of the steel pipe pile. To ensure and maintain the correct position of the reinforcement cage during concreting, spacers or other devices acceptable to the Engineer shall be provided between the reinforcement and surface of steel pipe and exposed rock surface of borehole.

10.5.5 Boring and Excavation

Prior to boring and excavation, the Contractor shall provide any necessary temporary staging, cofferdams or protective sheet piling required for construction. Piling equipment shall be installed on a rigid foundation to secure the piling accuracy. When boring is carried out in the river, except for the temporary stagings, the raft shall be securely held and anchored and the steel pipe piles shall be guided to prevent harmful movements during the execution of piling work.

Boring and excavation for a bored pile shall not be commenced until 24 hours after completion of the concreting of any pile within a radius of 5m centre to centre.

Steel pile piles shall be installed and driven in accordance with clause 10.4.4. The boring shall be done without disturbing an adjacent surface and bottom of the boreholes. The steel pipe piles shall be kept full of water or drilling mud suspension at all times, with water or suspension level inside the pile at a higher elevation than the ground or water level outside. Pumping of water into the pile will be necessary. The

excavation shall be done in such a way and with such equipment that soil and rock around the pile and beneath the bottom of the piles is not disturbed. If excavation is done by grabbing, care shall be exercised not to create suction at the underside when lifting the grab. Jetting is not allowed as an aid for the excavation, unless otherwise approved by the Engineer. The bottom of the completed borehole shall be horizontal.

10.5.6 **Clean-out and Control of the Pile Bottom**

The boreholes shall be drilled and excavated to the elevation shown on the Drawings provided that the piles penetrate at least 3m into a suitable layer with SPT-value approved by the Engineer.

Different foundation depths within one and the same group are subject to the approval of the Engineer.

After the excavation has been brought down to the proper elevation, all disturbed soil and loose materials shall be pumped out in such a manner that, after clean-out operation, the bottom of the borehole remains horizontal. Water shall be pumped continuously into the steel pipe pile and borehole during the clean-out operations, to keep the water level at the desired elevation. The clean-out pumping arrangement shall be such that the lower end of the pump can be moved all over the cross section by a routine operation. The suction of the pump shall be adjustable. At the end of clean-out operations, a pause shall be made for a period of at least five minutes, then pumping shall be resumed and shall continue until the water being pumped out is clean.

The cleaning of the bottom of the boreholes is subject to checking and approval by the Engineer. The checking shall normally be performed by the Contractor under the supervision of the Engineer. If required, additional cleaning shall be performed.

After cleaning the bottom of the borehole, the Contractor shall perform at least two Standard Penetration Tests in each borehole. Equipment and method of performing the tests are subject to approval by the Engineer, and the tests shall be performed under his supervision. If the results of the Standard Penetration Tests are not satisfactory, the borehole must be driven to a lower elevation. In the latter case, cleaning and testing shall be repeated at the new bottom elevation.

When the Engineer is satisfied that the bottom of the borehole is located at an elevation where the load carrying a capacity of the rock is sufficient and that the cleaning has been properly done, he will approve the

borehole in writing. This approval shall not relieve the Contractor of any of his responsibilities.

10.5.7 Concreting

Concrete shall be grade 30 and water cement ratio is to be 50%. Cement shall be Portland Cement conforming to this Specification. An admixture agent may be added to the concrete subject to the approval of the Engineer. The maximum size of coarse aggregate shall be 20mm. The cement content shall be in accordance with clause 14.6.1 of this Specification. In case of concreting under water, the quantity of cement in the concrete shall be increased 25% above approved minimum cement quantities for the grades of concrete designated. The consistency shall be such that the concrete will flow evenly out of the tremie tube.

Concreting shall commence as soon as possible after approval of the bottom of the borehole and after the reinforcing cage has been installed. If concreting has not been started within four hours of cleaning the bottom of the borehole, the cleaning shall be repeated.

Concreting of a borehole and steel pipe pile shall be done without construction joints. Concreting under water shall be done by the tremie method. The water level inside the steel pipe pile and borehole shall be kept at a constant elevation, well above ground or water elevation outside. The tremie tube shall be filled with concrete while slowly lowering a valve or plug. The tremie tube shall at all times be kept full of concrete to the bottom of the hopper and the discharge end shall be kept sufficiently submerged (2 to 6 metres) in already deposited concrete to prevent water from surging into the tube. The location of the discharge end of the tremie tube relative to the surface of deposited concrete shall be kept under close surveillance at all times. If inadvertently the concrete in the tremie tube sinks below the bottom of the hopper, then the tube shall be refilled in such a way that no air or water is trapped in the tube.

It is the sole responsibility of the Contractor to continue concreting until the cut-off elevation of the steel pipe pile, as shown on the Drawings.

Before commencing the piling work, the Contractor shall have on the Site approved equipment and trained personnel for drilling cores for the full length of the piles. The Engineer shall decide if and when core drilling is to be performed. Core drilling will be required when the concrete or irregularities during the execution of work indicate that the quality of the pile

may be below the required standard. Testing of the cores shall be performed by the Engineer.

The Engineer will approve each pile in writing when he is satisfied with all test results. No consecutive work on any foundation shall be commenced until all piles in that foundation have been approved.

10.5.8 Daily Records

During drilling of the boreholes, a bore log shall be prepared. Each layer of the encountered soil type shall be described and entered in the bore log. Observations regarding water loss in the borehole and drilling obstacles encountered shall also be recorded and be reported to the Engineer immediately.

A complete record of the construction of each pile shall be kept by the Contractor on forms to be approved by the Engineer and submitted to te Engineer for each day's work within 24 hours.

Pile records shall indicate but shall not be limited on:

(a) Time of start and termination of placing steel pipe pile;
(b) The upper and lower levels of the steel pipe;
(c) Time of commencement and completion of boring and excavation;
(d) The lower level of the bored hole;
(e) Reinforcement installation, timing and any irregularities;
(f) The level of water, if any;
(g) Start and termination of concreting and any special occurrences;
(h) Quantity of deposited concrete;
(i) Errors in position and inclination;
(j) SPT results

On completion of the piling for each pile group, the Contractor shall submit to the Engineer a copy of the complete records together with an as built location plan showing the exact location, inclination and founding level for each pile.

10.6 Defective Piles

The procedures incident to the driving of steel pipe piles shall not subject them to excessive and undue abuse producing damage to the pile. Manipulation of piles (to force them into the planned position) considered by the Engineer to be excessive will not be permitted. Any pile damage as a result of internal defects, or improper driving, or any pile driven outside the tolerances specified above or below the level authorized by the Engineer shall be corrected at the

Contractor's expense by one of the following methods as determined by the Engineer for the pile in question:

(a) The pile shall be withdrawn and replaced by a new pile.

(b) A second pile shall be driven adjacent to the defective or low pile.

(c) The pile shall be spliced or built up as otherwise provided herein, or the headstock shall be extended to embed the pile.

In case of broken, split or misplaced piles for cast-in-situ bored piles, additional piles shall be placed at the expense of the Contractor who shall also bear the cost of all special constructions required due to the new situation.

All piles raised by the driving of adjacent piles or by any other causes shall be re-driven by the Contractor at his own expense.

10.7 Load Tests

10.7.1 Test Piles

(1) The Engineer may order the execution of test piles as he may consider necessary to ascertain the arrangement of the foundation piles. The Contractor shall furnish and execute test piles at the locations designated by the Engineer. The number and location of test piles will be decided by the Engineer, but his number shall be not more than one for each structure. The length and diameter of test piles shall be those as shown on the Drawings or as directed by the Engineer.

(2) When requested by the Engineer, the test pile will be load tested in conformity with clause 10.7.2 of this Specification.

(3) In the immediate vicinity of the test pile, a test boring shall be carried out by the Contractor prior to the load test.

10.7.2 Load Test

(1) Unless superseded by the requirements of this Clause, load tests shall meet the requirements of AS2159:1978 and shall be made by the Contractor in accordance with the methods approved by the Engineer. The Contractor shall submit to the Engineer for review and approval the detailed procedures and detailed drawings of the loading apparatus he intends to use.

The apparatus shall be so constructed as to allow the various increments of the load to be placed gradually without causing vibration to the test piles. The reaction may be provided by kentledge supported above the pile head or a suitable system of anchor piles. As the force has to be varied smoothly from zero to the ultimate bearing capacity, it is most convenient to use a hydraulic jack inserted between the pile head and the reaction system. The jacking force may be measured by the use of a calibrated jack and pressure gauge, or by means of a calibrated load gauge.

Load tests shall be made on the test pile driven in accordance with Clause 10.7.1 of this Specification, or may be executed on a works pile (Contract Pile) selected from the structural piles as directed by the Engineer.

Each test pile shall be driven to its required depth and/or set, the pile left to stand for 24 hours and then re-driven to the direction of the Engineer. The set immediate on re-driving and any subsequent set shall be taken as and when directed by the Engineer.

Load tests shall not be carried out before a period of at least thirty (30) days has elapsed after cessation of piling where a pile is considered by the Engineer to be predominantly supported by skin friction.

Load tests for the cast-in-situ bored piles shall not be carried out until the concrete has attained the design 28-day compressive strength and without the approval of the Engineer.

Load test on test piles shall be applied by jacking against a kentledge or anchor piles approved by the Engineer. Load tests on work piles shall be applied only by jacking against a kentledge. If the approved method requires the use of anchor tension piles, such anchor piles shall be of the same type and diameter as the test pile.

The Contractor shall keep a competent engineer on Site at all times during the execution of pile load tests. The Engineer shall at all times have access to the Contractor's pile record.

(2) Suitable approved apparatus for determining accurately the load on the pile and settlement of the pile under each increment of load shall be applied. The apparatus shall have a working capacity of three times the design load shown on the Drawings for the pile being tested. Reference points for measuring pile settlement shall be

located sufficiently far from the test pile to preclude all possibility of disturbance.

(3) All pile load settlements shall be measured by adequate devices and gauges. Increments of deflection will be read just after each load increment is applied and at 15 minute intervals thereafter. The safe allowable load will be considered as 50% of the load which, after 48 hours of continuous application, has caused not more than 6.5mm of permanent settlement, measured at the top of the pile.

(4) The test load for the test piles shall be twice the pile design load. The test load for the selected works piles shall be a load equal to 1.5 times its design load. The first increment of load to be applied to the test pile shall be less than the pile design load. The load on the pile shall be increased from time to time by about ten (10%) percent of the test load. No load increment shall be added until a settlement of less than 0.12 mm has been observed for a 15 minute interval under the previously applied increment. Settlement readings will be made immediately after and before every load increment is applied or removed.

(5) If there is a question as to whether the test pile will support the test load, the load increments shall be reduced by 50%, at the direction of the Engineer, in order that a more closely controlled failure curve may be plotted. The full test load shall be maintained on the test pile for at least 48 hours and settlement shall be recorded at intervals of not more than 12 hours. The full test load shall then be removed and the permanent settlement read.

(6) When requested by the Engineer, loading shall then continue beyond the double design load in an increment directed by the Engineer until the pile fails or the capacity of the loading apparatus is reached, whichever is the lesser. The ultimate load test shall only be carried out on test piles which do not form part of a final structure unless otherwise authorized by the Engineer.

(7) After the completion of loading tests, the load shall be removed and the piles, including tension piles, shall be utilized in the structure if found by the Engineer to be satisfactory for such use. Test piles not loaded shall be utilized similarly. If any pile, after serving its purpose as a test or tension pile, is found unsatisfactory for utilization in the structure, it shall be removed if so ordered by the Engineer or shall be cut off

below the ground line or footings, whichever is applicable. The working piles load tested shall be utilized in the structure after the Engineer's approval.

(8) The results of the load test together with the driving record of the tested pile shall be submitted to the Engineer in duplicate within 7 days of carrying out a test. A report shall be prepared by the Contractor on each load test, and the report will be accompanied by the following documents:

- plan of the foundation;
- stratigraphy of the soil and rock;
- calibrating curve of the gauges;
- drawing of the jack diameter of the piston;
- graph of the test, having for abscissae the loads (tons) and for ordinates the settlement in fractions of mm;
- tables showing, as a function of the times (date and hour), the readings of the gauge in atmosphere, the loads in tons, the settlements and average of the settlement.

(9) The Engineer may order that no load testing or additional load testing to that specified above shall be carried out and such variations shall be adjusted at the scheduled rate for load testing.

(10) The Contractor will be advised of the Engineer's interpretation of the results of the test within seven (7) days of the receipt, by the Engineer, of the results of the test and the driving record. The Contractor will be deemed to have allowed for any resultant delays, including idle time of plant, in his rates and programme.

10.7.3 Safe Loads

When the safe bearing capacity of any pile determined by test is found to be less than the design load, longer piles or additional piles shall be executed as directed by the Engineer. If as a result of the load test, or for any other reason, redriving of piles is considered necessary by the Engineer, it shall be carried out by the Contractor as specified elsewhere in the Specification.

10.8 Rubber Buffers

Rubber buffers shall be installed in position between the pile cap and the draftwood prevention pile as shown on the Drawings. The size and dimension shall be specified on the Drawings. The Contractor shall submit details of the rubber buffer for the review of the

Engineer. Rubber buffers shall be fixed on the pile cap concrete with approved anchor bolts or equivalent anchorage method.

10.9 Cofferdams and Other Temporary Facilities

10.9.1 Cofferdams

Foundation excavation shall include the removal of all materials of whatever nature necessary for the construction of foundations and substructures requiring cofferdams in accordance with the Drawings or as directed by the Engineer. It shall include the furnishing of all necessary equipment and the construction of all cofferdams, dewatering etc, which may be necessary for execution of the work.

It shall also include the subsequent removal of cofferdams and the placement of all necessary backfill as hereinafter specified. It shall also include the disposal of excavated material, which is not required for backfill.

All excavated material not required for backfill shall be disposed of in a manner and in locations so as not to affect the carrying capacity of the channel or be unsightly or, if directed by the Engineer, the material may be used as filling for approach embankments.

All cofferdams shall be carried to adequate depths and heights, be safely designed and constructed and be made as watertight as is necessary for the proper performance of the work done inside them. They shall be of sufficient height to protect green concrete from sudden rising of the stream and to prevent erosion of the foundation.

At least four weeks before he proposes to work on a cofferdam the Contractor shall furnish the Engineer with drawings of the cofferdam and supporting calculations for the Engineer's review. Works shall not commence until the Engineer's consent in writing has been obtained. The Contractor's attention is drawn to Section 12 of the NAASRA Bridge Design Specification, 1976.

All shoring, timbering and tomming must be carried out in an effective and substantial manner and to the approval of the Engineer. No timber bracing shall be left inside any excavation as to extend into the substructure concrete.

Upon completion of the footings, all sheeting, bracing, timber construction piles and sheet piling shall be withdrawn and removed from the Site. In waterways, all sand islands and obstructions to the waterway shall be removed and disposed of as directed by the Engineer.

10.9.2 Other Temporary Facilities

Piling work shall include the required earthwork, cofferdams, stagings, platforms, rafts, protective sheet piling, dewatering, etc. The earthwork and cofferdams shall conform to the relevant Clause of this Specification.

Stagings and platforms for providing piling work shall be carried out to adequate depths and heights, and be safely designed and constructed for the performance of the work done on them. The Contractor shall propose and provide the Engineer with the structure drawings and supporting calculations for the Engineer's review, four weeks before the commencement of these temporary facilities. If the Contractor provides protective sheet piling for foundation excavation and piling works and requires rafts for piling equipment, the Contractor shall provide the Engineer with the drawings and specifications for such facilities.

Upon completion of the bridgeworks, all these temporary facilities shall be withdrawn and removed from the Site.

10.10 Measurement and Payment

10.10.1 Piling

(1) Scheduling of Quantities

Group 10 of the Bill of Quantities covering the supply and driving of piling is measured in metres, along the axis of the pile from the cut-off level to the Contract Toe Level as shown on the Drawings.

(2) Steel Pipe Piles

Payment for the supply of piles shall be based on the distance from the cut-off level to the Contract Toe Level or amended toe level as ordered by the Engineer. This supply of piles shall include the cost of all materials including the backing ring and stopper, delivering, handling, storing and other incidentals necessary to complete the supply.

Payment for driving of piles including positioning and pitching shall be based on the distance from the Contract Toe Level or amended toe level as ordered by the Engineer, after the pile has been approved by the Engineer, to the original ground level or the excavated foundation level as shown on the Drawings. The driving cost shall include full compensation for plant and equipment, materials, labour, all required recordings, and for other incidentals necessary to complete the work in

accordance with the Drawings. The cost of removal of surface boulders or other obstructions affecting the position or rake shall be included in the driving cost.

Cut-off and splicing of piles and welding of pile joints will not be measured or paid for separately, but the cost thereof shall be considered as included in the scheduled rate for driving of piles including positioning and pitching in the Bill of Quantities.

Filling concrete and reinforcement shall be measured and paid for separately in the Bill of Quantities and in accordance with sub-clause 10.10.1(4) of this Specification.

Driftwood prevention piles, measured above, as specified in Clause 10.2(4) shall be paid for at the scheduled rate respectively, for each of the items listed above.

(3) Timber Piles

Measurement for timber piles shall be made in linear metres in accordance with the Drawings or as directed by the Engineer. Payment for the timber piles shall be made at the scheduled rate of the Bill of Quantities which is full compensation for furnishing materials, labour, equipment, tools and piling and other incidentals necessary to complete the work.

(4) Cast-in-situ Bored Piles

Measurement and payment for the cast-in-situ bored piles shall be made separately for the supply and driving of steel pipe pile, boring and excavation of bored piles, steel reinforcement, filling of concrete.

Payment for the supply and placing steel pipe piles shall be based on the length to be left in place and shall be made in linear metres in accordance with sub-clause 10.10.1 (1).

Payment for the boring and excavation of piles shall be based on the specified diameters and the distance from the original ground level, or the base of foundation excavation, whichever is lower, to the Contract Toe Level or as amended toe level as ordered by the Engineer. The boring and excavation shall be measured in cubic metres with no allowance for overbreak or bulking. This payment shall be at the scheduled rate in cubic metres and shall be full compensation for the cost

of materials, labour, plant and equipment, tools including boring, excavating, disposing, pumping, all required recordings, sampling, testing (SPT), and other incidentals necessary to complete the boring and excavation work.

Payment for the supply and placing of concrete and reinforcement shall be based on the distance from the cut-off level to the Contract Toe Level or amended toe level as ordered by the Engineer. The measurement and payment for reinforcement shall be made at the scheduled rate per tonne in accordance with Group 13 of this Specification. The measurement and payment for concrete shall be made at the scheduled rate per cubic metre in accordance with Group 14 of this Specification.

Driftwood prevention piles, measured above, as specified in clause 10.2 (4) shall be paid for at the scheduled rate respectively for each of the items listed above.

(5) **Load Tests**

The load test piles for steel pipe piles and cast-in-situ bored piles and incorporated concrete and reinforcement will be paid separately under the corresponding items for the supply, driving, boring and excavation and cast-in-situ reinforced concrete. The length of test piles shall be specified on the Drawings.

Anchors and anchor piles which are necessary for testing piles, will not be paid for separately but considered as included in the load test item of the Bill of Quantities.

Measurements for load tests shall be made on the basis of the number of load tests completed and accepted by the Engineer. Payment for load tests shall be made for the number stated in the Bill of Quantities and the schedule rate shall include full compensation for the cost of materials, labour and equipment, including furnishing, supplying and setting testing apparatus and the cost of recording, analysis and reporting of each load test and incidental items necessary to complete the work in accordance with this Specification and instruction by the Engineer.

(6) **Setting up Piling Rig & Boring Equipment on Site**

Measurement for setting up the piling rig and boring equipment on Site shall be by number. This item covers the transportation and setting up of the piling rig, boring equipment and related

facilities from either the Contractor's camp or another bridge site in the Contract area.

(7) Repurchase of Steel Piling

Provided that the quantity of piling material approved by the Engineer is delivered to the Site, the Employer will purchase from the Contractor any surplus piling which may remain at the end of the Contract, at the rate stated in Item 10.2 and 10.3 of the Bill of Quantities.

Such pile lengths shall be full lengths supplied by the manufacturer and lengths made up to at least ten (10) metres from sections of pile no shorter than 1.2 metres, the butt welds to be in accordance with Clause 10.4.3 of this Specification or as directed by the Engineer. The surplus piling material shall be safely stacked in a location directed by the Engineer.

(8) Rubber Buffers

The measurement and payment for rubber buffers shall be by number. Payment shall include full compensation for the supply of materials, labour equipment, tools and incidentals necessary to complete the work. The cost of anchors, drilling of holes and grout shall be included in the scheduled rate per number.

10.10.2 Cofferdams and Other Temporary Facilities

Where cofferdams, stagings, platforms, rafts, protective sheet piling, bund and other necessary temporary works are used to facilitate the piling works, these costs shall be included in Item 10.1 of the Bill of Quantities.

GROUP 11

FALSEWORK

GROUP 11

FALSEWORK

11.1 Falsework

This Group covers temporary works necessary for the temporary support, and erection of the permanent works but excludes cofferdams, stagings, platforms, rafts, protective sheet piling, bund and temporary river crossings.

The Contractor shall provide the Engineer with full detailed drawings and supporting calculations for his proposed temporary works at least four weeks before work on the temporary works commences, and shall not use the temporary works without the written consent of the Engineer. In no case shall the Contractor be relieved of responsibility for results obtained by the use of these drawings.

Falsework which cannot be founded on a satisfactory footing shall be supported on piling which shall be spaced, driven and removed in a manner consented to by the Engineer. Subject to the Engineer's consent, falsework may be supported on constructed portions of the substructures provided the structure is not overstressed or rendered unstable.

All timber shall be well seasoned and free from knotholes, loose knots and other defects. Structural strengthening rendered necessary by falsework loads shall be effected at the Contractor's expense. Falsework shall be released only at the time and in the order and manner consented to by the Engineer.

Falsework shall be designed to the requirements of Section 12 of the N.A.A.S.R.A. Bridge Design Specification 1976. The stresses permitted in Article 12.2.4 of the N.A.A.S.R.A. Specification shall, for the combination dead load, live load, erection stresses and such environmental loadings as are likely to occur during the life of the falseworks, such as normal stream flow, be limited to the basic allowable stress.

The falsework shall also comply with the British Code of Practice for Falsework BS 5975:1982.

11.2 Measurement and Payment

Falsework will not be paid for separately but shall be deemed to be included in the rate for the item supported by the falsework.

GROUP 12

FORMWORK FOR CONCRETE

GROUP 12

FORMWORK FOR CONCRETE

12.1 General

Formwork shall be in accordance with AS 1509 "Rules for Design and Construction of Formwork" and with the N.A.A.S.R.A. Bridge Design Specification 1976 subject to the exceptions, modifications and additions as listed in applicable legislation and regulations.

All formwork shall be designed and constructed to ensure no loss of material from the placed concrete and be of the required rigidity to produce hardened concrete in the position and of the shape and dimensions described in the Contract. Where required sealing gaskets, or an alternative acceptable to the Engineer, shall be provided.

No concrete shall be deposited in the forms until they have been thoroughly cleaned out and inspected by the Engineer. Any forms not conforming to the requirements of the Engineer shall not be used, and shall be removed without delay. This shall not relieve the Contractor of the responsibility for the design and adequacy of all formwork.

Where stated on the Drawings or directed by the Engineer, provision shall be made for the attachment of external vibrators to the underside of forms.

In the case of concrete placed in earth excavation, forms shall be provided for all vertical surfaces unless otherwise shown on the Drawings or ordered by the Engineer.

In the case of columns, walls or other thin sections of considerable height, forms shall be designed and constructed with one side open from bottom to top, and the formwork of the open side shall be placed as successive layers of concrete, not more than twelve hundred (1200) millimetres in height, are placed, unless otherwise permitted by the Engineer. In the case of beams, girders and similar members, forms shall be constructed so that the side forms may be removed without interference to the remaining forms.

12.2 Construction

12.2.1 Material

(1) Timber

Timber for formwork shall be well seasoned and free from loose knots and other defects. Timber which

becomes warped or unsuitable for re-use in the opinion of the Engineer shall be replaced.

The class of timber selected for different portions of the structure shall be appropriate to the quality of line and surface required in the work, and shall be approved in advance by the Engineer. The formwork used for exposed surfaces shall have, in contact with the concrete, either dressed timber, or undressed timber lined with an approved watertight lining not liable to warp so as to give, on stripping, a smooth and even concrete surface true to dimensions shown on the Drawings. For the backs of abutments and wing walls timber need not be dressed or lined.

(2) Mild Steel

The design of mild steel forms shall be submitted for the review by the Engineer before work on the construction of the forms is commenced. All bolt and rivet heads shall be countersunk and all welds ground back to the correct dimensions.

12.2.2 Handling and Treatment

Forms shall be so designed and constructed that they may be removed without injury to the concrete or to the forms. The forms shall be built true to line and braced in a substantial and unyielding manner to maintain position and shape. Joints to forms shall be either horizontal or vertical. Timber forms shall be thoroughly soaked with water before application of release agents unless they are lined.

Where the effectiveness of external vibration, if used, is likely to be largely lost due to the nature of the contact with the supporting falsework or base, e.g. where forms are to be bolted to a concrete plinth, rubber padding shall be provided between the forms and supporting surfaces to the satisfaction of the Engineer. The padding shall be securely held by bolts or other means to ensure that it remains in position during concreting. The size, thickness, shape and quality of rubber padding shall be as approved by the Engineer.

Provision shall be made for the accurate location of all fittings, e.g. scuppers, reinforcement, anchorage devices, holding down bolts, tubes and bars for the formation of holes.

The use of wires and/or bolts extending to the surface of the concrete shall not be permitted. Where internal ties are permitted for support of formwork, they shall be such as to permit their extraction or that of their

removable parts without damage to the concrete. All holes shall be filled with mortar to the satisfaction of the Engineer.

Forms for re-entrant angles shall be chamfered, and forms for corners shall be filleted, the bevel in each case having a width as shown on the Drawings, or if not so shown, of twenty-five (25) millimetres on each side with equal angles in all cases. Alternatively re-entrant angles and corners shall be rounded to a radius equivalent to the width of bevel of the fillet or chamfer they replace.

12.2.3 Erection

Dimension of forms, especially those affecting the construction of subsequent portions of the work, shall be carefully checked after the forms are erected. Forms shall be aligned accurately and the location of all fittings, hole formers, etc., checked prior to placing concrete.

The interior surface of the forms, except for permanent formwork, shall be coated with a release agent acceptable to the Engineer which will permit the removal of the forms without injury to the concrete and will not stain or discolour the concrete surface.

Release agents shall be applied uniformly in accordance with the manufacturer's recommendation and any surplus shall be removed prior to the fixing of reinforcement and the placing of the concrete. No release agents shall be permitted to come into contact with reinforcement, structural steelwork, shear connectors or the like. Different release agents shall not be used on visible sections of the same structure.

Bolts, pipes and bars, if used, to form the holes in the members, shall be well greased and so arranged that they may be removed from the concrete before removal of forms without excessive jarring or hammering.

12.2.4 Removal of Formwork

The Engineer shall be informed in advance of when the Contractor intends to strike any formwork.

The Contractor's attention is drawn to the requirements of Clause 4.7.4 and Table 4.2 of AS 1509-1974. In no case shall formwork be removed before such time as the concrete has attained sufficient strength to support its own weight plus any imposed loading. The permissible stress to be used in determining the strength of the concrete shall be that given in Table 5.1 of the N.A.A.S.R.A. Bridge Design Specification 1976 where F'c is the cylinder strength at the time of stripping.

Forms shall be removed with care and without unnecessary hammering and wedging and so as not to injure the concrete or disturb the remaining supports. Centres shall be gradually and uniformly lowered in such manner as to avoid injurious stresses in any part of the structure.

Care shall be exercised that no tomming or bracing is removed, loosened or in any way altered without the Engineer's approval, during the removal of falsework.

When the forms are removed and are intended for re-use, they shall be thoroughly cleaned and made good to the satisfaction of the Engineer.

12.3 Formed Surfaces - Classes of Finish

Unless specifically indicated on the Drawings to the contrary, the formwork shall provide a surface finish to the concrete as given in AS 1510 Part 1, 1974.

The following classes will be used:

Class 1 - Not normally required.

Class 2 - Surfaces readily visible, i.e. abutment and wing wall faces, kerbs, soffit and edge of cantilever slabs, pier columns and caps.

Class 3 - Surfaces not normally visible. Soffit of deck between beams.

Class 4 - Surfaces not visible - pile caps to piers, back of abutments and wing walls.

Class 5 - Only to be used for mass concrete.

12.4 Unformed Surfaces - Classes of Finish

Refer to Clause 14.11 of this Specification.

12.5 Measurement and Payment

Measurement for formwork shall be made of the area of formed surfaces of concrete. Payment shall be at the scheduled rates per square metre stated in the Bill of Quantities, which rates shall include that cost of all labour, materials and equipment. The rates shall also include the cost of furnishing, transporting, fabricating, erecting, surveying, fixing, dismembering, removing the formwork and other items necessary to complete the work.

GROUP 13

STEEL REINFORCEMENT

GROUP 13

STEEL REINFORCEMENT

13.1 General

This work shall consist of the supply of all reinforcing bars and fabric of the type, shape, size and grade required for concrete structures and incidental concrete construction and placing them in accordance with this Specification, as shown on the Drawings or as directed by the Engineer.

13.2 Materials

Steel for reinforcement shall conform to the requirements of the following Australian Standards:-

(i)	for plain mild steel bars or where the type of reinforcement is not otherwise specified	1302
(ii)	for deformed mild steel bars	1302
(iii)	for cold-worked reinforcing bars	1302
(iv)	for hard-drawn steel wire	1303
(v)	for hard-drawn steel wire fabric	1304
(vi)	for Tempcore (TC) reinforcing bars Grade 410Y	1302

If the supplier can produce a Manufacturer's Certificate which states that the steel reinforcement supplied complies with the relevant standard and which can be readily identified with the steel reinforcement by identification marks, no further tests should be required.

If such Certificates cannot be produced, the Contractor shall supply three test pieces for each 5 tonnes in each size of reinforcing steel delivered to Site. These test pieces shall be of the sizes specified and shall be tested in accordance with AS 1204, 1227, 1302, 1303 and 1304 as appropriate.

Certificate and/or samples shall be delivered to the Engineer at least three weeks prior to fixing of the steel reinforcement represented by the certificate and/or samples in the Works.

Should the first test piece of three, when tested, fail to conform to the relevant Standard given in this Clause, the remaining two test pieces shall be tested. Should one or both of these two test pieces also fail to conform to the Standard, the steel reinforcement represented by such test pieces shall be rejected and removed from the site.

Any test carried out as a result of the Contractor's failure to produce Manufacturer's Certificates shall be at the Contractor's expense. All costs associated with any other tests requested by the Engineer and his representative shall be paid by the Contractor if the results show that the material tested is not in accordance with the Contract, otherwise these costs shall be recovered by the Contractor from the Employer.

When placed bars are shown on the Drawings and the Contractor wishes to use an equivalent fabric, his proposals, together with satisfactory supporting evidence of their structural sufficiency, shall be submitted to the Engineer for approval. Fabric shall not be used for bridgeworks.

All steel reinforcement shall be delivered to the Site straight and free from bends except where such bends have been formed in accordance with Clause 13.4 below. All bends other than those formed in accordance with Clause 13.4 below shall be cut from the bar at least six diameters from the start of the bend and removed from the Site. No reinforcing bars shall be straightened or rebent except as stated in Clause 13.4 below.

13.3 Protection

Steel reinforcement shall be protected at all times from injury. It shall be stacked in racks above the ground, and shall at all times be kept clear of mud. When placed in the work it shall be free from dirt, loose mill scale, loose rust, dust, paint, oil or other foreign substance. When steel has on its surface detrimental rust, loose scale and dust which is easily removable, it shall be cleaned by a method approved by the Engineer.

13.4 Cutting and Bending

Bent bar reinforcement shall be cold bent to the shapes shown on the Drawings. Unless otherwise stated on the Drawings or approved by the Engineer, bends shall be made in accordance with the following requirements. Stirrups and tie bars (encompassing bars) shall be bent around a pin having the same diameter as the bar around which the stirrup or tie bar will pass in the finished

work so long as this diameter is not less than twice the diameter of the stirrup or tie bar. Bends for other bars shall be made around a pin having a diameter not less than 4 times the diameter of the bar for Grade 230 bars and not less than 6 times the diameter of the bar for Grade 410 bars. See Figures 5.2 and 5.3 N.A.A.S.R.A. Bridge Design Specification 1976.

After cutting and bending, bars shall be bundled or stacked according to their respective "marks" as shown in the Reinforcement Bending Schedule.

Grade 410 shall not be straightened nor rebent once having been bent. Where, as shown on the Drawings, it is necessary to bend Grade 230 bars projecting from the concrete these bars shall be bent such that the internal radius of the bend is not less than four times the diameter of the bar.

At least 3 weeks prior to the cutting and bending of reinforcement for a section of the Works the Contractor shall satisfy himself as to the correctness of the relevant cutting and bending schedules and inform the Engineer of same. Should the Contractor consider the schedules to be in error he shall immediately inform the Engineer in writing for explanation and/or rectification if necessary.

13.5 Placing and Fixing

All steel reinforcement shall be accurately placed in the positions shown in the Drawings and firmly held during placing and setting of the concrete. Cover to the outside face of reinforcement from the concrete surface shall conform to the Drawings.

Bars shall be held in position by wiring at all intersections with annealed wire not less than 1.25mm diameter except where spacing is less than 300mm in each direction when alternate intersections shall be tied. The ends of all tying wire shall be turned back into the main body of the concrete. Cover to formwork shall be maintained by precast concrete blocks or other devices acceptable to the Engineer.

Metal supports and tie wires which extend to the surface of the concrete shall not be permitted. Stirrups and ligatures shall pass around the main bars and be securely wired thereto.

Precast concrete cover blocks shall be as small as possible consistent with their purpose. They shall be made of concrete with 10mm maximum aggregate size and the mix proportions shall be such as to produce the same 28 day cylinder strength as the adjacent concrete.

Tying wire cmplying with the requirements of this Clause shall be cast into the block for the purpose of tying it to the reinforcement. Precast concrete cover block shall be cured by immersion in watr for at least 7 days until 24 hours before the blocks are to be used. Layers of bars shall be separated by precast concrete blocks or by other equally suitable devices. The use of pebbles, pieces of broken stone or brick, metal pipe and wooden blocks and the like shall not be permitted.

Welding of Grade 230 bars to form a rigid cage shall be kept to a minimum and not more than one third of the main reinforcement at any cross section shall be so welded.

If fabric reinforcement is shipped in rolls, it shall be straightened into flat sheets before being placed.

Reinforcement in any member shall be placed and then inspected and approved by the Engineer before the placing of concrete begins. Concrete placed in violation of this provision may be rejected and removal required.

13.6 Splicing

All reinforcement shall be furnished in the full lengths indicated on the Drawings and bar bending schedules. Splicing of bars, except where shown on the Drawings, will not be permitted without written approval of the Engineer. Splices shall be staggered as far as possible. Where bars are spliced they shall be lapped the lengths shown on the Drawings and bar bending schedules. Where unscheduled laps are authorized the lap length shall be calculated on the basis of the full strength of the bar using the formula given in Article 5.10.3 of the N.A.A.S.R.A. Bridge Design Specification 1976.

Welding of reinforcement shall only be permitted where shown on the Drawings except where authorized by the Engineer.

All welding procedures shall be submitted for the consent of the Engineer at least four weeks prior to commencement of welding of reinforcement. However, the following conditions shall also apply:-

(i) Non-scheduled welded splices will only be permitted in a region where the stress in the bar is less than 75 percent of the permissible stress.

(ii) Welding electrodes complying with AS 1552 "Classification of Covered Electrodes" Code

No. E 4816 shall be used.

(iii) Welding of reinforcing bars shall be carried out in accordance with the appropriate clauses of this Specification and with AS 1554 Part 3.

(iv) Cold worked deformed bars shall not be welded or tack welded or heated.

13.7 Lapping of Reinforcing Fabric

Sheets of reinforcing fabric shall overlap by a distance equal to 70 diameters of the wire making up the fabric. In no case shall the edge lap be less than one mesh in width.

13.8 Substitutions

Substitution of different size or grade bars or bars produced by a different process from those specified on the Drawings will not be permitted unless written application to the Engineer is made for such substitution at least four weeks before the reinforcing steel is to be placed. Such permission will only be given if the structure is not adversely affected. No additional payment will be made on account of these alterations.

13.9 Measurement and Payment

13.9.1 Measurement

The quantity of steel reinforcement incorporated in the work in accordance with the Drawings or as directed by the Engineer will be determined from the calculated mass of the various sizes and lengths of the bars shown on the Drawings or authorized by the Engineer. Where a continuous bar or welded or other type of splice is used instead of a lapped splice, the weight will be calculated as for a lapped splice. Additional steel required in splices authorized for the convenience of the Contractor shall not be measured for payment.

Quantity of steel wire fabric placed as shown on the Drawings or as directed by the Engineer will be determined from measurements taken of the area covered by the steel wire fabric with no allowance for laps.

Payment will be made only for the quantity of steel shown on the Drawings or authorized by the Engineer and incorporated in the work.

The mass of reinforcing steel used in precast units, and other items for which the reinforcing steel is included in the scheduled rate for the item, will not be included in the quantity of reinforcing steel for payment.

13.9.2 Payment

The scheduled rate per tonne for bar reinforcing steel measured as above shall include full compensation for furnishing all labour, materials, tools, equipment and incidentals and for doing all the work involved in furnishing and placing the bar reinforcing steel complete in place, as shown on the Drawings and as specified by this Specification and as directed by the Engineer.

The scheduled rate per square metre for steel wire fabric measured as above shall include full compensation for furnishing all labour, materials, tools, equipment and incidentals and for doing all work involved in furnishing and placing the steel wire fabric complete in place as shown on the Drawings and as required by this Specification and as directed by the Engineer.

Full compensation for furnishing all tie wires, precast concrete cover blocks and supporting devices shall be considered as included in the scheduled rate paid for bar reinforcing steel and steel wire fabric and no additional compensation will be allowed therefor.

GROUP 14

CONCRETE FOR STRUCTURES

GROUP 14

CONCRETE FOR STRUCTURES

14.1 General

The work specified herein shall include the furnishing, placing, compacting and finishing of all Portland Cement Concrete in Ordinary Reinforced Concrete, Mass Concrete and Blinding Concrete to the lines, levels and dimensions shown on the Drawings, or where not shown, as directed by the Engineer.

14.2 Definitions

The following definitions shall apply to this Specification:

"Compressive Strength" shall mean the compressive strength of concrete, 28 days after placing, determined as provided for herein.

"Construction Joint" shall mean a joint provided in the concrete work as a construction necessity, whether provided for in the Drawings or not, where the concrete to one side of the joint will have set before placing concrete to the other side of the joint.

"Measurement" shall mean the measurement of batching of the constituent materials.

"Ready Mixed Concrete" shall mean all concrete for which any or all of the constituent materials are batched or mixed away from the Site.

14.3 Responsibility

Regardless of approvals having been given for the use of various constituents and the methods of manufacture, the Contractor shall be wholly responsible for the production of concrete in place to the specified properties and requirements. If any Governmental or other authority assists the Contractor with the design or control of the mix used, the Contractor's responsibility shall not be waived.

14.4 Inspection

The Contractor shall give the Engineer forty-eight (48) hours notice of his intention to proceed with the work involved in concreting. Unless otherwise required or directed by the Engineer, or requested of the Engineer by

the Contractor, periodic inspections only shall be carried out on blinding concrete and the Contractor's obligations to advise the Engineer before proceeding shall be waived, provided that, as required by Clause 4.13 of this Specification, the Contractor has obtained the Engineer's approval of the founding surface.

14.5 Materials

Unless otherwise stated, all concrete shall be Portland Cement Concrete and shall be composed of Portland Cement, fine aggregate, coarse aggregate, additives if approved and water proportioned and mixed as specified herein. All materials for use in concrete shall conform with the requirements of this Specification and shall be approved by the Engineer. Any materials which do not conform shall be immediately removed from the Site at the Contractor's expense.

Nominated material sources are given in Part III of Conditions of Contract.

14.5.1 Portland Cement

All cement used shall be Portland Cement of an approved brand and shall comply with AS 1315. The type of cement used shall be Type A "Ordinary or Normal Cement" unless otherwise designated. If the Contractor wishes to use Type B "High Early Strength Cement" to facilitate his operations he shall use such cement (other than where its use is designated) only on the written authority of the Engineer, and no extra payment will be made for the use of such cement. Type B cement shall not be permitted in ambient temperatures over 30°C nor in concrete of strengths greater than Grade 20. Documentary or other acceptable evidence of the quality of the cement shall be furnished by the Contractor if requested by the Engineer.

Fly ash and blended cements shall not be used without the written approval of the Engineer. If approved, fly ash shall comply with AS 1129 and 1130 and blended cement with AS 1317. Fly ash and blended cements shall not be used in concretes of strength greater than Grade 20. No more than 1 part of fly ash to 3 parts of Portland Cement shall be used in any concrete mix.

14.5.2 Water

Water shall be free from matter harmful to concrete and reinforcing and shall be fit for human consumption. Where water is not free from colour or taste, a sample shall be submitted to the Engineer for analysis. Brackish water, bore water with excessive salts, effluents containing sugar, salts or waste dairy products, muddy water and water with a heavy organic content will be rejected.

14.5.3 Fine Aggregate

Fine aggregate shall consist of natural sand, a combination of natural sands, or a combination of natural and manufactured sands containing not less than 50 per cent of natural sands. Particles shall be clean, hard and durable and shall not contain harmful materials such as iron pyrites, coal, mica, shale or vegetable matter. It shall conform with AS 2758.1: 1985.

14.5.4 Coarse Aggregate

Coarse aggregate shall consist of clean, durable, uncrushed gravel, crushed gravel, stone, or combinations thereof, free from coatings of clay or dirt, organic or other deleterious matter. Aggregates shall not contain harmful materials such as vegetable matter, iron pyrites, coal, mica, shale or similar laminated materials. They shall conform with AS 2758.1: 1985.

The proportion of misshapen particles shall not exceed 10% as determined in accordance with Clause 9.3 of AS 2758.1: 1985.

Unless noted otherwise on the Drawings, the maximum nominal size of aggregate which may be used in all grades of concrete shall be 20 mm except in mass concrete where the maximum nominal size shall be 40 mm and for bearing plinths where the maximum size shall be 10 mm.

14.5.5 Testing

The Contractor shall submit for approval for each concrete grade 50 kg of coarse aggregate and 25 kg of fine aggregate. The Contractor shall at his own expense sample from each different source of supply and deliver same to the testing laboratory. Each sample shall be clearly labelled. Aggregate testing shall be at the Employer's expense. No material shall be used until approved in writing by the Engineer. The Engineer may waive this requirement if the concrete is to be supplied by an established ready mixed or precast concrete supplier.

14.5.6 Storage

Cement shall be stored above ground level in dry, weatherproof sheds, well protected from dampness acquired from contact with floors or walls. Cement shall be stored on the Site in sufficient quantity to ensure that there is no interruption or suspension of concreting. Bags shall be stacked so as to permit access for tallying, inspection and identification of each consignment. It shall not be stacked more than seven bags high for more than seven days, and shall never be stacked more than twelve bags high.

If bulk cement is used only watertight storage silos and weighing attachments approved by the Engineer shall be used.

As far as practicable, cement shall be used in order of receipt. If the Contractor proposes to use cement which has been stored for two months or more on works, the Engineer may require a re-test of the cement at the Contractor's expense before it is used in the work. Cement showing lumps which cannot be broken to the original fineness by finger pressure will be rejected irrespective of age, and replaced at the Contractor's expense.

Aggregates shall be stored on site in such manner that they will not segregate , become contaminated by foreign matter, or intermixed nor shall water be permitted to drain into them. Aggregates shall not be stored in direct contact with the ground. Generally, storage areas shall be surfaced with concrete slabs, which shall be removed on completion of the works.

14.5.7 Admixture

Admixtures shall not be used in concrete without the written approval of the Engineer. Should the Contractor desire to use an admixture he shall give the Engineer notice in writing of:-

(a) Type and brand of admixture to be used.
(b) Rate of application.
(c) Type and location of metering device.
(d) Part of the structure where admixture is proposed to be used.
(e) Reasons for use.

Generally, admixtures approved will be restricted to air entraining agents, and for certain approved applications, retarders and water reducing retarders. Admixtures shall not be used in dosages greater than those recommended by the manufacturer or permitted by the Engineer.

Despite the use of admixtures, the quantity of cement shall in no case be reduced below the minimum value specified hereunder. Calcium chloride shall not be used as an admixture in reinforced concrete. No admixture shall be used for steam cured concrete. Any air entraining agents if approved shall comply with the requirements of AS 1478 and 1479. Concrete containing fly ash shall not be air entrained. Where air entrainment is allowed, the air content shall be within the range 3% to 5% except where otherwise specified.

The Contractor shall have a suitable air content gauging device on the job so that the air content of the freshly mixed concrete may be accurately determined in accordance

with AS 1012, Part 4. Admixture metering shall be by an approved and well maintained dispenser. Sampling and testing for air content shall be carried out at the discretion of the Engineer but shall generally be of every batch or transit-mixer delivery for the first five batches or deliveries and not more than every fifth batch or delivery if the first five comply with the Specification and show evidence of satisfactory control.

14.6 Concrete Proportions and Design

14.6.1 Grades of Concrete

Concrete shall be graded as "Grade X" where X is the minimum 28 day compressive strength in megapascals. The compressive strength shall be determined in accordance with AS 1012 Part 9, for 300 mm x 150 mm cylinders. Slump values, maximum water/cement ratios and minimum and maximum cement content shall be within the following values:

Grade of Concrete	Minimum 28 day Compressive Strength	Slump mm	Cement Content Kg/m^3		Maximum Water/Cement Ratio by weight
			Min.	Max.	
40	40 MPa	0 - 50	400	470	0.4
30	30 MPa	0 - 50	350	420	0.45
25	25 MPa	0 - 65	330	400	0.5
20	20 MPa	25 - 75	300*	380	0.5
15	15 MPa	40 - 80	270	350	0.52
Blinding Concrete	-	-	170	-	-

*For concretes containing fly ash or blended cement this figure shall not apply and combined cement plus fly ash content shall not be less than 335 kg/m^3.

The quantity of water shall not exceed that required to produce concrete with sufficient workability or be placed and compacted at the required location.

14.6.2 Grouts

Grouts shall consist of a mixture of Portland cement and water (cement grout) or of Portland cement, sand and water (cement-sand grout). The water content ratio shall not exceed 0.4 by weight and the quantity of water used shall not exceed that required to produce grout mortar of the required workability. No admixture shall be used which

contains chloride or nitrate or which entrains gaseous hydrogen. The Contractor is to provide the Engineer with details of this proposed mix and six standard test specimens for test. The tests will be carried out to the requirements of Appendix A11 of AS 1640-1974.

The minimum compressive strength of grout shall not be less than 17.5 MPa.

Where mortar is indicated on structural drawings (other than for use in brickwork and masonry) i.e. below handrail post baseplates, it shall be a stiff cement-sand grout complying with the above.

14.6.3 Concrete Mix Design and Acceptance - General

The Contractor shall be solely responsible for the design and production of concrete to comply with the Specification. The Contractor shall submit for approval, details of the concrete mix he proposes to use for each particular grade of concrete. The following information shall be forwarded to the Engineer:

(i) Mix designation mark.
(ii) Concrete grade.
(iii) Type and source of cement.
(iv) Source of aggregates.
(v) Proportion by weight of individual ingredients including added water and free water.
(vi) Grading of fine and coarse aggregate in tabular and graphical form.
(vii) Grading curves of combined aggregates in tabular and graphical form together with details of proportions in which the fine and coarse aggregates are combined.
(viii) Mixers to be used.
(ix) Water/cement ratio by weight.
(x) Aggregate/cement ratio by weight.
(xi) Slump.
(xii) Design target strength.

Minimum target strength shall be as follows:-

Grade 40 concrete	-	49 MPa
Grade 30 concrete	-	38 MPa
Grade 25 concrete	-	33 MPa
Grade 20 concrete	-	28 MPa
Grade 15 concrete	-	22 MPa

These minimum target strengths have been calculated on the assumption that all solid constituents of the concrete are batched by weight, the cement is batched separately from the aggregates, and a reasonably high standard of control in the production and storing of aggregates and the batching and mixing of the concrete is maintained at all

times by the job management. Mixing water is assumed to be measured, and the aggregate moisture and slumps checked. The Contractor shall nominate target strength for the Engineer's approval, which target strengths must be consistent with the degree of control provided but which shall in no case be less than the minimum tabulated above, unless, after examination of documentary records of test results of comparable mixes performed by the same plant and with the same materials the Engineer approves slightly lower values.

The Contractor shall state his proposed degree of control when submitting details of his proposed mix design. If, during the course of the job, the proposed degree of control is not maintained, as evidenced by either the batching and mixing methods employed or by the strength of test cylinders taken on the work, a new mix design shall be prepared and tested at the Contractor's expense.

14.6.4 Concrete Mix Design and Acceptance - Preliminary Mixes

The Contractor shall make preliminary mixes of Grades 40, 30, 25,20 and 15 concrete, using the approved materials. The mixes shall be made under closely controlled laboratory conditions in the presence of the Engineer. Nine cylinders shall be cast from each preliminary mix and delivered to the Engineer.

Three shall be tested at 7 days and six at 28 days. Clause 14.7.6 "Cost of Testing" of this Specification shall apply. If precast units are manufactured by an established precasting manufacturer who can produce evidence of a history of good quality control in the manufacture of concrete of adequate strength, the Engineer may waive this Clause with regard to concrete produced by that manufacturer.

If concrete is supplied by an approved supplier of ready mixed concrete, the Engineer at his sole discretion may accept the results of test cylinders cast from identical mixes produced previously by the supplier in lieu of preliminary mixes. The information relating to the mix shall nevertheless be supplied.

The strength of the preliminary mixes as represented by the crushing strength of cylinders tested at 28 days shall not be less than the following:-

Grade	Average of 6 Cylinders MPa	Lowest Cylinder Mpa
40	49	40
30	38	30

Grade	Average of 6 Cylinders MPa	Lowest Cylinder MPa
25	33	25
20	28	20
15	22	15

Should cement be separately weigh batched and in the opinion of the Engineer, the batching equipment and quality control to be used on the site be of sufficient standard, the Engineer may at his discretion accept slightly lower average strengths provided that the Contractor can provide the necessary data to justify that acceptance.

The selection of suitable target strengths will be at the Contractor's discretion but the values selected shall not be less than the average 28 day preliminary mix strengths fixed by the Engineer.

14.6.5 Concrete Mix Design and Acceptance - Approval of Mixes

No concrete shall be placed until the preliminary mixes have been made, tested and/or the mixes approved in writing by the Engineer. Upon request of the Contractor, the Engineer may give provisional approval of the mix if the average of the 7 day strengths is not less than 0.8 of the specified 28 day preliminary mix strengths. The Engineer may accept lower than 7 days strengths at his discretion when fly ash is incorporated in the concrete mix. Notwithstanding any approval given, the concrete shall meet the specified preliminary mix strength of 28 days. No approval will be given for the use of Grade 25, Grade 30 or Grade 40 concrete until satisfactory 28 day results have been received. Once approved, the mix shall not be altered without the written approval of the Engineer.

The Engineer may at any time require the Contractor to submit new mix designs for acceptance should they be required.

14.7 Control of Concrete Quality

14.7.1 General

When trial mixes are used in design, in addition to the number of cylinders specified below, one additional cylinder shall be taken from three different batches on each of the first 6 days after the commencement of concreting, and tested at 7 days. The strengths will be adjusted to 28 day strengths assuming the ratio of 7 days to 28 days strengths is the same as that obtained from the

preliminary cylinder strength tests. The mean strength shall be calculated from these first 18 cylinder tests. Should the adjusted mean strength be less than the target strength used in the design of the mix, or should more than one of the individual results of the first 18 cylinders tested fall below the specified minimum, or any result fall below 90 per cent of the specified minimum, the mix shall be re-designed and re-submitted for approval as specified in Clause 14.6.

14.7.2 Sampling and Testing

The concrete shall be sampled and tested in accordance with the provisions of AS 1012, "Methods for the Testing of Concrete" under the direction of the Engineer.

All cylinders shall be efficiently capped to make ends truly parallel to each other and at right angles to the cylinder axis. The 28 day cylinder strength of the concrete in any portion of the work shall be determined by the average crushing strength of two cylinders taken from one batch of concrete. Both cylinders shall be moulded from the one sample of concrete taken from one batch of concrete in the manner specified in AS 1012. (The sample shall be obtained by taking three or more approximately equal portions regularly spaced throughout the discharge of the whole batch from the mixer or transit mixer). The following minimum number of 300 x 150 mm diameter test cylinders shall be taken:-

For cast insitu concrete to be tested at 28 days - one sample of 2 cylinders for each 15 cubic metres or part thereof placed in an essentially continuous manner with a minimum of two samples of 2 cylinders for each casting day.

For precast concrete to be tested at 28 days - one sample of 2 cylinders for each batch of units cast in an essentially continuous manner.

If the standard of control appears to have changed from that prevailing at the time of the check of quality control, in addition to the above numbers the Engineer may order further cylinders for testing at 7 days.

The ratio of 28 day strength to 7 day strength established by the preliminary mixes shall be applied to these 7 day tests and, if these results indicate a decrease in the standard of control or strengths obtained, the Engineer will order such remedial action as he deems necessary.

14.7.3 Failure to Obtain Required Strength of Cylinders

(1) Concrete Specimens Cut from Work:

Should the strength of a sample representing

reinforced concrete work fail to reach the specified twenty-eight (28) day strength, the Contractor may elect to submit for testing a specimen cut from the completed work. The form and dimensions of the specimen and the location in the work from which it is to be cut and the manner of restoring the cut portion of the work shall be subject to the approval of the Engineer. The specimen shall be taken by means of a core drill.

(2) Cost of Cutting Specimens from Work and of Restoring Cut Work:

The whole cost of cutting specimens from work and of restoring the work from which any specimens have been cut shall be borne by the Contractor.

(3) Delivery and Testing of Specimens Cut from Work:

Specimens cut from work shall be delivered to the Engineer to conduct the compression tests thereon in such a manner as he, at his absolute discretion, may direct. Facilities will be given to the Contractor to have a representative witness the tests if he so desires.

(4) Determination of Strength of Specimens Cut from Work:

The actual test strength of the specimen cut from the work shall be adjusted to obtain the equivalent strength of a 300 mm x 150 mm diameter cylinder in accordance with AS 1012, Parts 9 and 14.

Further should any specimen cut from the finished work be tested at an age (i.e. number of days after pouring) greater than twenty-eight (28) days its strength shall be adjusted to the equivalent 28 days strength by dividing the actual strength by the factor given in the following table:

Age of test specimen in days at date of testing	Factor
28	1.00
35	1.02
42	1.04
49	1.06
56	1.08
70	1.10
84	1.12
112	1.14
140	1.16

Age of test specimen in days at date of testing	Factor
168	1.18
196	1.20
224	1.22
308	1.24
365 and greater	1.25

Notes: (i) For intermediate ages the factor shall be determined on a pro-rata basis;

(ii) If specimens are tested at seven (7) days for the purpose of preliminary information and control, the approximate equivalent strength at twenty-eight (28) days may be obtained by dividing the actual strength of seven (7) days by the factor 0.70.

Seven day tests are not to be regarded as acceptance tests.

Concrete containing high early strength cement, additives or specially cured shall be adjusted for age as set out above for Ordinary Portland Cement unless determined otherwise by the Engineer.

14.7.4 Determination of Strength for Acceptance of Concrete

After tests of concrete specimens cut from the work have been made, if any, the Engineer will consider the test results and other information and may at his absolute discretion determine the strength of the concrete to be taken for acceptance (necessary adjustments for form and age of specimens being made as herein specified) as one of the following:

(i) the average strength of the pair(s) of cylinders moulded at the time of pouring if no specimens are cut from the work, or

(ii) the average strength of the pair(s) of cylinders moulded at the time of pouring (i.e. rejecting the specimens cut from the work on the grounds of being unsatisfactory in some respect), or

(iii) the mean of the average strength of the pair(s) of cylinders moulded at the time of pouring and the equivalent strength of the specimens cut from the work, or

(iv) the equivalent strength of the specimens cut from the work, (i.e. rejecting tests on cylinders moulded at the time of pouring on the ground that such cylinders do not truly represent the concrete as placed).

14.7.5 Basis of Acceptance

The basis of acceptance of concrete in the Works will be the twenty-eight (28) day strength determined by the Engineer in accordance with Clause 14.7.4 for each continuous section of the work or one day's pour as directed by the Engineer. Concrete having a deficiency in strength will be treated as follows:

(i) should the strength of the concrete fail to reach the specified minimum value by more than ten (10) per cent, the Engineer may reject the whole or part of the concrete represented by the test specimen;

(ii) alternatively, the Engineer may give consideration to the acceptance of the whole or part of such concrete, subject to a deduction of two (2) per cent of the schedule rate for each one (1) per cent, or fraction thereof, deficiency in strength, up to a maximum deficiency in strength of ten (10) per cent.

Notwithstanding acceptable strength, any concrete used in the Works not of the grades shown on the Drawings or specified, and/or not made or placed in accordance with this Specification as and where shown on the Drawings or directed by the Engineer, may be rejected. Also, hardened concrete which is porous, segregated, honeycombed or in which the placing was so interrupted as to require a construction joint which was not specified, or where concrete or embedded steel has been disturbed by vibration or movement of forms after initial set has taken place, or which in the opinion of the Engineer is otherwise defective, may be rejected.

Concrete rejected for any reason shall be removed in accordance with the Engineer's directions.

14.7.6 Cost of Testing

Unless otherwise directed by the Engineer, all test cylinders shall be manufactured, handled and cured by the Contractor and delivered to the testing laboratory nominated by the Engineer in sufficient time for testing at 7 or 28 days as determined by the Engineer. The cylinders shall be marked for identification purposes according to the system directed by the Engineer. The cost of manufacture, handling and curing the cylinders and delivery to the testing laboratory shall be borne by the