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LOT 01 : 1/3 PALESTINIAN BRIDGE REHABILITATION

FINAL DESIGN REV 0

TECHNICAL SPECIFICATIONS

JULY,2017

G E N E R A L I N D E X

PART T H R E E : P A V E M E N T

31 SUBBASE

3101 SCOPE

The work covered by this Section of the Specification's consists in furnishing all plant, equipment, material and labour and in performing all operations in connection with the construction of a subbase course on a prepared subgrade complete, subject to the terms and conditions of the Contract and in >^strict accordance with this Section of the Specifications and the applicable drawings and the directions of the Engineer's Representative.

3-102 MATERIALS

The materials shall consist of sand, gravel or a sand-gravel mixture from sources approved by the Engineer's Representative. Approval of a source does not mean that all material in the source is approved. The portion retained on the No. 10 sieve shall be known as coarse aggregate,and the portion passing the ASTM No. 10 sieve shall be known as fine aggregate.

Coarse Aggregate: Coarse aggregate shall consist of hard, durable particles or fragments of gravel free from dirt and other objectionable matter. It shall have a percentage of wear not to exceed 35 when tested in accordance with AASHTO standard method T 96.

Fines: The fine aggregate shall consist of sharp natural sand and shall be free from organic and other objectionable matter.

The material passing the No. 40, sieve when prepared in accordance with AASHTO method T 146 and tested by appropriate methods, shall conform with the following requirements:

AASHTO Standard Method	Maximum
Liquid Limit T 89	25 %
Plasticity Index T 90	6 %

3103 GRADATION

The gradation, as determined by AASHTO method T 27,sha11 conform with one of the following gradation groups:

Sieve Size		Passing per cent by weight		
mm	ASTM	Type A	Type B	Type C
	3"	100		
50	2"	80 - 100	100	-
25	1"	55 - 90	70 100	100
10	3/8"	35 - 65	50 80	65 - 95
5.0	No. 4	25 - 55	40 65	50 - 80
2.0	No. 10	20- 40	30 50	40 - 65
0.4-	No. 40	10 - 25	15 25	20 - 35
0.08	No. 200	3-10	3 in	3 - 10

The gradation, as used in the work, shall not vary from the low limit on one sieve to the high limit on the adjacent sieve but shall be uniformly graded.

The California Bearing Ratio of the subbase$_s$course when tested in accordance with AASHTO T 193,shall not be less than 30 % at 95 % of the maximum density established according to AASHTO T 180.

Granular base for the standing lane on a previously prepared sub-base shall be executed in accordance to section 31 of the Specification but with a California Bearing Ratio of not less than 50 % at 95 % of the maximum density.

3104 EQUIPMENT

All equipment, tools and machines used in the performance of the , work shall be new and subject to the approval of the Engineer's \ Representative ,and shall be maintained in satisfactory working
condition at all times equipment may be used.

Sprinkling Equipment: Sprinkling equipment shall be suitable for applying water uniformly and at controlled quantities to variable widths of surface.

Compaction Equipment: Compaction equipment shall be of most suitable type for compacting the subbase course to the density specified. Vibration compactors and rubber tired compactors may be used.

3105 OPERATION OF PITS AND STOCKPILING

All strata and pockets of unsuitable material overlying or occuring in the deposit shall not be used and shall be run to spoil as per the direction of the Engineer's Representative. The method of processing and blending the material and of operating the pit shall be changed or modified to obtain material conforming to the specified requirements. Approved material may be stockpiled in the manner and at the locations approved by the Engineer's Representative. Prior to stockpiling storage sites shall be cleared and levelled *by* the Contractor.

3106 WEATHER LIMITATIONS

Subbase shall be constructed only when weather conditions do not detrimentally affect the quality of the finished formation level. Any areas of the subbase that are damaged by the effects of unfavourable weather conditions during any phase of construction shall be completely scarified, reshaped and recom-pacted in conformance with the requirements of this Specification without additional cost to the Employer.

3107 PREPARATION OF SUBGRADE

Prior to construction of the subbase course, the previously pre-pared subgrade shall be cleaned of all foreign substances. Any ruts or soft yielding spots which occur in the subgrade, any area having inadequate compaction or any deviations of surface from the requirements specified, shall be corrected by scarifying, removing and/or adding approved material, re-shaping and re-com-pacting the unsatisfactory areas to the required density and to the established line and grade. Appreciable irregularities in the surface of the subgrade shall be corrected by blading and rolling, adding water where necessary.

3108 GRADE AND ALIGNMENT CONTROL

Grade and alignment control stakes shall be furnished, set and maintained by the Contractor, subject to checking by the Engineer's Representative. The stakes shall be set in rows on and parallel with the centerline of the pavement and spaced so that string lines may be stretched between them, but in no case more than 15 m apart.

3109 PLACING AND SPREADING

Where subbase course thickness exceeds 20 cm,it may be constructed in two or more layers of equal thickness depending on the compaction equipment available. No superimposing layer should be placed before the previous layer has been approved by the Engineer's Representative. A templet cut to the camber of the finished course is required.

3110 MIXING

Mixing shall be accomplished in one or more passes of the mixer through the material, but in any event shall be continued until the resulting mixture is entirely uniform and of proper moisture content. If at any time the material is excessively moistened during construction, it shall be aerated by re-mixing until the moisture content is acceptable. Areas of segregated material shall be corrected by removing and replacing with satisfactory material or by re-mixing. When necessary to meet the requirements specified, additional approved material shall be spread in such amounts as are found to be necessary and the added material shall be uniformly mixed into the subbase material, adding water as required to obtain the specified density.

3111 COMPACTION

Each layer shall be compacted until the entire depth of the course is at least 95 % of density at optimum moisture as determined by AASHTO T 180. The plate bearing value "E 2", ascertained in accordance with Clause 3114 of this Specification shall be not less than 1.000 kp/sq.cm. Beneath the binder course of the standing lane the E 2-value shall be more than 1.200 kp/sq.cm

3112 THICKNESS AND FINISH

The completed subbase courses will be tested for the required thickness and surface before acceptance. Any areas of the completed subbase having a compacted thickness less than the thickness shown in the respective items of the Bill of Quantities and/or on the drawings shall be corrected by scarifying the surface* adding approved material, reshaping, recompacting and finishing as specified and as approved by the Engineer's Representative. Skin patching of an area without scarifying the surface to permit proper bonding of the added material will not be permitted.

The surface of each subbase course shall be properly shaped to a smooth uniform surface parallel to the finished surface of the carriageway and shall not vary more than 2 cm when tested with a 4 m straight edge.

The entire work must be constructed to the exact position and elevation in conformity to the lines and grades shown in the drawings. The tolerances are + 0 mm to - 20 mm.

3113 MAINTENANCE OF SUBBASE

The completed subbase shall be maintained in an acceptable condition at all times as directed by the Engineer's Representative prior to the construction of the base course. Traffic on the sub-base during the rainy season will not be permitted.

3114 SAMPLING AND TESTING

Tests shall be made as often as deemed necessary to ensure compliance with the requirements of this Specification. Reference is made to Section 14.

The minimum number of tests is generally for every 2,000 cu.m of completed subbase.

In situ density:	AASHTO T 191 or AASHTO T 205 or AASHTO T 238
Gradation Test Plasticity Index	AASHTO T 27 AASHTO T 90
For *every* 20,000 cu.m:	
Moisture density relation	AASHTO T 180
CBR Test at 95 % of max. density	AASHTO T 193

For *every* 4,000 cu.m on the finished surface, plate bearing test should be done according to the German Standards (Merk-blatt fur bodenphysikalische Prufverfahren im StraSenbau, edited 1963 by ForschungsgeselIschaft flir das StraBenwesen e.V. Cologne, West Germany).

For the plate bearing test a 30 cm diameter bearing plate shall be used. A load giving a total settlement of about 1.5 mm shall be applied by 6 to 8 load increments. Then the load shall be completely released in stages. A second application and release of the same load resp. pressure shall be done in this manner and load resp. pressure - settlement curve shall be graphically established.

Then the plate bearing value E~ shall be calculated as follows:

$$E2 = \frac{1.5 \times r \times \Delta p}{\Delta S}$$

E_2 = Plate bearing value, calculated in respect of the results of the second pressure - settlement curve.

r = Radius of the bearing plate (cm)

Δp = Difference of the pressure appearing at the be-^{p} ginning and end of that part of the pressure - settlement curve .which is nearly a straight line.

Δs = Difference of the settlement in the above-mentioned scope.

The plate bearing test shall be made on an area with an optimum moisture content according to AASHTO T 180.

The plate bearing tests shall be made immediately before the construction of the bituminous gravel base course or binder course to guarantee a sufficient bearing capacity of the subbase. In rainy periods the results of the flat bearing tests will be the basis for permission to construct the bituminous layers above the subbase course.

Any material found to be in nonconformance with the requirements will be cause for rejection. All rejected material shall be removed and replaced by the Contractor with material meeting the requirements at no cost to the Employer.

Not less than 20 days before granular material is required for use in the Works, the Contractor shall submit adequate representative samples and test results.

3115 MEASUREMENTS

The unit of the measurement for payment shall be the cubic meters of completed and accepted subbase and/or granular base course as shown on the drawings, plus any areas authorized by the Engineer's Representative and measured separately.

3116 PAYMENT

The cubic meters of subbase and/or granular base course, determined as specified in Clause 3115_vwill be paid for at the price tendered per cubic meter, which payment shall constitute full compensation for the construction and completion of the subbase courses including preparation of subgrade, the furnishing of all materials, supplies, plant, equipment, tools and labour, the handling, manipulating, placing, shaping, compacting including the necessary water for compaction, rolling and finishing, correcting unsatisfactory areas, testing of materials and density, maintenance and for furnishing of all other labour and incidentals necessary to complete the work required by this Section of the Specification.

32 CEMENT STABILIZED SUBBASE

3201 SCOPE

The work covered by this Section of the Specification consists in furnishing all plant, equipment, material and labour and in performing all operations in connection with constructing cement stabilized subbase layer and all incidentals subject to the terms and conditions of the Contract and in strict accordance with this Section of the Specification and the applicable drawings and the directions of the Engineer's Representative.

3202 MATERIALS

, Aggregate: The aggregate shall comply with Clause 3102 of the Specifications or other sources selected by the Contractor and approved by the Engineer's Representative.

Cement: The cement to be used for stabilization shall be PORTLAND Cement or sulphate resistant cement as directed by the Engineer's Representative after execution of laboratory tests.

For storage of cement at least two silos shall be used. Before recharging a silo it shall be emptied completely and cleaned. During the time of charging a silo it shall not be used for batching. The silos and all batching devices shall be maintained regularly.

At the time of use all cement shall be free-flowing and free of lumps. Cement that has been in storage so long that there is doubt of its quality will be tested by standard mortar tests to determine its suitability for use and such cement shall not be used without approval.

Water: The water to be used for cement stabilization shall be clean and free from injurious substances. Water from doubtful sources shall not be used until tested as specified in AASHTO designation T 26 and approved by the Engineer's Representative.

3203 COMPOSITION OF MIXTURE

The cement content shall be determined at the laboratory so that the compressive strength is between 30 and 80 kp/sq.cm.

The tests shall be carried out in accordance with AASHTO T 134 at the optimum moisture content. The samples shall be kept for 7 days moist in a storage box located in the shade at the site of the Works. Before crushing, the samples should be kept for 2 hours in the water. A swelling test has to be performed according to AASHTO T 135. The permissible swelling shall be 2 % in volume, the maximum loss of weight shall be 8 %.

3204 EQUIPMENT

Equipment, tools and machines, used in the performance of the work covered by this Section of the Specification, shall be subject to the approval of the Engineer's Representative and shall be maintained in a satisfactory working condition at all times.

Processing equipment shall be designed, constructed and operated to such capacity so as to mix the aggregate, cement and water thoroughly in one layer of 20 cm thickness to produce a mixture that is homogeneous, uniform and of the consistency required for compaction. When plant mixing is used, the mixing plant shall be equipped with weight or volume measuring apparatus capable of proportioning cement, aggregate and water exactly to the specified proportion and shall be approved by the Engineer's Representative.

The cement treated subbase courses shall be compacted with tamping steel-wheeled, vibratory or pneumatic-tired rollers as approved by the Engineer's Representative.

3205 WEATHER LIMITATIONS

Cement stabilized subbase course shall be constructed only when the atmospheric temperature is above 4 C and when the weather is not rainy.

3206 PREPARATION OF AGGREGATE

Road Mix: When the road-mix type equipment is used, the material shall be placed in either windrows or layers on the prepared underlying course. The material shall be in uniform windrows or layers of such quantity that when processed and com- pacted, the subbase course will be of the required thickness. The placing and distributing of the material shall be done in such a manner as to prevent segregation, and shall be approved by the Engineer's Representative.

Plant Mix: When.the mixing plant is used, the aggregates for cement treatment shall be transported from the approved sources to the storage site and placed separately for sizes and sources as directed by the Engineer's Representative.

3207 MIXING AND SPREADING

Road Mix: Where flat-type mixing equipment is used, the cement shall be spread in the necessary quantity as approved by the Engineer'.s Representative *over* the full width of the lane being processed. Immediately after the cement has been distributed, it shall be mixed with the loose aggregate for the full depth of the treatment. Care shall be exercised so that the cement is not mixed with soil below the desired depth.

Water shall be incorporated in the mix in the amount to guarantee the optimum moisture content during compaction according to the test results of AASHTO T 134 and under such conditions as will permit accurate control of the amounts of water added. The net amount of water to be added shall be adjusted for the moisture content of the aggregate, for the moisture that will be absorbed and for any moisture loss between the time of mixing and compaction.

Plant Mix: Where mixing plant is used, the cement, aggregate and water shall be exactly proportioned as found necessary in the test series described under Clause 3203 and accepted by the Engineer's Representative. The loss of moisture content during transportation and spreading has to be taken into account. Proportioning may be accomplished by means of either weight or volume measuring apparatus approved by the Engineer's Representative. ..

Mixing shall be continued until the mixture gains uniform water and cement content and uniform gradation. Mixing time shall be directed by the Engineer's Representative.

The time between end of mixing and end of compacting shall not exceed one and a half hours.

3208 COMPACTION

Immediately upon completion of spreading operation and shaping the mixture shall be thoroughly compacted with approved rollers. Compaction shall continue until the entire depth and width of the subbase is uniformly compacted to the maximum density of 95 % mod. AASHTO according to AASHTO T 134.

3209 PROFILING, SMOOTHNESS AND THICKNESS

In case the profiling is not sufficient, the modification has to be finished together with the compaction within one and a half hours after mixing. No profiling or compaction whatsoever shall be made after this time.

The smoothness of the finished .subbase shall be the same as prescribed in Clause 3112.

The thickness of the stabilized layer shall not be less than 10 % from the specified thickness, and in no case the difference shall be more than 2 cm. Otherwise the deficient areas have to be removed and made good at no cost to the Employer. For deficient areas with a missing thickness of 0.75 cm to 2.0 cm the reduced actual thickness shall apply for measurement and payment.

3210 CURING

The stabilized subbase layer after compaction shall be protected against drying out by keeping it continuously damp or wet for a period of at least 3 days or as directed by the Engineer's Representative. The rate of application of the curing material shall be as directed by the Engineer's Representative.

3211 MAINTENANCE

The completed cement stabilized subbase shall be maintained in an acceptable condition at all times as directed by the Engineer's Representative prior to the construction of the base course. For 7 days after finishing, any traffic upon surface is prohibited.

3212 SAMPLING AND TESTING

Tests shall be made as often as deemed necessary to ensure compliance with the requirements of this Specification. Reference is made to Section 14.

The minimum number of tests is generally:

- For every 5,000 sq.m of completed stabilized layer immediately after completion of compaction -

– In situ density	AASHTO T 191 or AASHTO T 205 or AASHTO T 238
Gradation Test	AASHTO T 27 Cement
Content Test	AASHTO T 211

- For every 10,000 sq.m of completed stabilized . layer respectively for one day's run -

  One set of 3 test specimen for testing the compressive strength, size and curing of specimen according to Clause 3203.

  The material shall be taken from the construction site before compaction.

- For every 50,000 sq.m of completed stabilized layer - One moisture density relation AASHTO T 134 with material taken fresh from the construction site.

3213 MEASUREMENT

The unit of measurement shall be the cubic meter of completed and accepted cement stabilized subbase course. The number of cubic meters of completed cement stabilized subbase course shall be determined by the length along the centerline and upon the surface of the stabilized subbase, times the width as shown on the drawings plus any area authorized and measured separately, times the specified thickness. In case of missing thickness of 0.75 cm up to 2.0 cm, the reduced actual thickness shall be measured.

3214 PAYMENT

The cubic meters of the cement stabilized subbase course, which specified thickness does not fall short of more than 0.75 cm, determined as specified in Clause 3213, will be paid for at the unit price tendered per cubic meter in the Bill of Quantities, which payment shall constitute full compensation for the construction and completion of the cement stabilized subbase course, including conditioning of subgrade, the furnishing of all materials, supplies, plant equipment, tools and labour, the handling, mixing, manipulating, placing, shaping, compacting, including the necessary water, correcting unsatisfactory areas and unsatisfactory mixtures, curing maintenance and for furnishing all other labour and incidentals necessary to complete the work required by this Section of the Specifications.

For cement stabilized subbase course found deficient in thickness by more than 0.75 cm but not more than 2 cm, the adjusted unit price for cement stabilized subbase course shall have the same ratio to the contract unit price that the square of the average thickness found, has to the square of the thickness called for.

33 BITUMINOUS GRAVEL BASE COURSE

3301 SCOPE

The work covered by this Section of the Specifications consists in furnishing all plant, labour, equipment and materials and in performing all operations in connection with the construction of bituminous gravel base course on a previously prepared subbase complete, subject to the terms and conditions of the Contract and in strict accordance with this Section of the Specifications, applicable drawings and the directions of the Engineer's Representative.

3302 MATERIAL

3302.1 AGGREGATES

Aggregates shall be of uniform quality and shall be co'mposed of sound, tough, durable particles with or without natural or mineral fillers as required. All material shall be clean, free from clay balls and clay coated particles, organic matters and other deleterious substances. The aggregate shall have a percentage of wear of not more than 35 when tested in accordance with AASHTO T 96. The plasticity index shall not exceed 3 as determined by AASHTO T 89 and T 90. The aggregate shall not have a gypsum content ("Juss") in excess of 1 % by weight corresponding to a SO™ content of 0.6 %.

The materials to be used in the work shall be of such nature that a mixture of them, proportioned in accordance with the job-mix-formula, will have a retained strength of not less than 60 % when tested in accordance with AASHTO T 165.

The gypsum content may be up to 1.8 % by weight if the retained strength is more than 70 % when tested in accordance with AASHTO T 165, and the swelling after 28 days of soaking (see Clause 3519.2) is less than 2 vol.%. The test specimen for determining retained strength and swelling must have a void content of 3 to 5 vol.%.

3302.2 COARSE AGGREGATE

That portion of the combined aggregates retained on the 2 mm (No. 10) sieve shall be natural or crushed gravel of such gradation that, when combined with other required aggregate fractions and fillers in proper proportion, the resultant mixture shall meet the gradation required.

The coating and stripping shall be above 95 % when tested according to AASHTO T 182 or ASTM D 2727.

3302.3 FINE AGGREGATE

That portion of the combined aggregates passing the 2 mm (No. 10) sieve shall consist of natural sand and/or stone screenings or a combination thereof of such gradation that, when combined with other required aggregate fractions and fillers in proper proportions, the resultant mixture shall meet the gradation required.

Fine aggregate shall be composed of clean,, tough grains, free from lumps or balls of clay or other objectionable material. If natural sand is used, the grains shall be sound, hard, dry and durable and shall not contain any organic or other foreign matter.

3302.4 MINERAL FILLER

Mineral filler (material passing No. 200 sieve) shall be added where required to conform with the specified grading.

The requirements described in Clause 3502.4 shall be considered.

3302.5 BITUMINOUS MATERIAL

As specified in Clause 3502.5, bitumen of grade 40-50 shall be used. The use of grade 50-60 and/or 60-70 is only permitted if authorized by the Engineer's Representative. Bitumen mixtures carried out on the site are prohibited.

3302.6 ADHESION PROMOTING AGENTS

As specified in Clause 3502.6

3303 COMPOSITION OF MIXTURE

The mixture for the bituminous base course shall generally be composed of natural gravel.

If the grading of the natural material does not conform with the following requirements, a screening of the natural material and/or adding of missing grade components will be necessary.

The following grading requirements are' based on washed samples:

Sieve Size		Passing % by weight of total Aggregates
mm	ASTM	
31.5	1 1/4"	100
20	3/4"	70 - 100
10 5 2	3/8"	50 - 80
0.63	No. 4	30-65
0.25	No. 10	20 - 50
0.08	No. 30	12 - 34
	No. 60	6-25
	No. 200	4 - 10

Bitumen percentage by weight of total aggregate 3.5 - 5.0

The aggregate,, as used in the work, shall not vary from the low limit on one sieve to the high limit on the adjacent sieve but shall be uniformly graded. Adjustment of the aggregate gradation and/or bitumen content within the foregoing limits may be made. as directed by the Engineer's Representative.

3304 JOB MIX FORMULA

A job mix formula shall be prepared and submitted by the Contractor and approved by the Engineer's Representative before the mixture is manufactured.

The Contractor will be allowed the following tolerances from the approved job mix formula within the grading specified in Clause 3303.

Aggregate passing sieve 2 mm (No. 10)	+ 6 %
Filler (passing sieve No. 200)	+ 6 % or - 2 %
Bitumen	+ 0.5 %

The bituminous mixture shall have the following test properties (when compacted by 50. blows of a standard Marshall hammer on each face)

Stability Marshall	min. 500 kp
Flow Marshall	1-4 mm
Percent voids - mix	2-6 vol.%

Should a change in source of material be made, a new job mix formula shall be established before the new material is used.

3305 APPLIANCE OF SECTION 35

For equipment, weather limitation, alignment control, mixing, transportation of bituminous mixtures, placing, compaction, joints, sampling and testing, the respective Clauses of Section 34, bituminous concrete, pavement, shall apply.

3306 PREPARATION OF SURFACE

Before applying the bituminous gravel, the smoothness of the underlying course shall be tested with a 4 m straight edge. It shall not vary more than 2 cm and must be corrected if necessary.

Immediately before applying the bituminous gravel the surface of the underlying course shall be thoroughly cleaned of all loose or foreign material as directed. The surface shall be primed if so directed by the Engineer's Representative in accordance with Section 34.

3307 SMOOTHNESS

The finished surface shall not vary more than 10 mm when tested with a 4 m straight edge. After the completion of the final rolling, the smoothness of the course will be checked and any irregularities that exceed the specified tolerances or that retain water on the surface shall be corrected by removing the defective area and replacing with new base course without additional cost to the Employer.

3308 THICKNESS

The completed course will be tested for thickness at such intervals as directed by the Engineer's Representative.

Where some specified thickness quoted in the Bill of Quantities are missing, the deficient thickness shall be compensated by the successive courses.

Where the thickness specified in the Bill of Quantities exceeds more than 10 mm, the excess thickness must be removed to the satisfaction of the Engineer's Representative.

3309 PROTECTION OF BASE COURSE

After final rolling, no vehicular traffic of any kind shall be permitted on the base course for at least 24 hours. After this period,vehicular traffic of any kind shall be permitted only as directed by the Engineer's Representative.

3310 MEASUREMENT

The unit of measurement for payment shall be the square meters of the completed and accepted bituminous gravel base course. The number of square meters of the completed bituminous gravel base course shall be determined by the length measured along the center!ine and upon the surface of the course, times the width as shown on the drawings, plus the areas of any widening on turnouts and intersections, authorized by the Engineer's Representative.

3311 PAYMENT

The square meters of completed and accepted bituminous gravel base course for the thickness, as called for in the Bill of Quantities measured as specified in Clause 3310, shall be paid.

No additional payment will be made for any thickness of bituminous gravel base course in excess of the thickness specified in the Bill of Quantities or shown on the drawings.

Such payment and/or payments shall constitute full compensation for preparing the surface of the subbase, furnishing all materials, equipment, plant and tools, handling, mixing, manipulating, placing, shaping, compacting, rolling and finishing, correcting unsatisfactory areas and all labour and incidentals necessary to complete the work required by this Section of the Specifications.

34 PRIME AND TACK COAT

3401 SCOPE

The work covered by this Section of the Specification consists in furnishing all plant, labour, equipment and materials and in performing all operations in connection with the application of a bituminous prime or tack coat on a previously prepared course complete, subject to the conditions of Contract and in strict accordance with this Section of the Specifications and the applicable drawings and the directions of the Engineer's Representative.

3402 BITUMINOUS MATERIAL

For Prime Coat:

The bituminous material shall be a medium curing cut-back bitumen MC 30 conforming to AASHTO designation M 82, produced by fluxing in an approved manner an 85/100 penetration bitumen with GORA "Kerosine". The cutback bitumen shall be free from water, shall show no separation or curdling prior to use and shall be tested in accordance with the following standard AASHTO methods:

Sampling	T 40
Water content	T 55
Viscosity	T 72
Separation	T 78

For Tack Coat:

The bituminous material shall be a rapid curing cut-back bitumen RC 250 conforming to AASHTO designation M 81, produced by fluxing in an.approved manner an 85/100 penetration bitumen with GORA standard "motor spirit". The cut-back bitumen shall be free from water, shall show no separation or curdling prior to use and shall be tested in accordance with the standard AASHTO methods as stated above.

3403 SAMPLING AND TESTING

All bituminous material shall be sampled and tested as frequent ly as deemed necessary by the Engineer's Representative for con formance with the requirements of Clause 3402 of this Section of the Specifications.

3404 QUANTITIES TO BE APPLIED

For Prime Coat:

Bituminous material shall be applied in quantities of 1.0 kp/sq.m

For Tack Coat:

Bituminous material shall be applied in quantities of 0.4 kp/sq.m

3405 WEATHER LIMITATIONS

The prime and tack coat shall be applied only when the surface to be treated is dry or contains moisture not in excess of that which will permit uniform distribution and the desired penetrations. It shall not be applied when the atmospheric temperature is below 15 C unless otherwise directed by the Engineer's Representative and when, in the opinion of the Engineer's Representative, there is no excessive wind.

3406 EQUIPMENT

All equipment, tools and machines used in the performance of the work shall be subject to the approval of the Engineer's Represen- tative and shall be maintained in satisfactory working condition at all times.

Pressure Distributor for Prime Coat:

The distributor shall be self-propelled, pneumatic-tired and shall be so designed and equippped as to distribute the bituminous material uniformly on variable widths of surface at readily de- termined and controlled rates.

Hand Power Spray Attachment for Tack Coat:

A hand power spray attachment to a bitumen pressure distributor or other container having an independently operated bitumen pump pressure gauge, thermometer for determining the temperature of the asphalt tank contents and a hose connected to a hand power spray suitable for applying the bituminous tack coat in the amounts specified - all to be such as to meet the approval of the Engineer's Representative-shall be furnished.

Heating Equipment:

The equipment for heating bituminous material shall consist of steam coils and equipment for producing steam so designed that steam will not be introduced into the material or of other approved means so that no flame will come into direct contact with the material container, and there will be no local overheating of material. In the event storage tanks are used, an armored thermometer with a range from OOQ to 120°C shall be fixed to the tank so that the temperature of the bituminous material may be determined at all times. Bituminous material, which has been heated above 100 C,will be rejected. All storage tanks, piping, retorts, booster tanks and distributors used in storing, handling or heating bituminous material shall be kept clean and in good operating condition at all times and shall be operated in such manner that there will be no contamination by foreign material.

Attention is called to the fact that bituminous material, particularly cut-back bitumen, is highly inflammable. The utmost care shall be taken to prevent open flames from coming in contact with the bituminous material or gases therefrom. The Contractor will be responsible for any fire or accidents which may result from heating or handling the bituminous material .

Power Brooms and Power Blowers:

Brooms and blowers shall be of the power type and shall be suitable for cleaning the surface to which the prime or tack-coat is to be applied.

3407 PREPARATION OF SURFACE

The surface of the base course will be inspected and tested for smoothness by the Engineer's Representative. Any areas showing deviations in excess of the straight edge requirements,, as described in other Sections of this Specification, or any areas showing ruts or soft yielding spots shall be corrected by scarifying, removing and/or adding approved material, reshaping and recompacting to the required density and to the established line, grade and cross section. Skin-patching of an unsatisfactory area without scarifying the surface sufficiently to permit proper bonding will not be permitted.

Immediately before applying the prime or tack-coat, all loose material, dirt or other objectionable material shall be removed from the surface to be treated by power brooms and/or blowers, supplemented by hand brooms as directed by the Engineer's Representative. Prior to application an inspection of the prepared surface will be made by the Engineer's Representative to determine its fitness to receive the bituminous material and no bitumen shall be applied until the surface has been approved. If the surface is excessively dry and/or dusty so that the bituminous material freckles , it shall be lightly and uniformly sprinkled with water immediately prior to priming, but bituminous material shall not be applied until all free surface water has disappeared.

3408 APPLICATION OF BITUMINOUS MATERIAL

General:

Immediately following the preparation of the surface, the bituminous material shall be applied by means of the pressure distributor at an adequate temperature, in the amounts specified in Clause 3404 as directed by the Engineer's Representative. The material shall be applied so that uniform distribution is obtained at all points of the surface to be treated. All spots unavoidably missed by the distributor shall be properly treated with bituminous material.

Before beginning application, building paper shall be spread over the surface from the joint back, for a sufficient distance for the spray bar to begin spraying and operating at full force when the surface to be treated is reached. After the bitumen is applied, the building paper shall be removed and destroyed. It shall be ensured that no areas are covered two times.

Prime Coat:

Following the application of prime material, the surface shall be allowed to cure for a period of at least 24 hours without being disturbed or for such additional period of time as may be necessary to attain penetration into the base course and aeration of the volatiles from the prime material. The Contractor shall furnish and spread sufficient approved sand on all areas which show an excess of bituminous material to effectively blot up the excess as directed by the Engineer's Representative.

Tack Coat:

The tack coat shall be applied only a short distance and not more than 2 hours in advance of the placement of the bituminous mixture so as to provide a thin adhesive film of bitumen to ensure. a good bond.

3409 PROTECTING SERVICES WHILE SPRAYING

All services, structures, manhole covers, kerbs, gutters, poles, etc. are to be left in their original condition. Approved methods are'to be adopted to covering and protecting such services during spray operations.

3410 MAINTENANCE

The treated surface shall be maintained in satisfactory condition until the succeeding layer of pavement has been placed During this interval the Contractor shall protect the treated surface against damage and shall repair all broken spots.

3411 MEASUREMENT

The unit of measurement shall be the square meter as actually covered by a prime or tack coat in accordance with this Specification.

Measurement for payment will not consider any bituminous material placed in excess of the specified rate of application.

3412 PAYMENT

The number of quare meters of prime or tack coat, measured as specified, will be paid for at the price tendered in the Bill of Quantities, which payment shall constitute full compensation for furnishing, delivering and applying the materials, for furnishing and spreading blotter material, for preparation of surface, for maintenance and for all labour and incidentals necessary to complete the work required by this Section of the Specification.

35 BITUMINOUS CONCRETE PAVEMENT

3501 SCOPE

The work covered by this Section of the Specifications consists in the furnishing of all plant, labour, equipment and materials and in performing all operations in connection with the construction of bituminous concrete pavement on a previously prepared course, complete subject to the terms and conditions of the Contract and in strict accordance with this Section of the Spedification, the applicable drawings and the directions of the Engineer's Representative.

3502 MATERIAL "

3502.1 AGGREGATES

Aggregates shall be of uniform quality, crushed to size as necessary and shall be composed of sound, tough, durable particles, with or without natural or mineral fillers, as required. All material shall be clean, free from clay balls and clay coated particles, organic matters and other deleterious substances and shall not contain more than 20 % of flat or elongated pieces wjth a relation of more than 3 to 1 between length and thickness. Tfte aggregate shall have a percentage of wear of not more than 30 \ when tested in accordance with AASHTO T 9.6.

The plasticity index shall not exceed 3 as determined by AASHTO T 89 and T 90. The aggregate shall not have a gypsum content ("Ouss") in excess of 1 % by weight, corresponding to a S0« content of 0.6 %.

The material to be used in the work shall be of such nature that a mixture of them, proportioned in accordance with the job-mix formula, will have a retained strength of not less than . 70 % when tested in accordance with AASHTO T 165. The swelling snail not exceed 1.0 *vo.%* after 28 days of soaking and tested on a specimen with a void content of 3 to 5 vol.Si.

3502.2 COARSE AGGREGATE

That portion of the combined aggregates retained on the 2 mm (No. 10) sieve shall be crushed stone or crushed gravel of such gradation that when combined with other required aggregate fractions and fillers in proper proportion, the resultant mixture shall meet the gradation required under the composition of mixture for the specific type under contract. At least 75 % per weight of the particles shall have at least 50 % of the surface fractured. Only one kind shall be used on the project except by permission of the Engineer's Representative. When used as a wearing course the Los Angeles value shall be not more than 20.

The coating and stripping shall be above 95 % when tested according to AASHTO T 182 or ASTM D 2727.

3502.3 FINE AGGREGATE

That portion of the combined aggregates passing the 2 mm (No. 10) sieve shall consist of stone screenings or of a combination of natural sand or stone screenings of such gradation that when combined with other required aggregate fractions and fillers in proper proportions, the resultant mixture shall meet the.gradation required under the composition of mixture for the specific type under Contract.

The content of natural sand shall not exceed 20 % of the total fine aggregate including filler.

Fine aggregate shall be composed of clean, tough, rough-surfaced and angular grains free from lumps or balls of clay or other objectionable material. If natural sand is used the grains shall be sound, hard, dry and durable and shall not contain any organic or other foreign matter.

Stone screenings shall be produced from stone meeting the requirements for coarse aggregate.

3502.4 MINERAL FILLER

Mineral filler shall consist of limestone dust, hydrated lime or other inert material matters from approved sources. The use of specific type or types may be limited by the Engineer's Representative. Mineral fillers shall be thoroughly dry and free

from lumps *or* aggregations of fine particles. It shall conform to the following grading requirements:

Sieve Size		Percentage by Weight Passing
0.08 mm 0.02 mm 0.005 mm	T 90)	30 - 100 min. 100 max. 5 2
Plasticity Index {AASHTO	(No. 200)	

The amount of filler to be added shall be only that amount which is necessary to the grading requirements for the completed mixture prescribed.

3502.5 BITUMINOUS MATERIAL

The refinery which supplies the bituminous materials shall furnish a certificate of analysis signed by an authorized employee of the refinery for each shipment made to the project. The certificate of analysis shall show the test results for all the specified requirements and in addition the net weight for each shipment. The certificates of analysis shall be furnished to the Engineer's Representative.

The bituminous material shall conform with the following requirements:

	Test	Grade of Bitumen		
		B 40/50	B 50/60	B 60/70
1. Penetration at 25 C (100 g, 5 sec.)	AASHTO			
1/10 mm	T 49	40 - 50	50 - 60	60 - 70
2. Flash point C min.	AASHTO T 73	240	230	230
3. Loss on heating (5 hrs. at 163°C)	AASHTO			
% max.	T 47	0.75	0.80	0.80
4. Penetration after heating	AASHTO			
min. % of original	T 49	52	50	50
5. Ductility (at 25 C, 5 cm per min.)	AASHTO			
cm min.	T 51	100	100	100
6. Ductility after heating (at 25 C, 5 cm per min.)	AASHTO			
cm min.	T 51	50	50	50
7. Softening point				
R.B; °C	T 53	54 - 60	52 - 57	49 - 54
8. Increase of softening point R.B. after heating (5. hrs. of 163 C) C max.	AASHTO T 83	10	10	10
9.. Solubility in Organic Solvents	AASHTO			
% min.	T 44	99	99	99
10. Paraffin content				
% max.		2	2	2

The bituminous material used shall be a product prepared by the refinement of crude petroleum, it shall be homogenous, free from water and shall not foam when heated to 180 C.

3502.6 ADHESION PROMOTING AGENTS

If found necessary, adhesion promoting agents shall .be added in accordance with the direction and/or approval of the Engineer's Representative. The agents shall be heat resistant and conform with the used aggregates and bituminous material. Before use the necessary tests have to be carried out. The required quantity shall be defined in the job-mix formula.

No additional payment will be made to the Contractor for adding adhesion agents.

3502.7 SOURCE OF SUPPLY

Approval of source of supply of aggregate and mineral filler shall be obtained from the Engineer's Representative prior to delivery of the material. Samples of each shall be submitted as directed.

Samples of the bituminous material that the Contractor proposes to use in the work shall be submitted and approved before construction begins. No bituminous material other than-that represented by the sample submitted shall be used by the Contractor except with the written consent of the Engineer's Representative. Blending of bituminous materials from different refineries will not be permitted.

3503 COMPOSITION OF MIXTURES

The bituminous mixtures for both binder and wearing courses shall be composed basically of coarse mineral aggregate, fine mineral aggregate, mineral filler, adhesion promoting agents, if any and bituminous material (B 40/50). The several mineral constituents shall be sized, uniformly graded and combined in such proportions that the resulting blend meets the grading requirements for the specific type under contract. To such composite blended aggre gate (considered as 100 % by weight) shall be added bitumen with-

in the percentage limits set in the specifications for the speci fic type.

The requirements for the bituminous mixtures shall conform to the following gradings (all gradings are based on washed samples):

Sieve Size		Passing % by Weight of total Aggregate	
mm	ASTM	Binder Course	Wearing Course
25.0	1 "	100	-
20.0	3/4"	90 - 100	100
12.5	1/2"	70 - 90	80 - 100
10:0	3/8"	60 - 80	70 - 85
5.0	No. 4	42 - 60	60 - 80
2.0	No. 10	27 - 47	40 - 60
1.0	No. 18	20 - 37	28 - 48
0.63	No. 30	1 5 - 3 0	22 - 40
0.25	No. 60	8 - 20	10 - 30
0.125	No. 120	6 - 15	8 - 20
0.080	No. 200	5 - 8	6 - 12
Bitumen B 40/50 (% weight of total mix.)		5.0 - 6.5	5.5 - 7.0

The aggregate, as finally used in the work, shall not vary from the low limit on one sieve to the high limit on the adjacent sieve but shall be uniformly graded.

The relationship filler: Bitumen shall be more than 1.5.

3504 JOB MIX FORMULA

No bituminous mixture shall be manufactured until a job-mix formula has been submitted by the Contractor and approved by the Engineer's Representative. The formula shall indicate the exact percentage of each sieve fraction and the exact percent-. age of bitumen to be used in the mixtures and the mix temperature. The Contractor will be allowed the following tolerances from the approval job mix formula:

Aggregate passing sieve 5 mm (No. 4) or larger	+6 %
Aggregate passing sieve 2 mmand smaller (No. 10 and 40)	+4 %
Filler (No. 200)	+2.0I
Bitumen	+_ 0.3 %
Mix temperature	+ 10°C

The bituminous mixtures shall have the following test properties (when compacted by 75 blow of a standard Marshall hammer on each face):

	Property Binder Course	Surface Course
Stability Marshall Flow Marshall Percent voids in mix % Swelling after 28 days % volume	min. 700 kp mm 2-5 3 - 7 max. 1.0	1,000 kp 2 - 5 2 - 5 1.0

Should a change in sources of material be made, a new job-mix formula shall be established before the new material is used.

3505 EQUIPMENT

3505.1 EQUIPMENT GENERAL

All equipment, tools and machines used in the performance of the work covered by this Section of the Specifications shall be new and subject to the approval of the Engineer's Representative and shall be maintained in satisfactory working condition at all times. All equipment, plant and transport shall be in harmony and with a balanced capacity. An equipment for cutting bituminous layers shall be provided (milling machine).

3505.2 MIXING PLANT

The mixing plant shall be designed, coordinated and operated so as to produce mixture within the job-mix formula, and shall have a sufficient capacity to feed the finisher continuously. A capacity of at least 400 t/hrs. will be required. The plant shall be a weight-batch type. A volumetric-proportioning, continuous mixing type may be substituted for the above type, provided the equipment has demonstrated that it is suitable for producing finished mixtures complying with the job-mix formula specified herein.

The equipment shall have proper and approved thermometers and be equipped with a dust collector.

3505.3 FINISHERS

The finisher shall be the crawler type equipped with the gradline electronic levelling system to ensure perfect levels irrespective of variation in the layer's thickness and irregularities in the underlaying layer. The finisher shall be designed for executing a 12.50 m wide lane of finished pavement in one working operation. For the execution of the standing lane and/or widenings additional finishers, 4 m operating width, working in staggered echelon shall be used. Finishers on tires shall not be permitted. At least two 12.50 m and at least two 4 m wide finishers shall be available simultaneously on the site. All finishers shall be equipped with edging sleeves.

The 12.50 m wide finisher shall be equipped with a combined tamper and vibratory screed with an adjustable amplitude at 5 and 9 mm. The frequency of tamper and vibratory screed shall be infinitely variable and indefinitely adjustable from each other. The speed of the.bar conveyors and the revolutions of the augers are infinitely variable and independently controlled for each side. The flow of material shall be additionally controlled by two hydraulically operated gates on the rear hopper-wall. The finisher shall be equipped with a gearbox of at least sixteen different speeds in order to guarantee constant operating speed. The finisher screed shall be heated by gasburner. The crawler unit shall be suspended at three points to permit independent vertical movement of each of the crawler tracks.

The 4 m wide finisher shall be equipped with the compaction components of the same type as the 12.50 m wide finisher, and shall be capable of placing a layer of at least 20 cm compacted in one single pass.

3505.4 COMPACTION EQUIPMENT

The specified compaction shall be carried out by flat, pneumatic and/or vibrating rollers.

3505.5 CRUSHING EQUIPMENT AND FILLER MILL

Crushing equipment shall be suitable to produce aggregates composed of angular and free of elongated pieces. A filler mill shall be set up.

3506 CONTRACTOR'S PERSONNEL

The Contractor shall employ only such personnel to operate the mixing plant, the mechanical finisher and the compaction equipment who have several years of experience in operating such machines and who are approved by the Engineer's Representative.

3507 WEATHER LIMITATION

Bituminous courses shall be constructed only when the base course *or* binder course is dry, and when tht weather is not ra i ny.

Such courses may be constructed when the atmospheric temperature is at least 5 C and rising unless otherwise directed by the Engineer's Representative. When the atmospheric temperature falls below 15°C, special precautions shall be taken in controlling the temperature of the delivered material and compacting the mix, all loads shall be delivered in covered and/or insulated vehicles.

3508 PREPARATION OF SURFACE

Before applying the bituminous pavement the smoothness of the underlying course shall be tested with a 4 m straight edge, it shall not vary more than 1 cm and must be corrected if necessary.

Immediately before applying the bituminous pavement, the surface of the underlying course shall be thoroughly cleaned of all loose or foreign material to the approval of the Engineer's Representative.

A tack coat shall be applied as ordered by the Engineer's Representative.

3509 ALIGNMENT CONTROL

For the main operations/ pavers shall be equipped with electronic ,leveling systems which ensure perfect levels. In areas where automatic pavers are not practical, alignment stakes shall be furnished, set and maintained by the Contractor, subject to checking by the Engineer's Representative in order that the

Works will conform to the lines shown on the drawings. The stakes shall be set in lines parallel with the centerline of the area to be paved, offset and spaced as directed by the Engineer's Representative at distances not wider than 10 m apart.

3510 MIXING

The bituminous mixture shall be produced in an approved plant. Crushed aggregates shall be furnished and stockpiled separately and delivered to the dryer in desired proportions. The aggregate shall be heated and thoroughly dried before entering the hot bins. The temperature shall be such that the finished temperature will be within the tolerances of the job-mix-formula and always controlled. Filler shall be calibrated so that always natural and mineral filler have the same proportions. All components shall be accurately weighted and conveyed into the mixer$_3$ and the required amount of bitumen introduced. In no case shall the aggregate be introduced into the mixer at a temperature of more than 15 C above the temperature of bitumen. The temperature of both the aggregates and the bitumen at the time of mixing shall be in accordance with the job-mix-formula and strictly controlled. All.overheated and carbonized mixture or mixtures, which foam or show indications of moisture, will be rejected.

3511 TRANSPORTATION OF BITUMINOUS MIXTURES

3511.1 BIN AND HOPPER

The mixer shall be equipped with a heated bin for stocking the finished mix, which shall be so designed that no segregation of mix can occur and no material rests are attached at the walls. The mixer shall be equipped with a hopper at the discharge end of such size and design that no segregation of mix occurs. Any elevator used for loading mixture into vehicles shall have an equally satisfactory hopper.

3511.2 TRUCKS

Trucks for hauling bituminous mixtures shall have tight, clean and smooth metal beds that have been sprayed with a minimum amount of soapy water, thinned or emulgated fuel oil, paraffin oil or lime solution to prevent the mixture from adhering to the beds. Each load shall be covered by a canvas or other suitable material of such size as to protect the mixture from the weather or dust and/or prevent the loss of heat. Any truck causing excessive segregation of material by its spring su'spen-' sion or other contribution factors or that shows oil leaks in detrimental amounts or that causes undue delays shall, upon direction of the Engineer's Representative, be removed from the work until such conditions are corrected.

The transportation (distance, time control, sequence of vehicles, etc.) is to be organized so that the temperature loss of the mixture during the hauling from the plant to the finisher will not be more than 10 %.

Deliveries shall be made so that spreading and rolling of all the mixtures, prepared for a day's run, can be completed during daylight unless artificial light satisfactory to the Engineer's Representative is provided. Any loads wetted excessively by rain will be rejected. Hauling over freshly laid material will'not be permitted.

3512 PLACING

The bituminous pavement shall be placed by mechanical means in accordance with the required finished thickness as stated in the Bill of Quantities or shown on the drawings.

The supply of the mixture into the spreader shall be completely harmonized so that the work is carried on continuously without, any interruptions.

The temperature of the mixture,, when dumped into the spreader, shall be as directed by the Engineer's Representative plus or minus 10 C. Mixtures with a temperature of less than 140 C when dumped into the spreader will be rejected. The spreader shall be adjusted and the speed regulated so that the surface of the course will be smooth and the course of such depth that, when finally compacted, it will conform to the cross section shown I on the drawings. Where the width of the lane requires, two finishers shall operate in staggered echelon, the 12.50 m wide finisher in front and the 4 m wide finisher approx. 15 m behind.

When placing binder, the 12.50 m wide finisher shall follow the 4 m wide finisher. No single lane shall be laid in advance of the adjoining lane further than will permit a satisfactory hot longitudinal joint between lanes. Where forming a hot longitudinal joint5 the 15 cm strip along the edge against which additional material is to be laid shall not be rolled until such additional material is placed except when the work is to be discontinued. After the first lane has been placed and rolled, the adjacent lane shall be placed while the unrolled 15 cm strip is hot and in a readily compactable condition. Rolling of the adjacent lane shall begin along the joint.

Placing of the mixture shall be as continuous as possible. A sufficient number of experienced shovelers and rakers shall follow the spreading machine, dressing the surface as required to produce a course of uniform surface texture and the required smoothness. In areas where the use of machine spreading is impractical, the mixture may be spread by hand and dressed with rakes. The loads shall not be dumped any faster than can be properly handled by the shovelers and rakers. Rakers shall not be permitted to stand in the hot mixture. Contact surfaces of previously constructed pavement kerbs, manholes and similar structures shall be painted with a thin coat of cut-back bitumen prior to placing the bituminous .mixture at no cost to the Employer.

A templet cut to the camber of the finished course is required. Next layer is not to be superimposed without the approval of the Engineer's Representative.

Wearing course shall not be placed in short sections, the length of the section to be executed shall be as directed by the Engineer's Representative, but not less than 1,000 m per day.

3513 COMPACTION

Immediately after the mixture has been spread and struck off, the surface shall be checked and irregularities adjusted and then compacted thoroughly and uniformly by rolling.

The work shall be rolled when the mixture is in proper condition and when the rolling does not, in the opinion of the Engineer's Representative, cause undue displacement, cracking or shoving.

Initial rolling for each layer shall be effected by a three-wheel roller or tandem roller operating immediately in back of the spreader, and they shall be of such weight that the mixture will not be shoved or displaced. The roller shall be operated with the drive roll nearest the spreader unless otherwise directed by the Engineer's Representative.

Immediately following the initial rolling, the mixture shall be thoroughly compacted.

Rolling shall begin at the low side and progress toward the high side overlapping each preceding track until the entire surface has been rolled. Alternate strips of the roller shall be terminated in stops at least 1 m distant from any preceding stop. The rollers shall be in good condition, capable of reversing without back lash and shall be operated by experienced rollermen, and must be kept in continuous operation in such a manner that all parts of the pavement shall receive substantially equal compression.

Any displacement occuring as a result of reversing of the direction of a roller or from any other cause shall be corrected at once as specified and/or removed and made good.

The rollers shall not be permitted to stand on pavement which has not been fully compacted and whose temperature is still more than 80 C. Necessary precautions shall be taken to prevent dropping of oil, grease, petrol or other foreign matter on the pavement either when the rollers are operating or,standing.

Along forms, kerbs, headers, walls or other places not accessible to the roller, the mixture shall be thoroughly compacted with hot-hand tampers or with mechanical tampers giving sufficient compression. Each hand tamper shall weigh not less than 15kp,and shall have a tamping face area of no more than 30 sq.cm. Skin patching of an area that had been rolled shall not be permitted.

The compaction rate of each finished course shall be tested by bulk density (AASHTO T 166) on core samples or by nuclear method (ASTM-D 2950). The bulk density of the finished mixture shall hot be less than 98 % of the laboratory bulk density of the mixture. The deficient pavement shall be removed and replaced with satisfactory pavement by the Contractor at no additional costs.

3514 SMOOTHNESS

The finished surface shall not vary more than 4 mm for the wearing course nor more than 6 mm for the binder course when tested with 4 *m* straight edge. 'After the completion of the final rolling, the smoothness of the course will be checked and any irregularities.that exceed the specified tolerances or that retain water on the surface shall be corrected by removing the defective area and replacing with new pavement without additional cost to the Employer. The maximum tolerances of the crossfall shall be + 0.4 %.

3515 THICKNESS

The completed bituminous pavement will be tested for thickness at such intervals as directed by the Engineer's Representative.

Where more than 4 mm of the thickness of the total bituminous pavement specified in the Bill of Quantities is missing, the deficient pavement shall be removed and replaced with satisfactory pavement without additional cost to the Employer.

3516 JOINTS

Spreading shall be as continuous as possible. All joints shall present the same texture, density and smoothness as other areas of the course. The joints between old and any new lanes or sections shall be carefully made in such manner as to ensure a continuous, bond between the old and new pavement. All trimmed contact surfaces of previously constructed pavement shall be painted with a thin, uniform coat of cut-back bitumen before the fresh mixture is placed.

Transverse: The roller shall pass over the unprotected end of the freshly laid mixture only when laying of the course is to be discontinued for such length of time as to permit the mixture to become old. The end of the previously laid section shall be trimmed to expose an even, vertical surface for the full thickness of the course. The fresh mixture shall be raked uniformly against the joint and initial compaction secured with the tandem roller followed by regular rolling.

Longitudinal: When the edges of the longitudinal joints are irregular, honey-combed or poorly compacted, all unsatisfactory sections of joint shall be trimmed to expose an even, vertical or sharply sloping surface for the full thickness of the course. Fresh mixture shall be raked uniformly against the joint followed by rolling.

The longitudinal joint in one layer shall offset that in the layer immediately below by at least 25 cm.

3517 PROTECTION OF PAVEMENT

After final rolling, vehicular traffic of any kind shall be permitted only as directed by the Engineer's Representative.

3518 EDGES

The edges of the bituminous pavement shall be free from all irregularities and honeycombs and shall be cut as necessary to obtain a uniform edge with a slope of approx. 1 to 1, they shall be dense and well compacted.

3519 SAMPLING AND TESTII

3519.1 SAMPLING

The sampling shall be carried out under the Engineer's control and supervision at the Contractor's expense. Sampling shall be done in accordance with these specifications:

Samples from plant:

Samples of the plant mixtures will be taken and tested as frequently as deemed necessary to determine if gradation, asphalt content and all mixing conditions conform to the job-mix formula requirements.

The size or weight of the samples taken from the plant shall be directed by the Engineer's Representative, but it shall be at least 1 sample for one day's run of each mixing plant.

Samples from roadway:

Suitable sized samples for the determination of the compaction irate (density) and thickness of each completed layer shall be cut from the finished work by the Contractor and at his expense as often as deemed necessary by the Engineer's Representative but not less than 2 samples for each day's run. In addition samples shall be taken whenever a substantial change is made in the job-mix formula. Where samples have been taken, new material shall be placed and compacted satisfactory by rolling or tamping.

The size of sample shall be governed by the maximum size of particle of mineral aggregate in the mixture but not less 'than 30 x 30 cm (900 sq.cm). The samples from the pavement should be taken by core drilling with a minimum diameter of 150 mm.

Identification of samples:

Each sample shall be accompanied by a description giving the following information:

(1) Source of sample, name of plant or location on construction site (expressway or branch road, left or right side, etc.)

(2) Location of the point in which sample was taken (number of the car from which sampled, the point at the roadway measured transversally of the centerline in cm).

(3) By whom sampled and date of sampling.

(4) By whom or to whom submitted and address.

3519.2 TESTING

Aggregates bitumen and bituminous mixtures shall be tested as frequently as deemed necessary by the Engineer's Representative.

Samples of the plant mixtures shall be taken at the plant and/or on the working site and tested as frequently as deemed necessary by the Engineer's Representative to determine if the mixtures conform to the job-mix formula requirements and if the temperature is as directed.

Swelling after 28 days of soaking shall be calculated according to the volume of the Marshall test specimen (AASHTO T 166). The soaking shall be done in a distilled water bath of 20 to 30°C under normal atmospheric pressure. The volume shall also be measured after one and three days of soaking.

Calculation:

$$S = 100 \times \frac{V_2 - V_1 \text{ (vol.\%)}}{V_1}$$

S = swelling in % volume

V_1 = volume of specimen before soaking

V_2 = volume of specimen after soaking

3519.3 PAVEMENTS

The samples from roadway shall be tested as follows:

Bulk density (bulk specific gravity) of compacted bituminous mixtures AASHTO T 166 and/or density of bituminous concrete in place by nuclear method ASTM D 2950; Percent of voids in total mix. Thickness of the pavement.

3519.4 INSPECTION OF PLANT AND EQUIPMENT

For the verification of weights or proportions and character of materials and determination of temperatures used in the preparation of the mixture, the Engineer or his authorized Representatives shall have access, at any time, to all parts of the mixing plant.

3520 BITUMINOUS PAVEMENT ON STRUCTURES

The bituminous pavement on structures shall be constructed in accordance with the required thickness, as stated in the Bill of Quantities or shown on the drawings. A tack coat shall be applied on the concrete slab, as described in these Specifications if directed by the Engineer's Representative.

The binder course shall have an average thickness of 4 cm, depending on the specified tolerances of +_ 1 cm for the concrete slab of the structure.

3521 MEASUREMENT

The unit of measurement for payment shall be the square meters of the completed and accepted pavement for both binder and wearing course. The number of square meters of the completed bituminous courses shall be determined by the length measured along the center!ine and upon the surface of the ,road$_s$ times the width as shown on the drawings, plus the areas of any widenings, turnouts and intersections, authorized by the Engineer's Representative.

3522 PAYMENT

The square meters of completed and accepted pavement for the uvarious thickness, as called for in the Bill of Quantities, measures as specified in Clause 3521, will be paid.

No additional payment will be made for any thickness of pavement in excess of the thickness specified in the Bill of Quantities or shown on the drawings.
ISuch payment and/or payments shall constitute full compensation *for preparing the surface of the base course, furnishing all 'materials, equipment, plant and tools, handling, mixing, mani-Lpulating, placing, shaping, compacting, rolling and finishing, correcting unsatisfactory areas and all labour and incidentals r-necessary to complete the work required by this Section of the ISpecifications.

36 DOUBLE SURFACE DRESSING

3601 SCOPE

The work covered by this Section of the Specifications consists of the furnishing of all plant, labour, equipment and materials, and in performing all operations in connection with the construction of double surface dressing on a previously prepared and primed base course or properly cured surface, complete, subject to the Conditions of the Contract, in strict accordance with this Section of the Specifications^ the applicable drawings and the directions of the Engineer's Representative.

3602 MATERIAL

Aggregate:

The aggregate material shall be crushed stone. It shall consist of hard durable fragments of stone of accepted quality and crushed to the specified grading.

The aggregate shall consist of hard durable particles or fragments and shall not contain more than 20 % flat elongated particles with a ratio of more than 3 to 1 between length and thickness, soft or disintegrated pieces, and shall have a percentage of wear of not more than 35 as determined by AASHTO T 96.

The portion of the aggregate passing the No. 40 sieve shall have a liquid limit of not more than 25 and be nonplastic as determined by AASHTO T 89 and 90. The sand equivalent value, as determined by AASHTO T 175 shall be a minimum of 65. The grading, of aggregate, determined by AASHTO T 27, shall be as follows:

Sieve Size		Percentage by Weight Passing	
mm	ASTM	Grading A	Grading B
25	1 "	100	-
20	3/4"	90 - 100	-
12.5	1/2"	20 - 55	100
10	3/8"	0 - 15	85 - 100
5	No. 4	0 - 5	10 - 30
2	No. 10	-	0 - 10
0.4 "	No. 40	—	0 - 2

Unless otherwise specified, the first application of aggregate for double surface dressing shall conform to grading A and the second application shall conform to grading B. The aggregate to be used shall show no evidence of stripping when tested in accordance with AASHTO T 182.

The use of adhesion promoting agents for control of stripping shall be used if necessary.

The material will be accepted at the latest practical point for testing prior to incorporation into the work.

Bituminous Material:

The bituminous material shall be MC-800, or RC-800 subject to the approval of the Engineer's Representative and shall meet the requirements of AASHTO M 81, M 82, respectively.

3603 EQUIPMENT

All equipment, tools, and machines used in the performance of the work covered by this Section of the Specifications shall be new and subject to the approval of the Engineer's Representative, and shall be maintained in satisfactory working condition at all times.

Pressure Distributor:

See Section 34

Heating Equipment:

See Section 34

Power Rollers:

Power rollers shall be self-propelled tandem or three wheel type rollers, weighing not less than 6 t and shall be suitable for rolling bituminous pavements.

Pneumatic Rollers:

The pneumatic-tired rollers shall be self-propelled and shall have a minimum contact pressure of 3 kp/sq.cm. The operating contact pressure will be specified by the Engineer's Representative.

Mechanical Spreaders:

Mechanical spreaders shall be adjustable and capable of spreading aggregate uniformly to the specified grading at controlled amounts per square meter.

Power Brooms and Power Blowers:

Brooms and blowers of the power type shall be suitable for effectively cleaning the surfaces to be treated.

3604 WEATHER LIMITATIONS

The double surface dressing shall be applied only at *dry* weather and when the air temperature in the shade is 15 C and rising. The Engineer's Representative may require the Contractor to delay the application of bituminous material until the atmospheric and pavement surface conditions are satisfactory. No bituminous material shall be- placed which cannot be cared for during daylight hours.

3605 PREPARATION OF SURFACE

Immediately before applying the first course of surface dressing, the primed base course surface shall be cleaned of all loose or foreign material, as directed by the Engineer's Representative. The first course of surface treatment will not be placed until the Engineer's Representative has inspected and approved the prepared surface.

3606 QUANTITIES TO BE APPLIED

Quantities of bituminous material and aggregate in the first and second course may be varied to meet the specific field conditions, as directed by the Engineer's Representative, without adjustment of the price tendered;but in all cases the total amount of bituminous material and aggregate in the first and second course shall be as detailed in Clause 3602 and within the following limits:

:	Rate of Application	
	1st Course	2nd Course
Bituminous material MC 800 (kp/sq.m) RC 800 (kp/sq.m) Aggregate (liter/sq.m)	Grading A 1.50 - 1.80 1.50 - 1.80 11 to 15	Grading B 0.90 - 1.10 0.90 - 1.10 6 to 8

3607 APPLYING BITUMINOUS MATERIAL

Bituminous material shall be applied by means of a pressure distributor in a uniform continuous spread over the section to be treated.

The spraying temperature shall range from 55°C to 85°C for MC-800 and RC-800.

A strip of building paper, at least one meter in width and with a length equal to that of a spray bar of the distributor plus one meter, shall be used at the beginning of each spread. If the - cut-off is not positive, the use of the paper may be required at the end of each spread. The paper shall be moved forward at proper application speed at the time the spray bar is opened. Any skipped areas or deficiencies shall be corrected. Junctions of spread shall be carefully made to assure a smooth riding surface. The length of spread of bituminous materials shall not be in excess of that which trucks loaded with cover aggregate materials can immediately cover.

The spread of bituminous material shall not be more than 15 cm wider than the width covered by the cover "material" from the spreading device. Under no circumstances shall operations proceed in such manner that the bituminous material will be allowed to chill, set up, dry or otherwise impair retention of cover

coat. The distributor when not spreading shall be parked so that the spray bar or mechanism will not drip bituminous material on the surface of the travelled way.

3608 APPLYING OF AGGREGATE

The application of aggregate shall follow the application of bituminous materials immediately after each spray of bituminous material. The aggregate shall be spread with a mechanical spreader uniformly over the surface in the specified amount or as directed by the Engineer's Representative. The aggregate shall be spread evenly by hand on all areas missed by the aggregate spreader. Aggregate trucks shall be operated backwards so that the bituminous material will be covered ahead of the truck wheels.

3609 ROLLING OF AGGREGATE

Rolling shall begin immediately and shall be continued until at least three complete coverages are obtained. Rolling shall start at the sides and proceed towards the crown of the road.

Rolling shall be completed the same day the bituminous material and cover coat material are applied. After the application of the cover coat material, the surface where specified shall be lightly broomed and maintained for a period of four days or as directed by the Engineer's Representative. Maintenance of the surface shall include the distribution of cover coat material over the surface to absorb any free bituminous material and cover any area deficient in cover coat material. Maintenance shall be conducted so as not to displace imbedded material. Excess material shall be swept from the entire surface by means of rotary brooms. The surface shall be swept at the time determined by the Engineer's Representative.

To reduce the traffic speed on the freshly constructed surface dressing to a maximum of 40 km/hour for at least one week, the necessary traffic signs shall be installed and maintained as directed -by the Engineer's Representative.

3610 SAMPLING AND TESTING

All bituminous material will be sampled and tested as frequently as deemed necessary by the Engineer's Representative for conformance with the requirements of this Section of the Specification. Reference is made to Section 14.

3611 MEASUREMENT

The unit of measurement for payment shall be the square meter. The number of square meters to be paid for shall be the square meters of completed and accepted double surface dressing as measured along the centerline and upon the surface of the road, times the width as shown on the drawings plus any areas authorized and measured separately.

3612 PAYMENT

The number of square meters, determined as provided in Clause 3611 will be paid for at the price tendered per square meter, which payment will constitute full compensation for furnishing, delivering and placing all materials. For furnishing supplies, equipment and tools, for preparation of the primed surface, for brooming, back-spotting, compacting and rolling, for maintenance traffic signs and for furnishing all other labour and incidentals necessary to complete the work required by this Section of the Specifications.

37 BITUMINOUS KERBS

3701 SCOPE

The work covered by this Section of the Specification consists in the furnishing of all plant, labour, equipment and materials and in performing all operations in connection with the construction of bituminous kerbs, complete, subject to the terms and conditions of the Contract and in strict accordance with this Section of the Specification, the applicable drawings and the directions of the Engineer's Representative.

3702 MATERIALS

Aggregates:

The aggregates shall consist of material approved by the Engineer's Representative in accordance with Clause 3502 of the Specifications

Bituminous Material:

The bituminous material shall conform to Clause 3502 of the Specifications.

Asbestos Fibers:

Asbestos fibers shall conform to classification 7 M, Quebec Standard Testing Machine Method, Quebec'Asbestos Mining Association.

3703 COMPOSITION OF MIXTURES

The bituminous mixture generally shall be composed of:

Sieve Size	Passing, Percent of Weight	
Mm	ASTM	
20	3/4"	100
12.5	1/2" .	85 –100
5	No. 4	65 –80
2	No. 10	50 –65
0.25	No. 50	18 –30
0.08	No. 200	5 –15
Bitumen B 40/50 (% weight of total mix'		6.0 - 9.0
Asbestos fibers (% weight of total mix^		2.0 - 3.0

The aggregate as finally used in the work shall not vary from the low limit on one -sieve to the high limit on the adjacent sieve, but shall be uniformly graded.

3704 JOB MIX FORMULA

A job mix formula shall be determined by field trial. Adjustments shall be made as necessary for the definite percentage of filler, bitumen and asbestos fibers to provide sufficient workability and to assure a finished kerb of adequate stability, desired surface texture and relatively low (5 % - 10 %) air void content.

The best mixing and placing temperature of the mixture shall be established. The proposed mixture shall be approved by the Engineer's Representative.

3705 EQUIPMENT

All equipment, tools, and machines used in the performance of the work covered by this Section of the Specifications shall be new and subject to the approval of the Engineer's Representative, and shall be maintained in satisfactory working condition at all times

Mixing Plant:

The mixing plant shall be designed, coordinated and operated so as to produce mixture within the job-mix formula.

Kerb Machine:

The machine for laying the kerb shall be self-propelled type, equipped with a material hopper, distributing screw and adjustable kerb forming devices capable of laying and compacting the bituminous mix to the lines, grades and cross-section as shown on the drawing and in an even homogenous manner free of honeycombs.

3706 WEATHER LIMITATION

Bituminous kerbs shall be constructed only when the underlying course is dry and when the weather is not rainy.

Such kerbs may be constructed when the atmospheric temperature is at least 5 C and rising', unless otherwise directed by the Engineer's Representative. When the atmospheric temperature falls below 15 C, special precautions shall be taken in controlling the temperature of the delivered material and compacting the mix, all loads shall be delivered in covered and/or insulated vehicles.

3707 PREPARATION OF KERB FOUNDATION

Before applying the bituminous kerbs, the smoothness of the underlying course shall be tested with a 4 m straight edge, it shall conform to Clause 3514 of this Specification and must be corrected if necessary.

Immediately before applying the bituminous kerbs, the surface of the underlying course shall be thoroughly cleaned of all loose or foreign material to the approval of the Engineer's Representative.

Except for newly-laid bituminous pavements with the surface still tacky and free from dust, a tack coat, as specified-in Section 34, shall be applied before placing the bituminous kerb without additional cost to the Employer.

3708 PREPARATION AND TRANSPORTATION OF THE MIX

The mixture shall be produced in a mixing plant approved by the Engineer's Representative and be transported to the job site in tight vehicles. Vehicles shall be cleaned of all foreign material which may affect the mix. Covers and other insulation shall be provided when necessary. The dispatching of the vehicles shall be so scheduled that all material delivered may be placed in daylight unless artificial light approved by the Engineer's Representative is provided. In no case shall the temperature of the delivered material vary more than + 10 C from the temperature specified in the job mix formula. When variations in the size of .loads, speed of trucks, length of haul and conditions of trucks interfere with orderly continuous operations, the .Engineer's Representative may order suitable corrections to be made.

3709 PLACING MIX . . .

The kerb shall be placed to the cross-section shown on the - drawings. Machine-laid work requires no additional compaction, but in areas where it is evident that compaction is inadequate, the mix shall be adjusted, forward movement of the machine re-tarded by braking or other measures taken to provide .adequate compaction.

If permitted by the Engineer's Representative, material may be placed exceptionally by hand in wood *or* metal, forms. Material placed by hand shall be tamped into place and screeded to a smooth finish in a workmanlike manner. Forms may be.removed as soon as the material has cooled to air temperature.

The newly-laid kerb shall be protected from traffic by a bar-ricade or by some other suitable method until the heat of the bituminous mixture has dissipated and the mixture has attained its proper degree of hardness. .

3710 . JOINTS

Unless conditions warrant, bituminous kerb construction at the specified temperature shall be a continuous operation in one direction so as to eliminate kerb joints. However, where con-ditions are such that this is not possible, the joints between successive day's work shall be carefully made in such a manner as to ensure a continuous bond between the old and new sections

of the kerb. All contact surface of previously constructed kerb shall be painted with a thin, uniform coat of hot bituminous material just prior to placing the fresh bituminous kerb material to the old joint.

3711 SAMPLING AND TESTING

In accordance with Clause 3519 as far as applicable.

3712 MEASUREMENT

The unit of measurement for bituminous kerbs shall be the linear meter of the completed and accepted kerb. No deduction will be made for flattening of kerbs and no addition will be made for curved alignment and for connections to drainage installations.

3713 PAYMENT

The linear meters of the completed and accepted kerbs will be paid and measured as defined in Clause 3712.

Such payment shall constitute full compensation for the furnishing of all plant, labour, equipment and materials and in performing all operations in connection with the construction of bituminous kerbs. No extra payment will be made for tack coat.

38 CONCRETE KERBS, PAVINGS AND FOOTWAY

3801 SCOPE

This work covered by this Section of the Specification consists in furnishing all plant, equipment, materials and labour and in performing all operations in connection with constructing and. placing all precast concrete kerbs, pavings and footways complete, subject to the terms and conditions of the Contract and in strict accordance with this Section of the Specification, the applicable drawings and the directions of the Engineer's Representative.

3802 DESIGN

Kerbs, paving blocks and footway tiles shall be precast and be of the forms and dimensions as shown on the drawings.

The locations, where they are to be installed and the type or design to be used- at each location,shall be as indicated on the drawings and/or as directed by the Engineer's Representative.

3803 MATERIALS

Concrete shall comply with the provisions of Section 54 of the Specifications as far as applicable.

3804 FINISH AND COLOUR

The exposed surfaces of cast-in-situ kerbs, paving blocks and footway tiles shall be steel trowelled to a smooth, densey uniform finish before the concrete has commenced to harden.

Unless otherwise specified, the products shall be supplied in natural colour. Special surface finishes or colour may be ordered and have to be approved by the Engineer's Representative.

3805 KERBS

3805.1 QUALITY REQUIREMENTS

The flexural strength .shall be in accordance with DIN 483 at least 60 kp/sq.cm. The kerbs shall be tested for wear according to DIN 52108. The max. abrasion loss shall be 15 cu.cm per 50 sq.cm.

The tolerances from the dimensions shown on the drawings shall not exceed: length _+ 6 mm, width _+ 3 mm$_s$ height +_ 3 mm.

No kerbs manufactured less than one month prior to delivery shall be used unless the whole of the cement used is rapid-hardening cements in which case they may be delivered fourteen days after manufacture. Each kerb shall be stamped with the date of manufacture on one of the end faces. No kerb shall be repaired, all kerbs with a damaged face or corner shall be rejected.

3805.2 CURVATURE

In case of a radius layer more than 20 m, straight kerbs of a length of 1 m shall be used. In case of a radius between 5 m and 20 m$_5$ straight kerbs of a length of 50 cm shall be used. In case of curves smaller than 5 m$_s$ precast curved kerbs shall be manufactured in accordance with the required curves with a length of 50 cm.

3805.3 PLACING

Precast kerbs shall be laid and haunched in concrete Bn 100 of 10 cm thickness in accordance with the drawings. The kerbs shall be laid true to line and levels, and the joints between them shall be run with 3 to 1 sand/cement mortar, properly jointed, cleaned and wetted before the mortar has set. The width of the joints shall be between 5 and 10 mm and they shall be pointed on exposed surfaces.

3806 PAVINGS

3806.1 QUALITY REQUIREMENTS

The interlocked blocks shall be of concrete Bn 550 according to Section 54.

3806.2 STARTER BLOCKS

Starter blocks, as shown on the drawings shall be manufactured of concrete Bn 550 in the necessary quantity.

3806.3 PLACING

The paving blocks shall be placed on a layer of sand 0/3 mm, 3 cm thick, after compaction. The sand layer shall be smooth to lines and levels, protected' and kept humid. The placing shall start with starter blocks and continue with the rows of normal size blocks. Every three rows string lines shall be stretched between stakes. Special sizes of blocks may be required and shall be made by a block-cutter. After placing, the area shall be compacted by vibrator starting from the inner edge. After compaction, the blocks shall be covered and swept with fine sand 0/3 mm. The joints between blocks shall be as narrow as possible and not exceed 5 mm on a width of one meter. The completed layer shall be tested for smoothness with a 4 m straight edge before acceptance. Irregularities in excess of 1 in 4 m shall be replaced. Where directed by the Engineer's Representative, coloured blocks shall be used for demarcation.

3807 FOOTWAYS

3807.1 QUALITY REQUIREMENTS

The flexural strength shall be in accordance with.DIN 485 at least 60 kp/sq.cm. The tiles shall be tested for wear according to DIN 52 108. The maximum abrasion loss shall be 10 cu.cm for 50 sq.cm. The tolerances from the diameter shown on the drawings shall not exceed + 2 mm in width and height.

3807.2 PLACING

The tiles shall be placed on a layer of sand 0/3 mm, 3 cm thick after compaction. The sand layer shall be smooth to lines and levels. The placing shall be done in accordance with string lines stretched between stakes. Half size tiles and special sizes of tiles shall either be manufactured or made by a tile-cutter. The joints shall not exceed 5 mm between the tiles. After placing, the area shall be covered with dry, fine sand 0/3 mm and cement at a rate of 8 to 1, and swept and watered.

The completed layer shall be tested for smoothness with a 4 m straight edge before acceptance. Irregularities in excess of 8 mm in 4 m shall be replaced.

3808 MEASUREMENT

The unit of measurement for precast kerbs shall be the linear meter of the completed and accepted kerb. No distinction will be made for flattening of kerbs for entrances and other places and no additions will be made for curved alignment.

The unit of measurement for pavings and footways shall be the . square meter of the completed and accepted paving and/or foot-"; way measured on the surface. Underlaying layers or haunching ; made from concrete, mortar and/or sand, as shown on the drawings, shall not be measured separately, but their price shall be included in the respective items of the Bill of Quantities.

3809 PAYMENT

The linear meters of the completed and accepted kerbs and the square meters of the completed and accepted pavings and/or footways will be paid in accordance with the unit prices in the Bill of Quantities for the various items in accordance with this Section and other applicable section of the Specifications and shall constitute full compensation for furnishing all material, equipment and labour and for performing all operations, including incidentals necessary to complete the work. No special payment for coloured and/or curved blocks or special sizes will be made.

39 STABILIZED SHOULDERS

3901 SCOPE

The work covered by this Section of the Specifications consists in furnishing all equipment, material and labour and in performing all operations in connection with constructing mineral stabilized shoulders, complete, subject to the terms and conditions of Contract and in strict accordance with this Section of the Specification and the applicable drawings and the direction of the Engineer's Representative.

3902 MATERIAL

The gravel.material shall consist of hard, durable particles or fragments of gravel with sand. Coarse aggregates {retained on No. 10) sieve shall have a percentage of wear when tested according to AASHTO designation T 96, of not more than 50.

Grading of gravel shall be within the following limits:

Sieve Size		Passing Percent by Weight
mm	ASTM	-
75	3"	100
25	1"	55 - 90
5	No.4	25 - 55
0.4	No.40	5 - 25
0.08	No.200	0 - 10

The subbase material Type A specified in Clause 3103 may also be used.

3903 MIXING EQUIPMENT

Equipment for mixing the gravel into the soil shall be of approved make that mixes the loose stabilizing agent with the soil to the specified depth and width.

3904 WEATHER LIMITATIONS

Stabilization of soil shall be executed only when the weather conditions do not detrimentally affect the quality of the work and the finished layer. Layers damaged by rain during any phase of construction shall be completely scarified and recompacted in conformance with the requirements of this Specification without additional cost to the Employer and to the full satisfaction of the Engineer's Representative.

3905 STABILIZATION WITH GRAVEL

The surface of earth fill before mineral stabilization shall be adjusted to ensure that the finished level after completion of the stabilization will be true to cross-section in line and level. The surface to'be stabilized shall be scarified and'levelled before gravel for stabilization is applied. $Gravel_5$ as specified in Clause 3902_s shall be spread uniformly over the full width and length by approved equipment at a rate of 0.1 cu.m per sq.m. Gravel shall be mixed thoroughly into the soil by approved equipment to ensure a total depth of 15 cm of mineral stabilization. Water shall be added as required to obtain the compaction specified in Clause 3906 of this Specification.

3906 FINISH OF STABILIZATION

The finished stabilization layer shall be constructed to the lines and grades shown on drawings and/or as directed by the Engineer's Representative.

The finished surface shall be 2 cm lower than the adjacent road surface.

The total thickness of the stabilized layer shall be compacted to at least 95 % of the maximum density according to AASHTO T 180.

A plate bearing valve E 2 of a minimum of 800 kp/sq.cm tested in accordance with Clause 3114 is required.

The Contractor shall make good at his own expense all stabilization layers that do not conform to the requirements of this Specification.

3907 SAMPLING AND TESTING

Tests shall be made as often as deemed necessary to ensure compliance with the requirements of this Specification. Reference is made to Section 14.

The minimum number of tests is generally for even 4,000 sq.m of completed stabilization.

In situ density:

AASHTO T 191 or
AASHTO T 205 or
AASHTO

for every 20,000 sq.m of completed stabilization.

1 Plate Bearing Test

for *every* 40$_a$000 sq.m of completed stabilization.

1 moisture density relation AASHTO T 180

3908 MEASUREMENT

The unit of measurement for stabilized shoulders shall be the square meter of completed and accepted stabilization. The stabilization of shoulders, as specified before shall be determined by the actual length, times the width on the surface of the stabilization as shown on the drawings, plus the areas of any widening authorized by the Engineer's Representative.

3909 PAYMENT

Payment will be made at the price tendered per square meter for stabilization of shoulders measured as specified in Clause 3908,which payment will constitute full compensation for all equipment, material, labour and incidentals required in accordance with this Section of the Specifications.

PART FOUR:
PIPE C U L V E R T S AND D R A I N A G E

41 CONCRETE PIPE CULVERTS

4101 SCOPE

The work covered by this Section of the Specification consists in furnishing all plant, equipment;, materials and labour and in performing all operations in conncection with constructing concrete pipe culverts or reinforced concrete pipe culverts completes subject to the terms and conditions of the Contract and in strict accordance with this Section of the Specification, the applicable drawings and the directions of the Engineer's Representative.

4102 EARTHWORKS

The earthwork required shall be performed in accordance with the provisions of Section 22 of the Specification.

4103 MATERIAL

The type of pipes - reinforced concrete or plain concrete - may be chosen by the Contract with regard to the bearing capacity of the pipes as well as to economic considerations. The stipulations of the relevant DIN specifications must be strictly observed in both cases, except as modified by this Specification, e. g. for factors of safety see Clause 4107,

Standard concrete pipes for surface water drainage shall be of "Ogee" or the spigot and socket type and be of approved manufacture and design conforming to the requirements of DIN 4032 and/or 4035. The Contractor shall submit to the Engineer or the Engineer's Representative for his approval certificates complying with the German Standard and the date of manufacture stamped on each pipe in respect of each consignment of pipes delivered on the site. Each batch of pipes intended to be delivered to the site shall be available for inspection by the Engineer's Representative at the place of manufacture, and such tests as the Engineer's Representative requires shall be carried out in accordance with the German Standard. Pipes, which are not approved by the Engineer's Representative, shall be immediately removed from the site.

4104 INSTALLATION

The installation of reinforced concrete or plain concrete pipes shall be in accordance with the German Standard Specification DIN 4033 unless otherwise specified hereinafter.

a) Construction Machinery: MoyQTie!^o£j^onstn over a culvert shall be at the Contractor's rTsk7 Any pipe damaged thereby shall be repaired l)l'~r1spTaceiF"a^the opinion of the Engineer's Representative and at the Contractor's cost.

b) Temporary Stream Flow: The Contractor shall provide and maintain, if necessary$_s$ for the temporary diversion of water to permit the installation of the culvert in the dry.

c) Multiple Pipe Culverts: Where multiple lines of pipes are used, they shall be spaced half the nominal pipe diameter apart, in case they are not encased in concrete and in accordance with the drawings if concrete casing is provided.

d) Laying Pipes: Pipes shall be laid starting at the outlet and with the bell end or groove end laid upstream and with the invert of the pipe conforming to the slope as shown on the drawings, and supported to prevent movement of pipes after they have been laid.

e) Backfilling: J* addition to what is s^j£Jj-£Uin Section 22 of this Specification or as sfiowrTon TRe"'Hrawings$_3$ backfilling of pipes.shall be carried out with approved material and compacted in layers not exceeding 15 cm in thickness.

Backfilling und^r present and future road surfaces shall be compacted to(95?^of modified AASHTO density. Road compaction equipmenTTnall not be used within 50 cm of the tops of pipes. Backfilling shall not be commenced without approval of the Engineer's Representative.

In the case of spigot and socket pipes, the socket joints on pipes shall be caulked with cement mortar and a fillet of the same worked round the side. The fillet shall be levelled off and extended for a length not less than 5 cm from the face of the socket.

Cement mortar shall consist of one part by volume of cement and two parts by volume of natural sand or crushed natural stone sand or a-combination of both. The constituent materials shall be accurately gauged and mixed in an approved manner. Cement mortar shall be made in suitable small quantities only, as and when required, and any mortar which has begun to set or which has been mixed for a period of more than 30 minutes shall be rejected.

Special care shall be taken to see that any excess of cement mortar, etc. is neatly cleaned off while each joint is being made and any earth, cement or other material thoroughly cleaned out of the pipes. A properly fitting plug shall be well secured at the end of the last laid pipe and shall be removed only when pipe laying is proceeding. The trenches and joint holes shall be kept free from water until the joints are thoroughly set.

The newly made cement fillet shall be protected by means of a cover of damp hessian which shall be kept moist for at least 24 hours after forming.

In the case of "Ogee" joints the inside faces of the tongue and the groove shall receive a coat of approved bituminous compound immediately before jointing. The pipes shall be fitted together tightly by a winch. After laying, the outer part of the joints shall be filled with an approved (performed) joint filler. The inside of the joint must be sealed with an approved cement-bitumen mix or plastic filler to the satisfaction of the Engineer's Representative.

4105 FOUNDATION BED

The pipes shall be placed on the excavated bed, which shall have a uniform density so that the pipes are uniformly supported. Compaction and backfill shall conform to the requirements of Section 22 of the Specification.

If ordered by the Engineer's Representative and/or shown on the drawings, a foundation slab, thickness 20 cm of concrete, shall be provided.

Where bell and spigot pipes are used, the pipes shall be laid on the concrete foundation before the concrete sets so that the pipes will be uniformly supported. .

6106 SURROUNDING OR HAUNCHING WITH CONCRETE

If necessary according to the statical calculation and where shown on the drawings or directed by the Engineer's Representative, pipes shall be surrounded or haunched with concrete Bn 100, as specified in Section 54. In carrying out this work the Contractor shall take care to pack the concrete under and around the pipes to ensure even bedding and solidity in the concrete. In no case shall the concrete be thrown directly on pipes. The upper surface of the concrete shall be struck off with a wooden screed or template and neatly finished off. The pipes shall be laid and jointed as specified above, and during the placing of the concrete they shall be adequately supported.

4107 REINFORCED CONCRETE PIPES OR CONCRETE PIPES

If a respective item has been inserted in the Bill of Quantities, reinforced concrete pipes shall be used according to the requirements of DIN 4035. The Contractor shall prepare the necessary statical calculation, however the security value shall be increased fromiS = 1.5 to S = 1.75. The reinforced concrete pipes shall be laid on"a foundation bed in concrete including haunching in Bn 100_s according to the drawings.

In the case plain concrete pipes are used, the Contractor shall prepare the necessary statical calculation, proving the sectional forces at the given height of the embankment over the pipe. They shall be compared with the bearing capacity of the pipe without or with concrete surrounding. The factor of safety to be achieved shall be not less than S = 2.0. Otherwise all requirements of DIN 4032 shall be strictly observed.

4108. CLEARING PIPE CULVERTS

On completion all pipe culverts, drains, etc., shall be flushed end to end with water and left clean and free from obstructions

4109 RE-INSTATEMENT OF ROAD SURFACES, ETC.

Where the surface of any road, footpath or verge has been disturbed it shall be fully reinstated by the Contractor without delay to the satisfaction of the Engineer's Representative and owner concerned.

4110 HEADWALLS

Where indicated on the drawings, the ends of the pipe culverts c shall be protected by concrete headwall constructed as shown on the drawings. When headwalls are installed, the ends of the pipes shall flush into the headwalls.

4111 NEASUREMENT.

The unit of measurement for concrete pipes shall be the approved linear meter measured in place and/or from face to face of the headwalls and in accordance with the applicable drawings. The unit of measurement for headwalls shall be the cu.m.

4112 PAYMENT

Payment will be made in accordance with the unit prices of the various items stated in the Bill of Quantities and shall constitute full compensation for furnishing of all equipment, plant, materials and labour, including any necessary earthwork excavation and backfill and for performing all operations in connection with precast concrete pipe culverts in accordance with this Section of the Specification.

42 CORRUGATED METAL PIPE CULVERTS

4201 SCOPE

The work covered by this Section of the Specification-consists in the furnishing of all plant* equipments materials and labour and in performing all operations in connection with constructing corrugated metal pipe culverts, complete, subject to the terms and conditions of the Contract and in strict accordance with this Section of the Specifications the applicable drawings and the directions of the Engineer's Representative.

4202 MATERIAL

Corrugated metal nestable pipes shall be in accordance, with AASHTO designation M 36.

4203 INSTALLATION

All pipes shall be laid, bedded and jointed in accordance with the manufacturer's recommendations and/or as shown on the drawings.

Multiple installations shall be laid with center-lines parallel. Unless otherwise directed or shown on the drawings, the clear distance between barrels of adjacent pipes shall be at least 50 cm.

Backfill shall be done in accordance with Section 4104 e) of this Specification.

Backfill material shall not contain lumps or stones. There shall be a cover of at least 50 cm over the crown of the pipe, before construction equipment is driven over it.

The earthwork required shall be performed in accordance with the provisions of Section 22 of the Specification.

4204 FOUNDATION BED

The pipes shall be placed on the excavated bed, which shall have a uniform density so that the pipes are uniformly supported. Compaction shall conform to the requirements of Section 22 of the Specification.

Where ordered by the Engineer's Representative, or recommended by the manufacturer the pipes shall be placed on a sand bed of approved material.

4205 APPLIANCE OF SECTION 41

For clearing pipe culverts and re-instatement of road surfaces, etc.$_3$ the respective clauses of Section 41 shall apply.

4206 END TREATMENT

For designing the ends of corrugated metal pipes two possibilities have been inserted. .

The first is shown on the drawing and includes cutting of pipe to the slope of embankment and inserting a beveled small headwall of concrete Bn 100 including bolts.

In the second case no cutting and no headwall is required, but the slope'is protected by stone pitching as directed, Section 43 shall apply.

Whether the first or the second case will be executed will be decided by the Engineer's Representative.

4207 MEASUREMENT

The unit of measurement for corrugated metal pipes shall be the linear meter single or multiple measured in place in accordance with the applicable drawings and/or directions of the Engineer's Representative.

The-unit of measurement for end treatment shall be for construetion in accordance with case one of Clause 4206, the cubic meter of concrete Bn 100. For case two of Clause 4206 the square meter of stone pitching shall be measured.

The cutting, steel bolts, sand layer and all other incidentals shall not be measured, but shall be included in the unit price of linear meter of the various types of pipes.

4208 PAYMENT

Payment shall be made in accordance with the unit prices of the various items stated in the Bill of Quantities, and shall constitute full compensation for furnishing of all equipment, plant, materials and labour including any necessary earthwork excavation and backfill, provision of sand-bed where ordered, and for performing all operations in connection with the construction of corrugated metal pipe culverts in accordance with this Section of the Specification.

The unit price of corrugated metal pipes shall include cutting, , steel bolts, and all incidentals in accordance with the applicable drawing and/or directions of the Engineer's Representative.

43 STONE PITCHING AND MASONRY

4301 SCOPE

The work covered by this Section of the Specification consists in furnishing all plant, equipment, materials and labour and in performing all operations in connection with stone pitching$_a$ rock fill, gabions and masonry., subject to the terms and conditions of the Contract and in strict accordance with this Section of the Specification, the applicable drawings and the instructions of the Engineer's Representative.

4302 EARTHWORK

The earthwork required shall be performed in accordance with the provisions of Section 22 of the Specification.

4303 MATERIAL

The stones for this work shall be durable, cubical field or quarry stones of approved quality, sound, hard, free from - seams and other structural defects. For hand placed masonry the stones shall be approximately rectangular in shape. The stones shall have a percentage of wear not to exceed 50 when tested in accordance with AASHTO standard method T 96.

Filter material shall consist of sand or gravel from a source and to a gradation approved by the Engineer's Representative.

Mortar shall be composed of one part of cement and three parts of approved sand unless otherwise directed by the Engineer's Representative.

Other material shall be in accordance with the provisions of this Specification and must be approved by the Engineer's Rep-resentative.

4304 AREA PREPARATION

The area on which the various layers of material shall be placed shall be shaped on the required lines and grades and thoroughly compacted. Where ordered by the Engineer's Representative or shown on the drawings, a trench of sufficient depth shall be excavated along the toe of the area to be handled to receive the base stone.

4305 PROTECTION

Channel bed and slope protection at the inlets and outlets of pipe culverts, box culverts and other structures shall be executed in accordance with the drawings and where ordered by the. Engineer's Representative.

The concrete channel for drainage of central reserve shall be of concrete Bn 150_5 laid over a 10 cm thick sandlayer, and a dividing layer of building paper as shown on the drawings. Expansion joints shall be at intervals of 5 m. The surface shall be smooth trowelled. The channel shall be constructed to lines and grade, and with the forms and dimensions as shown on the drawings. The concrete shall be cured for at least two days after construction.

Type 1 shall be made of plain concrete Bn 150 placed on top of the properly compacted earth, thickness 15 cm. Joints to be done in accordance with Section 54.

Type 2 shall be made of grauted stones or boulders roughly cubical in shape with dimensions of at "least 20 x 20 x 20 cm laid in a 10 cm thick bed Bn 50.

The stone shall be laid by hand on slopes shaped to the required lines and grades and to the thickness shown on the drawings. Where ordered, a trench of sufficient depth shall be excavated along the toe of the embankment to receive the base stone. Each stone shall be so placed that it will rest primarily on the slope of the embankment and not on the stone below it, and it shall be thoroughly tamped or driven into place. The space between the larger stones shall be filled with spalls of suitable size driven to face. The finished surface of the stone pitching shall be made as smooth as the shape and size of- the stones will permit, varying not more than 5 cm from the required contour and mortar grauted. When the thickness of the stone pitching is not indicated on the drawings, it shall be at least 20 cm measured perpendicular to the slope. Thickness of gravel or concrete bedding, if any, shall be as shown on the drawings or as stated in the Bill of Quantities. Where ordered by the Engineer's Representative, a footing block of concrete, as shown on the drawings or as.directed by the Engineer's Representative, shall be constructed to avoid undermining or damages of water.

Type 3 shall be made of grauted stones or boulders roughly cubical in shape with dimensions of at least 30 x 30 x ,30 cm, laid in a 10 cm thick concrete bed Bn 50.

Type 4 shall be as Type 2, but with a stone layer of 40 cm.

4306 STONE RIP RAP

In order to avoid undermining or damages of water, rip rap Type 5 shall be executed as shown on the drawings and/or where ordered by the Engineer's Representative.

The stones of various sizes shall be placed by mechanical means on a layer of crusher run, to the grade and thickness as indicated in the drawing.

4307 GABIONS

Stones shall have irregular forms with dimensions of not less than 15 cm. Galvanized chain link fencing for gabions shall be in rolls with mesh length of side of 5 cm and wire not less than 3 mm of diameter. Binder wire shall also be galvanized. All wire shall be in accordance with AASHTO M 181. .

The boxes shall be constructed to the shape and dimensions directed by the Engineer's Representative or as shown on the drawings.

The boxes shall be hand packed. The sides shall be packed first in the form of a wall using the largest pieces, with the majority placed as headers to broken joints, to present a neat outside face. The interior of the box shall be hand packed with the smaller pieces and the top layers shall be finished off with larger pieces. The whole interior and top layers shall be packed tight and hammered into place.

Adjacent boxes shall be stitched together with binder wire along all touching corners, both to the boxes in the same layer and boxes above and below, as specified for binding the box itself.

Where gabions are to protect the face of a new embankment, the gabions shall be erected concurrently with the placing of the embankment. The fill material shall be brought up in layers and compacted, as specified for earthwork in Section 22, behind each layer of boxes, before the next layer of boxes is placed. Where gabions are placed in or on the face of existing ground, the space behind the box shall be backfilled as directed by the Engineer's Representative and compacted.

At the top and bottom edges and ends of completed gabion work the existing soil shall be backfilled, thoroughly compacted against the sides of the gabions and finished flush with the top surface of the gabion.

The gabion box shall be stitched together with binder wire, with at least one stitch per 5 cm, and each end of the wire shall be fixed with at least two turns upon itself.

4308 MASONRY

No stone shall have dimensions less than 30 x 30 cm, nor a height less than 20 cm_s when measured at the thinnest section, The colour and texture shall be even.

The foundation upon which the masonry is to be placed shall be shaped to the required lines and grades. Unless otherwise ordered, a trench of sufficient depth shall be excavated along the foundation to receive the base layer of stones. Foundation trenches shall be excavated and approved before the placing of masonry is begun.

The stones shall be laid by hand in mortar after being manipulated sufficiently to secure a regular surface and mass stability. The finished surface of the masonry shall be made as smooth as the Shape and the size of the stones will permit varying not more than 4 cm from the required contour.

4309 FILTER LAYERS

Where shown on the drawings or where ordered by the Engineer's Representative a filter layer or a filter backfill to structures shall be constructed and well compacted.

4310 MEASUREMENT

The unit of measurement for drainage excavation shall be the cubic meter.

Measurement for drainage excavation shall only be made if specifically explained that excavation will be paid separately. Normally the earthwork and/or filter layer and/or concrete bedding shall be included in the price for slope protection, stone pitching, rock fill, masonry, etc.

The unit of measuranent for concrete channel for drainage of central reserve shall be the linear meter of completed and accepted channel,

The unit of measurement for stone pitching and channel bed and slope protection and rip rap shall be the square meter, including concrete bedding, mortar grouting and all incidentals. Footing blocks shall be measured in cubic meters.

The unit of measurement for gabions shall be the cubic meter measured in its final position including all incidentals.

The unit of measurement for masonry shall be the cubic meter in place.

4311 PAYMENT

Payment will be made in accordance with the unit prices in the Bill of Quantities for the various items in accordance with the Specification and shall constitute full compensation for furnishing all material, equipment and labour and for performing all operations necessary to complete the work. Provisions, delivery of material to the site, handling and storage and all incidentals shall be included in the unit prices for the various items.

44 DRAINAGE

4401 SCOPE

The work covered by this Section of the Specification consists in furnishing all plants, equipment, materials and labour and in performing all operations in connection with construction of all drainage work, gullies, pipe drains, manholes, gutters, catch basins and drop inlets complete, subject to the terms and conditions of the Contract and in strict accordance with this Section of the Specification, the applicable drawings and to the direction of the Engineer's Representative.

4402 EARTHWORK

The earthwork required shall be performed in accordance with the provisions of Section 22 of the Specifications,

4403 MATERIALS

All materials shall conform to the following requirements.

Concrete shall conform to the requirements of Section 54. Sulphate resistant cement shall be used in all cases.

Concrete brick shall conform to the Standard Specification for Concrete Building Brick, ASTM designation C-55, Grade "C".

Clay brick shall conform to the Standard Specification for Sewer Brick, AASHTO designation: M 91, Grade NA except that the dimensions may be 6.25 x 10 x 22.5 cm.

Gray-iron castings shall conform to the requirements of the Standard Specification for Gray Iron Castings, AASHTO designation: M 105 or the B.S. 497 and 1247. The class of castings to be furnished shall be that designated on the drawings or in the Bill of Quantities. Castings shall be boldly filleted at angles and the rises shall be sharp and perfect.

Iron castings shall be true to pattern in form and dimensions, free from pouring faults, sponginess, cracks, blow holes, and other defects in positions affecting their strength and value for the service intended.

4404 RUBBLE DRAINS

Rubble drains shall be constructed from the edge of the carriageway across the road shoulders at distance as directed by the Engineer's Representative.

Rubble drains shall have a slope of 4 % towards the sides of the embankments, a cross-section of 40 cm width and 30 cm depth. The bottom level shall be at such depth as directed by the Engineer's Representative or as shown on the drawings. They shall be filled up with filter material. The grading shall be as follows:

Sieve Size		Passing per Cent by Weight
mm	ASTM	-
10	3/8"	100
5	No. 4	90 - 100
2	No. 10	60 - 90
0.40	No. 40	15 - 40
0.08	No. 200	0 - 3

4405 HERRING-BONE DRAINS

Herring-bone drains shall be formed in the slopes of cuttings where directed by the Engineer's Representative and shall con sist of trenches 50 cm wide and 30 cm deep (depth shall be measured at right angle to the surface of the trimmed slope). The filling shall consist of broken stone of approved quality graded from 10 cm to 5 cm.

4406 . CONCRETE POROUS PIPES

Porous concrete pipes shall be of approved manufacture and design with rebated or butt joints conforming to the requirements of B.S. 1194. Approved plastic pipes may be used instead. The pipes shall be placed in an approved water tight material and be covered by an approved filter material.

4407 GULLY COVERS AND FRAMES

Gully covers and frames shall comply in all respect with DIN 4052.

4408 GULLIES

Precast concrete gullies shall be of approved design and manufacture. They shall be made from sulphate resistant cement and shall comply with the drawings and/or directions of the Engineer's Representative.

4409 SETTING OF GULLIES

The gully pot shall be set on a foundation of 15 cm thick sulphate resistant concrete and this shall be haunched up to a minimum thickness of 15 cm to form a base to receive the grating and frame which shall be set in cement mortar'at the correct level.

4410 PRECAST CONCRETE GUTTERS

Precast concrete gutter units in Bn 250 shall be constructed and laid in accordance with the drawings and the directions of the Engineer's Representative. The exposed surface of the gutter units shall be steel trowelled to a smooth, dense uniform finish.

In the upper end a wire mesh shall be inserted between the wearing course and the binder and placed in and covered with bituminious mixture to permit a good bond and eliminate the danger of washing out. On the lower end a footing block, class Bn 150,sha11 be constructed in accordance with the drawings.

4411 CONCRETE MANHOLES

All concrete manholes, catch basins and drop inlets shall be constructed in accordance with the drawings, and shall be built in class Bn" 250/150 concrete unless otherwise shown on the drawings. The manholes shall be provided with step irons and a precast concrete grating as shown on the drawing.

4412 PRECAST CONCRETE MANHOLES

Precast concrete manholes shall be constructed in accordance with the drawings. The base, invert and benchings shall be formed in cast in-situ concrete and the chamber and shaft shall be formed in purpose-made rings and components, precast of sulphate resistant concrete, all of an approved design.

Manholes shall be provided with step irons and a cast iron ring and cover, as shown on the drawings.

4413 CATCH BASINS AND DROP INLET CONNECTIONS

All catch basins shall be made thoroughly watertight.

Catch basins and drop inlet connections to the sewer shall be so placed that the connecting pipe may be easily rodded over its entire length. After the connections are made, the Contractor shall rod. all inlet and outlet pipes. Al1.connections that can not be successfully rodded shall be removed and new connections made.

All catch basins and drop inlets shall be provided with cast < iron rings$_5$ cover, inlet gating and outlet traps, as shown on the drawings.

4414 RESTORATION OF SURFACES

After filling and consolidating the excavations as specified, the Contractor shall carry out the reinstatement of all damaged and disturbed surfaces. The final surface shall be not less good than that pertaining prior to the Contractor's entry upon the various sites, and be fully to the satisfaction of the Engineer's Representative.

4415 MEASUREMENT '

The unit of measurement for rubble drains will be per each rubble drain, complete, including earthwork and incidentals.

The unit of measurement for herring-bone drains will be the linear meter, complete, including earthwork and incidentals.

The unit of measurement for concrete or plastic porous and agricultural pipes will be the linear meter, complete, including earthwork, connections, fittings and incidentals.

The unit of measurement for gully covers and gullies and frames will be for numbers, complete with earthwork, including all incidentals.

The unit of measurement for precast concrete gutters will be the linear meter, complete, including the bituminous mixture and wire mesh connection on the upper end and the footing block at the lower end, earthwork and all incidentals.

The unit of measurement for manholes, catch basins and drop inlets shall be per numbers for various depths, complete, with earthwork and all incidentals.

4416 PAYMENT

Payment will be made in accordance with the unit prices in the Bill of Quantities for the various items in accordance with the Specification and shall constitute full compensation for furnishing all material, equipment and labour and for performing all operations neccessary to complete the work. Provision, delivery of material to the site, handling and storage, all cutting and waste and all incidentals shall be included in the unit prices for the various items.

Special attention is called to Clauses 1103 and 1104.

PART FIVE: S T R U C T U R A L WORK

51 STRUCTURES - GENERAL

5101 SCOPE

The provisions of this Section of the Specification relate to certain structural features and incidental items which are either common to all types of structures *or* which may apply to any of them.

The provisions herein outlined shall apply whenever they are relevant to any structures in addition to the detailed Specifications, which apply only to the particular type or kind of structures under consideration and in addition to the requirements of conformity with the lines, grades, dimensions and details shown on the drawings.

5102 STANDARD SPECIFICATIONS

English translations of Standard Specifications mentioned hereinafter may be ordered from:

Beuth Verlag GinbH BurgenstraBe 4-7 1000 Berlin 30 / Germany	– DIN 488 Sheets 1-5 – DIN 1048 Sheets 1, 2 – DIN 1050 – DIN 1054 – DIN 1055 Sheets 1-4, 6 – DIN 4030 – DIN 4100 – DIN 17100
British Standards Institution Technical Help to Exporters Maylands Avenue Hemmel Hempstead, Herts/GB	– DIN 1045 – Code of Practice for the Grouting of Tendon Ducts Code of Practice for the Design and Construction of Prestressed Concrete Structural Members (June 1973) In consideration of DIN 1045 (Ed. Jan.1972) as a preliminary substitute of DIN 4227 DIN 1084 Sheets 1-3 DIN 1164 Sheet 5 DIN 4226 Sheets 1-3

Building Research Establishment - DIN 1164, Sheets 1-3
Department of the Environment Garston, Watford, WD 27 JR Great Britain

Dorsch Consult - DIN 1072
Ingenieurgesellschaft mbH - DIN 1075
8000 M'u'nchen 21, Germany - DIN 4014
Postfach 210243

5103 MATERIALS

The materials furnished and used shall comply with the provisions of the Sepcification pertaining to the various materials- and contract items which enter into and form part of the completed-structure.

5104 CONSTRUCTION REQUIREMENTS

All construction details shall be in accordance with the detailed requirements described in this Section and with the Specification for the various Contract items involved.

5105 CLEARING OF SITE

The Contractor shall clear the site of the proposed structure of trees, brush, stumps and debris, in the manner outlined in Section 2.1. Unless payment is otherwise specifically provided, the costs for such clearing shall be included in the price bid for the various items in the structure. Special clearing of the site such as removal of existing bridges, buildings, concrete pavements, etc. will generally be paid for at prices tendered for these items, but where no such prices are provided for, all cost in connection with this special clearing shall be included in the price tendered for the various items in the structure in the Bill of Quantities.

Removal or relocation of public or private utilities such as telephone and telegraph lines, power lines, sewer and water lines, railway tracks and their appurtenances, etc., shall be done by either the Contractor or the Utilities Company as provided therein. Where the Contractor is required to remove or relocate these utilities to provide the necessary room or clearance for the completed structure and their removal is not otherwise provided for. such work shall be done according to the Engineer's Representative instructions. The Employer does not guarantee to the Contractor

the removal or relocation either temporarily or permanently, of any utility or utilities that interfere with the Contractor's operations or equipment during the construction of the project or structure. The Contractor shall make his own arrangements and at his own expense for such removals or relocations.

5106 FOUNDATION DATA

Foundation data has been obtained from soil investigation by penetration tests, test boring, test pits or other sources and represents the best information in the possession of the Employer as to the character of the underlying material at the locations actually tested.

It is the Contractor's responsibility to ensure by additional investigations at the *very* beginning of the construction work that the foundation levels given in the drawings coincide with the local requirements.

The additional soil investigation shall consist of at least one standard penetration test (SPT) for ea'ch bridge, of two SPTs for each bridge over 50 meters total length but the number of SPTs shall be as directed by the Engineer's Representative.

The results of this investigation shall be precisely recorded. This record and the derived final foundation level shall be submitted to the Engineer's Representative for approval before any soil excavation may be undertaken.

For pile foundation reference is made to Clause 5509.

The Contractor shall provide for all this investigation including all necessary equipment at no additional cost to the Employer.

5107 ALIGNMENT AND GRADE

Structures on vertical curves, structures which have super elevated roadways because of horizontal curves and those spans on which a definite finished camber is necessary in order to form a uniform grade line, all require special care and attention in regard to the elevation and alignment of their railings and curbs.

All structural members such as prefabricated girders, cast in situ deck slabs, cast in situ superstructures, bridge railings, including kerbs, wheel guards and collision rails shall be so constructed and placed that the finished vertical alignment or grade shall be as shown on the drawings.

Rails, sidewalks and kerbs on the curved part of a structure shall be constructed in so far as possible, after the completion of the entire superstructure. In such cases the heights of rails, sidewalks and/or kerbs may be varied with respect to the grade line of the slabs in order to produce the desired appearance.

All costs in connection with the adjustments above mentioned shall be included in the price tendered for the various contract items involved.

5108 APPROACHES TO MOVABLE SPANS

The roadway and sidewalk slabs of approach spans adjacent to each of movable spans of minor structures shall not be completed until the movable span is completely erected, adjusted and placed in a closed position in accordance with the directions of the Engineer's Representative.

5109 ERECTION METHODS

Before moving any construction equipment to the site the Contractor shall submit for approval an outline of the method he proposes to follow in the erection of the structure. The method of erection finally decided upon and approved-shall be adhered to in its essential details but approval by the Engineer's Representative shall not relieve the Contractor from his responsibility for the sufficiency of the method used.

5110 NAVIGABLE STREAMS

The channels or navigable streams shall be kept clear for the safe passage of water traffic. The Contractor shall provide and maintain all necessary lights and signals in accordance with the requirements of the Directorate of Navigation's requirements. All material deposited in the channel shall be removed to the required depth and clearance 1ines.

5111 ARCHITECTURAL FEATURES

Architectural treatment of the various parts of concrete structures requires that the concrete be of uniform texture and colour. For this reason the Contractor shall secure all cement for the structure from the same manufacturing plant unless otherwise authorized in writing by the Engineer's Representative.

5112 APPROVAL OF MATERIALS

Promptly after the approval of the Contract, the Contractor shall submit to the Engineer's Representative a list or lists showing the names of the firms or manufacturers from whom he proposes to secure the various materials.

5113 FINAL CLEANING

Upon completion of the structure the Contractor shall clean up the site, remove all temporary buildings, falsework, piling, lumber, equipment and debris. He shall level off and fine grade all excavated material not used for backfill, fine grade around all piers, abutments and on slopes. The decks of the structures shall be swept and washed clean. The whole of the site and structure shall' be left in a clean and workman like condition. No specific payment for cleaning up shall be made but the cost shall be included in the price shown .in the Bill of Quantities.

5114 MEASUREMENT

Measurement of the several items entering into the completed structures shall be in accordance with the specifications of the various items.

5115 PAYMENT

Payment will be made in accordance with the. prices in the Bill of Quantities for the various items, in accordance with the Specification, and shall constitute full compensation for furnishing-all equipment and labour and for performing all operations necessary to complete the work.

Any item not included in the Bill of Quantities, which is shown in the drawings or called for by the Specification, shall be understood to be included in the rates quoted for other items.

52 CONCRETE STRUCTURES

5201 SCOPE

The work covered by this Section of the Specification consists in furnishing all plant, equipments material and labour and in performing all operations in connection with all concrete structures except concrete pipes, including box culverts, retaining walls, concrete substructures, composite structures of concrete and steel or concrete and timber. Such structures shall be indicated on the drawings and in conformity with the lines,, grades, dimensions and details there shown. They shall also be in accordance with the provisions of the Specification pertaining to the various materials and contract items which enter into and form part of the complete structure and with the directions of the Engineer's Representative.

5202 MATERIALS

The materials furnished and used shall be those prescribed for concrete in Section 54 and other sections for the various items which are to constitute the complete structure. The classes of concrete shall be as shown on the drawings and/or as prescribed in the Bill of Quantities.

5203 CONSTRUCTION REQUIREMENTS

All construction details shall be in accordance with the requirements prescribed in Section 54 and other sections for the various items involved. The drawings attached to the Contract Documents may be

5204 FALSEWORK

The Contractor shall submit to the Engineer's Representative for approval detailed plans for falsework or centering in accordance with the requirements of Clause 5206. For calculating the strength of falsework or centering, a weight of 2600kg/cubic meter shall be assumed for green concrete.

The concreting shall not be commenced until the falsework and forms are checked and approved by the Engineer's Representative. This approval does not relieve in any way the Contractor of his responsibility for the sufficiency and load carrying capacity of the falsework and forms.

In general falsework which cannot be founded upon a solid footing shall be supported by piling. Falsework piling shall be spaced and driven in accordance with the falsework plans or as ordered and approved by the Egnineer's Representative.

It is the Contractor's responsibility to dimension the footing in a way that settlement of the subsoil under concreting loads will be kept as small as calculated.

Falsework shall be set to give the structural camber indicated on the drawings or as directed by the Engineer's Representative plus an allowance for shrinkage or settlement.

Settlement of falsework and footing is to be measured and recorded while concreting. Provisions shall be made to permit the compensation of unexpected settlements by means of hydraulic jacks and where directed by the Engineer's Representative.

Compaction for falsework and falsework piling shall be included in the price tendered in the Bill of Quantities for the several pay items involved in the structure. No additional compensation will be allowed.

5205 FORMS

Requirements:
All forms shall be set true to the lines designated and the interior and dimensions shall be' such that the finished concrete shall coincide exactly with the drawings of the structure. For all structures, the Contractor, before proceeding with the form work, shall submit to the Engineer's Representative for approval detailed drawing of the forms j he proposes to use in accordance with the requirements of this Clause.

Form Footing and Posts:
All form footings must be properly designed to carry the maximum load that can come upon them. They shall be as nearly unyielding as possible under full load. Where piling is necessary, it shall

conform in all respects as to bearing power required. In case of footings on rock or coarse sand and gravel, grouting may be required to ensure uniform bearing.

All systems of supports shall be provided with screw jacks or other devices which will permit the uniform release and take up of forms.

Stringers and Beams:
All stringers and beams used to support form work shall be particularly rigid, their design shall be determined on the basis of deflection which shall not exceed 1/500 of the span under full load unless otherwise designated by the Engineer's Representative.

Bracing:
All bracing shall be as rigid as possible and where there is any likelihood of movements braces shall be provided with screw jacks to take up such displacements.

Form Ties:
Metal ties or anchorages within the forms shall be so placed as to permit their removal to a depth of at least 5 cm from the face without injury to the concrete. In case ordinary wire ties are permitted, all wires, upon removal of the forms, shall be cut back at least 1 cm from the face of the concrete with chisels or nippers. All fittings for metal ties shall be of such design that upon their removal the cavities which are left will be of the smallest possible sizes. The cavities shall be filled with cement mortar and the surface left sound, smooth,.even and uniform in order.

Sheating or'Shuttering:
All sheating or shuttering, either wooden or metal type required, shall be adequate for the type of construction involved.

All forms shall be as nearly water tight as possible. Standing water will not be permitted in the forms.

Forms for concrete shall be oiled with form oil acceptable to the Egnineer'S Representative. The oil shall be applied several days before the concrete is placed and shall be in such quantity that it will be fully absorbed by the wood and will not discolour the surface of the concrete.

Forms shall be thoroughly wetted on both sides in advance of placing the concrete. In no case shall concrete be placed in any form until the form has been checked by the Engineer's Representative.

Cleaning out Forms:
Where the inside of the bottom of the forms is inaccessible, the lower form boards shall be left loose so that they may be removed for cleaning out extraneous material immediately before placing the concrete.

Metal Forms:
The Specifications for forms, as regards design, mortar tightness, filleted corners, levelled projections, bracing, alignment, removal, re-use and oiling and cleaning out, shall apply with equal force to metal forms. The metal used for forms shall be of such thickness that the forms remain true to shape. All bolt and rivet heads shall be countersunk. Clamps, pins or other connecting devices shall be designed to hold the forms rigidly together and to allow removal without injury to the concrete. Metal forms which do not present a smooth surface or line up properly, shall not be used. Special care shall be exercised to keep metal forms free from rust, grease or other foreign matter such as will end to discolour the concrete.

Preformed filler:
Preformed filler shall be of approved material sufficiently compressible and durable.

5206 PLANS FOR FALSEWORK AND FORMS

The Contractor shall submit, if required, to the Engineer's Representative 'for approval plans showing details of the falsework and forms intended to be used.

The drawings shall show the proposed details of construction, such as sizes of members, spacing of bents, posts, studs, wales stringers, collars, bolts and wedges.

Falsework and forms shall not be constructed until drawings have been approved by the Engineer's Representative, but approval by the Engineer's Representative shall not relieve the Contractor of responsibility for the sufficiency of the falsework and forms.

When falsework for structures is placed over roads carrying regular traffic, light clearjjice^frames shall be erected over the road at a suitable distance~1[MTnfp^trm) from the falsework on both sides. The frames shall be c'o^ltructecTwith a clearance slightly smaller than the actual clearance under the falsework.

5207 REMOVAL OF FALSEWORK AND FORMS

Forms for various parts of-the structure shall not be removed until the approximate number of days specified in the following table shall have elapsed after the placing of the concrete, the exact number of days shall be determined by the Engineer's Representative and shall be dependent on curing conditions including average temperature at site, subsequent to placing the concrete.

If the temperature of the concrete after concreting has at no time been below + 5 C, the values given in the following table for the formwork stripping and falsework striking times can in general be adopted for approximate guidance. Longer times may be necessary if the strength of the concrete is "still low. The times indicated

in columns 3 and 4 of this table are - reckoned from the time of placing the in-situ concrete - to be taken as guiding values for temporary props under precast reinforced concrete components, if such components are supplemented with in-situ concrete and the strength (loadbearing capacity) of the composite components thus formed depends on the strength development of the in-situ concrete.

The stripping times given in this table shall be increased or doubled if the temperature of the concrete in the hardening period has been predominantly below +5 C. If frost occurs during hardening, the formwork stripping and falsework striking times for unprotected concrete shall be increased by at least the duration of the frost.

Table - Formwork Stripping Times (Approximate Values)

1	2	3	4
Cement$_w$. "strength class	For side formwork of beams and for formwork of walls and columns Days	For formwork of floor slabs Days	For falsework (propping of beams, portal frames and long-span slabs Days
1 250	4	10 8	28 20
2 350 L	3		
3 350 *f and* 450 L		5	10
	2		
4 450 F and 550		3	6
	1		

Falsework- under all spans shall be completely released before railings, sidewalks and kerbs are placed.

In order to determine the conditions of column concrete, forms shall always be removed from columns before releasing supports from beneath beams and girders.

All forms shall be removed, whether above or below the ground line or water. Level Inside forms of hollow piers, girders, abutments, etc. shall be removed if they consist of material apt to rot or to cause any other injurious influence on the structure, and when specified on the drawings through opening provided for that purpose.

In no case shall forms, centers of falsework be removed at any time without the approval and direction of the Engineer's Representative. In the case of post-tensioned structures see also Sections D and K of the Standard Notes on the drawings.

5208 CABLE CUCTS

Cable ducts shall be made of approved galvanized steel pipes or PVC-pipeS;, in accordance and to the dimensions of the drawings.

5209 OPENING TO TRAFFIC

Bridges having decks made with Portland Cement Concrete shall remain closed to all traffic subject to the results of tests made of the concrete, but not less than 21 days after placing of concrete. If rapid hardening cement concrete is specified, the opening time shall depend on the results of tests aide of the concrete, but in no case shall the time of opening to traffic be less than 7 days after the concrete is placed.

The above time of opening to traffic is applicable when temperatures are above 10 C. When temperatures are below 10° C, the time of opening to traffic shall be increased at the discretion of the Engineer's Representative.

Bridges with concrete decks shall not be opened to traffic before falsework ha-s been removed and without the approval of the Engineer s Representative.

5210 EXCAVATION AND BACKFILL

Backfilling ground and over concrete structures shall not be done until the concrete has set at least 21 days. Backfilling around retaining walls shall not be done until the concrete has set at least 21 days.

5211 MEASUREMENT

Measurement of the various items entering into the construction of "Concrete Structures" shall be made in accordance with the Specification for the several items involved.

5212 PAYMENT

Payment for the various items entering into the construction of "Concrete Structures" will be made in accordance with the Specification at the price tendered in the Bill of Quantities for the several items involved. Any item not included in the Bill of Quantities, which is shown on the drawings or called for by the Specification, shall be understood to be included in the rates quoted for other items.

Payment shall include the furnishing of all materials, labour$_3$ equipment and all items uncluding all additional drawings, tests, test certificates, working schedules, required to complete the work. The construction of weep holes and drains and the backfilling with coarse gravel or rock as specified above shall be included in the price tendered in the Bill of Quantities per unit for concrete in place.

53 PREFABRICATED STRUCTURES

5301 SCOPE

The term "prefabricated member" refers to all structural members not manufactured at the site and to those manufactured at the site, which are not in their final position and which are manufactured -by sufficiently mechanized means to guarantee the required quality.

In these cases all relevant clauses of DIN 1045 shall apply, moreover the Sections 54, 56 and 57 of the Specification shall govern* unless otherwise specified hereinafter.

5302 MATERIALS, FABRICATION

Materials used for the production of prefabricated reinforced concrete and prestressed concrete members must comply with the standards outlined in Sections 54, 56 and 57 of the Specification and/or the characteristics indicated by the Engineer's Representative.

Special attention must be given to placement and compaction of the concrete. The precise location of the reinforcement in the formwork must be checked carefully prior to the placement of concrete. Thin-walled prefabricated members must carefully be protected against quick drying, e.g. by means of relevant covers, wet job-site after-treatment or other measures. Curing-sealant, if used, shall not be applied on the joint surfaces between precast units and cast in situ concrete (e. g., top surfaces of precast girders).

Sampling and testing shall be carried out in accordance with Sections 54, 56 and 57 of the Specification.

5303 STORAGE AND TRANSPORT

In connection with the working schedules required, the Contractor shall, before taking up the production, submit for the approval by the Engineer's Representative, installation drawings of the plant showing all workshops, the work flow, the areas required, the means of transport and all other data necessary to anticipate the approval and detailed drawings of the prefabricated members showing all additional material and devices for shoring and support.

The prefabricated members, excluding vertical elements, shall be stored and transported in the same position as specified for their final placement. They shall be supported or suspended only at points indicated in the drawings, and they must adequately be protected against damages. Damaged or deformed members as well as those not meeting the demand stipulated in Specification 54, 56 and 57 and the characteristics indicated in the drawings shall be replaced by the Contractor *or* - if the Engineer's Representative agrees - they shall be repaired. All prefabricated members shall be marked properly in order to guarantee their correct placement according to the location and position specified in the detailed drawings. The date of fabrication shall be marked on each member.

5304 PLACEMENT OF PREFABRICATED MEMBERS

It is imperative that the placement of prefabricated members is supervised by the Engineer's Representative. All equipment, shoring, additional reinforcement and supports needed for the placement of prefabricated members must be approved by the Engineer's Representative, the location of these members shown in the drawings must be adhered too.

During the storage of prefabricated girders, shoring is needed at their ends. When placing prefabricated girders in final position it will be necessary, according to their length and the manner of loading, to install provisional diaphragms in intermediate points to provide for the required stability. It is the Contractor's responsibility to assure the stability at all times.

When placing prestressed girders, girders arranged next to each other are to be of nearly equal age. The difference in age of adjacent girders must not exceed 14 days. The storage period of prestressed girders must not exceed 6 months between concreting of the girder and concreting of the cast-in-situ deck slab.

Placing machinery, which is to work on completed parts of the bridge, must have supports of such kind that no overloading of or damage to any part of this bridge at any times is caused.

It is the Contractor's full responsibility to prove the unobjectionable operation of all such machinery and equipment at all stages of construction work, and he shall submit for approval by the Engineer's Representative working plans and working schedules thereof before installing this machinery at the site. For treatment of construction joint surfaces Clause 5409.2 applies.

5305 MEASUREMENTS AND PAYMENT

AIT prefabricated members must comply with the dimensions shown in the drawings. The unit prices shall include: fabrications transports storage and placement as well as formwork, shorings, materials and equipment needed for these works .the joint grouting work between prefabricated members, and - in particular - shorings during placement of members and pouring of the cast-in-situ slab, The prefabricated members will be paid after completion of the cast-in-situ slabs and according to the quantities listed in the Bill of Quantities.

54 STRUCTURAL CONCRETE

5401 SCOPE

The work covered by this Section of the Specification consists in furnishing all plant, equipment, material and labour and in performing all operations in connection with the materials used for the storing, measuring and handling of materials$_3$ for the proportioning and mixing, and unless specified elsewhere in other Sections of this Specification for the conveying, placing, compacting, forming, curing and finishing, of all structural concrete for bridges, box culverts, concrete piling and other incidental concrete construction, complete, subject to the terms and conditions of the Contract and in strict accordance with this Section of the Specification, the drawings and the directions of the Engineer's Representative.

5402 STANDARD SPECIFICATIONS AND TEST METHODS

Except as modified by this Specification the following German Standard Specifications and test methods shall govern in all cases for the work to be performed:

DIN 1045 Beton und Stahlbetonbau
Bemessung und Ausfiihrung (Jan. 1972)

Concrete and reinforced concrete
Structures
design and construction (Jan. 1972)

DIN 1048 Blatt 1 und Blatt 2 .
Prlifverfahren flir Beton (Jan. 1972)

Sheet 1 and sheet 2
Test Methods for Concrete (Jan, 1972)

1084 Blatt 1 bis Blatt 3
Gliteliberwachung in
Beton und Stahlbetonbau (Febr. 1972)
e Sheet 1 to sheet 3
e Quality control in concrete
t and reinforced concrete construction (Febr.
1972)
1

DIM 1.164 Blatt 1 bis Blatt 8
o Porl1 and-, Elsenpor 1:1 and-,
Hochofen- und TraSzement
s (Jan. 1970)
h
e Sheet 1 to sheet 8
e Portland, Iron Portland, Blast Furnace and
t Trass Cement (Jan. 1970)

3
DIN 4226 Blatt 1 bis Blatt 3
Zuschlag fur Beton (Dez. 1971)

Sheet 1 to sheet 3 ' Sand and
gravel

aggregates for concrete (Dec,
1971)

5403 MATERIALS

5403.1 AGGREGATE

Aggregate shall conform to DIN 4226. The combined aggregate should be as coarse-grained and dense-graded as possible, the maximum particles size should be so chosen as to be compatible with mixing, handling, placing and working the concrete. Its normal size shall not exceed one third of the smallest dimension of the component to be concreted. With closely spaced reinforcement or small concrete cover, the greater part of the aggregate shall consist of particles smaller than the distance between adjacent bars and between the' bars and formwork.

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The concrete shall contain a certain quantity of uitrafine particles to be properly workable and achieve a closed texture. The ultrafines content comprises the cement, the aggregate particles of 0 - 0.25 mm size, and such additional material of this particle size range as it may be necessary to introduce. Such additional material, if any shall consist of natural or artificial mineral substances, comprising as far as possible a mixture of different-sized particles, which do not soften and do not impair the durability of the concrete. An adequate content of uitrafine material is especially important in concrete which has to be conveyed long distances or through pipelines, in concrete for thinwa'iled densely reinforced components, and in waterproof concrete.

In general an uitrafine content as indicated in the following table is advantageous.

Table Approximate Guiding Values for the Ultrafines Content

-		
	Maximum particle size of the aggregate mm	Content of uitrafine particles in 1 cubic m compacted concrete
1	8	525
2	16	450
3	32	400
4	63	325

The granulometric composition of the aggregate is characterized by grading curves {see Figs..1-4) of Section 6.2.2. of DIN 1045 and - if necessary - by a characteristic value for the"tjrading or the water demand.

For example: Fineness modulus, grading, coefficients grading curve areas, water demand factor.

For determining characteristic values of grading or of water demand the percentage of particles actually present should be adopted as the particle percentage up to 0.5 mm. Only for comparison of the characteristic values with those of the standard grading curves is it necessary to obtain the percentage obtained at 0.50 mm by interpolation of the values of the 0.25 mm and the 1 mm test sieves.

For aggregates composed of particles size fractions which differ significantly in specific gravity, the grading curves shall be referred, not to parts by weight of the aggregate, but to parts by absolute volume.

The composition of the aggregate or of individual size fractions shall be determined by tests with test sieves (wire-mesh sieves and square-hole screens) - 0.25,' 0.5, 1, 2, 4, 8, 16, 31.5 and 63 mm -.

Continuous grading curves of aggregates shall be located between the grading curves A and C, I.E. in the regions (3) and (4), of Figs. 1-4. Region (3) between curves A and B comprises favourable granulometric compositions. Region (4) between curves B and C comprises granulometric compositions which are to be regarded as serviceable.

Deviations from the grading curve in the region above 8 mm have only little effect on the properties of the concrete.

Discontinuous grading curves (gap gradings), i.e. for aggregates in which individual si2e fractions are absent, shall lie between the bottom limit curve U and the curve C in Figs. 1-4 of DIN 1045.

Fine aggregate shall consist of natural sand or subject to approval of combination of not more than 50 percent by weight of stone screenings and natural sand, having hard, strong durable particles, and shall conform to the following requirements:

Fine aggregate from different sources of supply shall not be mixed or stored in the same piles nor used alternatively in the same class of construction or mix without written permission from the Engineer' Representative.

Wien the fine aggregate is subjected to five alternations of the magnesium sulphate soundness test, the weight loss shall not exceed 10 percent by weight.

The aggregate shall be free from salt or organic matter. It shall not contain more than 0.5 percent by weight of clay. When subjected to the colorimetric test for organic impurities, it shall not show a colour darker than the standard.

The chloride and sulphate content of the aggregate shall be determined and in any case be considered together with the con-tent, in the mixing water.

Coarse aggregate shall consist of gravel, or crushed gravel or other approved inert materials of similar characteristics, or combinations thereof, free from adherent coatings and conforming to the following requirements:

The coarse aggregate, when subjected to the Los Angeles American Test, shall have a-percentage of wear of not more than 35 percent according to AASHTO T 96 - Los Angeles abrasion of coarse aggregate.

When the coarse aggregate is subjected to 5 alternations of the magnesium sulphate soundness test, the weighted loss shall not exceed 10 percent.

The aggregate shall conform to the requirements given in this Clause, unless otherwise directed by the Engineer's Representative.

5403.2 MIXING WATER

A thorough chemical water analysis shall be made before using a certain water source for concrete mixing.

Mixing water for use with cement shall be reasonably clean and free from injurious amounts of oil, acid alkali $_5$. salt$_9$ organic matter, or other deleterious substances.

When comparative tests are made with distilled water of known quality, any indications of unsoundness, marked change in time of set$_9$ or reduction of more than 10 percent in mortar strength shall be sufficient cause for the rejection of the water under test.

The Contractor shall not take water for use in concrete from shallows muddy or marshy sources unless provision is made for the intake of the suction pipe to be enclosed in such manner as to exclude silt, mud, grass and other foreign materials. The depth of the water shall be maintained at least 60 centimeters below the intake of the suction pipe.

The chloride content of the mixing water shall not exceed 300 mg CL per liter for prestressed concrete, 600 mg CL~ per liter for reinforced concrete and 2000 mg CL per liter for non reinforced concrete.

The sulphate content of the mixing water shall not exceed 650 mg SO. per liter for prestressed concrete, 1300 mg SO, per liter for reinforced concrete, and 1500 mg SO. per liter for **non** reinforced concrete.

In any case the chloride and sulphate content of mixing water and aggregates is to be considered for both.

In special cases, where it is impossible to find mixing water complying with the above stated requirements within reasonable distance, the water available must be analyzed and judged by a concrete technologist as directed by the Engineer's Representative.

The conditions apply only for mixing water but not for water used for washing the aggregates and curing the concrete.

5403.3 CEMENT

All cement to be used such as ordinary Portland Cement, Rapid Hardening Portland Cement$_9$ Iron Portland Cement,, Blast Furnace Cement, Trass Cement, Sulphate Resistant Cement and all other shall comply In all respects with the requirements of DIN 1164, see Clause 5402.

Blast Furnace Cement can be used for prestressed concrete if permitted in writing by the Engineer's Representative. However, Blast Furnace Cement must neither be used in prestressed pretensioned concrete nor in grout for tendon ducts, see Clause 5707.2.

In prestressed pretensioned concrete members, the application of Blast Furnace Cement is only possible if the. content of slag does "not exceed 50 percent in weight.

Cement with high sulphate resistance is:

Portland Cement with calculated maximum content of tricalcium aluminate CJVof not more than 3 percent in weight and with a content of aluminium oxide AUCL of not more than 5 percent in weight and not more than 30 percent in weight of Portland Cement clinker.

For handling cement and for quality control thereof DIN 1164, sheet 1, Clause 6 resp. 7 shall be applied if not otherwise directed by the Engineer's Representative.

Unless approval is given for the handling of cement in bulk, all cement shall be delivered in sound and properly secured bags. Cement shall be delivered in quantities sufficient to ensure that there is no suspension or interruption of the work of concreting at any time and each consignment shall be kept separate and distinct. Any cement that shall have become injuriously affected by damp or other cause shall at once be removed from the site.

The Contractor shall furnish, free of cost, test certificates as directed by the Engineer's Representative relating to the cement to be used on the work. Each certificate shall indicate that the sample has been tested by an approved firm and that it complies in all respects with the requirements of the appropriate specification for the particular type of cement. Analysis of the cement shall be shown.

5403.4 ADMIXTURES AND ADDITIVES

For concrete and cement mortar and for fixing dowels it is only permissible to use admixtures having a valid test mark and only in accordance with the conditions stated in the test certificate and if permitted by the Engineer's Representative.

Chlorides, substances containing chlorides or other substances^ which promote the corrosion of steel shall not be added to reinforced concrete or to concrete which comes into contact with reinforced concrete,

A^fiif^mses are used to modify particular properties of concrete. However, as they may at the same time adversely affect other important properties, it is essential to carry preliminary tests with the concrete to which they are to be added.

Ac&tekwes are allowed to be added to concrete if they do not adversely affect the hardening of the cement, the strength and durability of the concrete and the corrosion protection of the reinforcement.

Additives which do not conform to DIN 4226 or to some other relevant .Standard, are allowed to be used only if certificate of approval by the Engineer's Representative or a test mark has been issued for them.

A latently hydraulic or a pozzolanic additive may be reckoned as constituting part of the.cement content only if this is specially authorized., e..g. under a general certificate of approval *or* under regulations.

5404 CLASSES OF CONCRETE

5404.1 STRENGTH CLASSES AND THEIR APPLICATION

Concrete is classified into strength classes Bn 50.to Bn 550 (see the following table) on the basis of its compressive strength determined in the quality control tests on 20 cms cubes at an age of 28 days.
The three cubes of a series shall be made from three different batches from the mixer or, in the case of ready-mixed concrete, from different deliveries so far as possible - of the same type of concrete.

A particular cube strength may also be necessary at an earlier age than 28 days, to satisfy particular stress conditions, e.g. for the transport of precast components. Alternatively, a particular strength may be agreed for a later point of time., e.g. if this is appropriate in special cases when slow-hardening cement is used and if it is permissible with regard to the stresses to which the concrete will be subjected.

Concrete Bn 550 is intended for precast concrete components manufactured under factory conditions,

uales-s otherwise specified, ordinary Portland Cement shall be used for all of the classes of concrete mentioned.in the table, When Rapid Hardening, White, Coloured or Sulphate Resistant Cement is required, it will be specified on the drawings and/or in the Bill of-Quantities.

Concrete Strength Classes and their Applications

TABLE

	1	2	3	4	5	6
	Concrete group	Strength class of concrete	Nominal strencth BwN BwN {minimum value for the compressive strength Bw28 of each cube in accordance with Clause 5418 kg/sq.cm (psi)	Series strength BwS (minimunr-Vcuue for.the average compressive strength BwM of each series of cubes) kg/sq=cm (psi)	Made in accordance with	**Application.**
1	**Concrete** B I	Bn 50	50 (710)	80 (1130)	Clause 5404.2	**For plain concrete only**
2	Bn 100		100 ' (1420)	150 (2130)		
3		Bn 150	150 (2130;	200 (2840)	i	**For plain and for reinforced concrete**
4		Bn 250 '	250 (3550)	300 (4260)		
5	**Concrete** B II	Bn 350	350 (4SS0)'	400 (5690)	Clause 5404.3	
6	Bn 450	Bn 550	450 (5400)	500 (7110)		
7			550 (7800)	600 (8530)		

The normal strength is based on the 5% fractile of the statistical parent population .

Concrete B I is a designation for concrete of the strength class Bn 50 to Bn 250.

Concrete B II is a designation for concrete of the strength class Bn 350 and higher, and as a rule for concrete with special properties.

Psi = pounds per square inch

5404.2 COMPOSITION OF CONCRETE B I

Cement Content:

The concrete shall contain so much cement that the required compressive strengths and in reinforced concrete an adequate degree of protection of the steel against corrosion, can be achieved.

If the cement content is determined on the basis of preliminary tests, it shall in any case not be less than the following amounts per cubic meter of compacted conrete:

For plain concrete: 150 kg.

For reinforced concrete, with a view to corrosion protection of Steel:

240 kg if the cement is of strength class 350 or higher,
280 kg if the cement is of strength class 250.

For concrete not containing admixtures or additives it is unnecessary to make preliminary tests if the composition of the concrete complies at least with the conditions in the following table and with the following requirements:

The cement content, as stated in the table which follows, shall be increased by

15 % if the cement is of strength class 250,
10 % if the maximum particle size of the aggregate is 16 mm,
20 % if the maximum particle size of the aggregate is 8 mm.

The cement content, as stated in the table, may be decreased by not more than 10 % if the cement is of strength class 450, and not more than 10 % if the maximum particle size of the aggregate is 63 mm.

The increases in cement content must be added together, the decreases may be added together, and however, for reinforced concrete the cement content shall not be less than indicated in the second paragraph of this Clause.

Aggregate:

For a mix composition in accordance with the following table and accompanying information the grading of the aggregate shall be continuous and be situated between the curves A and C of Figs. 1 - 4 of DIN 1045. It shall be in the favourable region (3) if the minimum cement content appropriate to this region according to the tables is used.

If the composition is determined on the basis of prelimary tests, the granulometric composition of the aggregate used in those tests shall be complied with in subsequently making the concrete. Besides continuous grading curves it is permissible to use gap gradings.

All-in unclassified aggregate from pits and dredgings is allowed to be used only for concrete of strength classes Bn 50 and Bn 100, provided that the aggregate fullfills the requirements of DIN 4226 and its granulometric composition complies with this Standard.

For concrete of strength classes Bn 150 and Bn 250 the aggregate shall comprise at least two particle size fractions, one of which shall be in the 0-4 mm range. These shall be delivered and stored separately; They shall be fed to the mixer in such a way that the required granulometric composition of the mix is obtained. Instead of separate fractions it is for aggregates with up to 32 mm. maximum particle size permissible to use ready-mixed aggregate conforming to DIN 4226, sheet 1, provided that its granulometric composition conforms to the conditions of Clause 5403.1.

Consistency:

The consistency of the fresh concrete shall be determined before the start of work, taking due account of the conditions of placing and working the concrete during construction (e.g. type of compaction).

Table Minimum Cement Content for Concrete J^with Aggregate of Maximum Size 32 mm and Cement of Strength Class 350 in Accordance with DIN 1164

	1	2	3	4	5
	Strength class of the concrete	Grading curve region of the aggregate	Minimum cement content in kg per cubic meter of compacted concrete for consistency range		
			K l x)	K 2	K 3
1	Bn 50 м)	favorable- (3)	140	160	-
2		serviceable (4)	160	180	-
3	Bn 100 к)	favorable (3)	190	210	230
4		serviceable (4)	.210	230	260
5	Bn 150	favorable (3)	240	270	300
6		serviceable (4)	270	300	330
7	Bn 250	favorable (3)	280	310	340
8		serviceable (4)	310	340	380

x) For plain concrete only.

Concrete B I will be required for all structural members cast-in-situ$_s$ except those for which a concrete with special properties is required as mentioned in Section 5404.4.

5404.3 COMPOSITION OF CONCRETE B II

Cement Content:

The requisite cement content shall be determined on the basis of preliminary tests. For reinforced concrete with a view to corrosion protection of the steel$_3$ it shall not be less than the following amounts per cubic meter of compacted concrete:

240 kg if the cement is of strength class 350 or higher, 280 kg if the cement is of strength class 250.

Aggregate:

The aggregate, its subdivision into particle size fractions and the granulometric composition of the combined aggregate, as used in making the concrete, shall conform to the preliminary tests.

For continuous gradings comprising particle sizes from 0-32 mm, there shall be at least three, and for discontinuous gradings, there shall be at least two particle size fractions, which shall be delivered, stored and batched separately, one of the fractions shall be in the 0-2 mm range. For combined aggregates comprising 0-8 mm or 0-16 mm particles, it is, however, sufficient to use two separate fractions, namely one of 0--2 mm and once containing larger particles.

An addition of ultrafine particles is not to be reckoned as a granulometric fraction.

Water/Cement Ratio and Consistency:

The water/cement ratio is the ratio of the water content W to the weight Z of the cement in the concrete.

The concrete shall not be made with a water/cement ratio higher than established in the preliminary tests. If the concrete with this consistency is found to be not adequately workable for difficult individual parts, and if the water content must therefore be increased, the cement content shall be increased in the same ratio by weight, Both increases shall be effected at the mixer.

For reinforced concrete, with a view to corrosion protection of

the steel, the water/cement ratio shall not exceed 0.65 if cement of strength class 250 is used, and shall not exceecToTTB if the cement is of strength class 350 or higher.

Concrete B II will be required for all precast, reinforced or prestressed concrete structures and/or as directed by the Engin-Representative.

5404.4 CONCRETE WITH SPECIAL PROPERTIES

General Requirements:

Prerequisite conditions for procuding concrete with special properties are that it shall be correctly composed, made and placed, that it must not segregate and that it shall be completely

compacted and carefully cured. It shall be made in accordance with the requirements applicable to concrete B II, except in so far as the following clauses permit making the concrete in accordance with the requirements applicable to concrete B I.

Waterproof Concrete:

Waterproof concrete for components with a thickness of about 10 to 40 cms shall be so dense (impermeable) that the greatest depth of water penetration on testing in accordance with DIN 1048 (average of three test specimens) does not exceed 5 cms,

The water/cement ratio shall be not more than 0.65 for components with a thickness of about 10 - 40 cms. and not more than 0.70 for thicker ones-Waterproof concrete of a lower strength class than Bn 350 may alternatively be made in accordance with the requirements applicable to' concrete B I, provided that the cement content is not less than 400 kg/cubic meter if the particle size range of the combined aggregate is 0-16 mm, and not less than 350 kg/cubic meter if it is 0-32 mm, and provided that the grading of the aggregate is within the favorable range 3 of Fig. 2 or 3 of DIN 1045.

Concrete with high Frost Resistance:

Concrete which is exposed to frequent and abrupt alternations of freezing and thawing in the moisture-saturated condition. This requires frost-resistant aggregate (see DIN 4225) and waterproof concrete.

The water/cement ratio shall not exceed 0.60. It may be increased up to 0.70 in massive components if air-entraining agents are added in such amount that the air content in the fresh concrete corresponds to the values in the table below and the components do not come in to contact with de-icing-salts.

The air content indicated in the table below is - except in *every* stiff concrete - also essential in concrete with lower water/cement ratios than 0.60 if it comes into frequent contact with de-icing salts and is exposed to alternations of freezing and thawing.

For concrete with high frost resistance and of a lower strength class than Bn 350 the last paragraph of the Clause for waterproof concrete may be applied.

Table Air Content in Fresh Concrete

	Maximum particle size of the aggregate mm	Average Air Content % by volume
1	8	5.0
2	16	4.0
3	32	3.5
4	63	3.0

Individual values can permissibly fall short of this requirement by not more than 0.5 %.

Concrete with high Resistance to Chemical Attack:

The resistance of concrete to chemical attack depends to a great extent on its denseness. The concrete shall therefore be at least so dense that the greatest water penetration depth on testing in accordance with DIN 1048 (average of three test specimens) does not exceed 5 cms in the case of "weak" attack and does not exceed 3 cms in the case of "strong" attack. The water/cement ratio must not exceed 0,60 for "weak" and not exceed 0.50 for "strong" attack.

Liquids, soils and vapours aggressive to concrete shall be judged in accordance with DIN 4030 and be classified according to "weak"., "strong" and very strong" aggressiveness.

For concrete with high resistance to "weak" chemical attack and of lower strength class than Bn 350 the last paragraph of the Clause for waterproof concrete may be applied.

Concrete which is exposed to "very strong" chemical attack for a substantial length of time shall be protected against direct access of the aggressive substances. In addition, this concrete shall be so composed.as is required for "strong" attack.

For concrete which is exposed to attack by water containing more than 400 mg of SO- per liter, or by soils containing more than 3000 mg of SO, per kg, cement with high sulphate resistance as specified in DIN 1164, sheet 1, shall always be used. In the case of sea-water, despite its high sulphate content, it is not necessary to use cement with high sulphate resistance, since concrete possessing high resistance to "strong" chemical attack is also adequately resistant to sea-water.

In-addition to this Specification of Clause 5404.2 and 5404.3 the 'directions of Iraq. Cement Indus-tries given in the following table shall be observed especially as far as they require higher cement content and/or lower water/cement ratios.

Concrete with high Wearing Resistance:

Concrete which is exposed to severe mechanical actions e.g. due to intensive traffic., sliding of bulk materials^ frequent impact blows or movements of heavy objects, or due to fast-flowing water carrying solids or other causes, shall possess high wearing resistance and correspond at least to strength class Bn 350, The cement content should not be too high, e„g.! it shall not exceed 350 kg/cubic meter for a maximum aggregate particle size of 32 mm. Concrete in which water segregation (bleeding) occurs on working is unsuitable.

The aggregate up to 4 mm size shall consist predominantly of quartz or materials of at least equal hardness. The coarser-particles shall consist of stone or artificial materials possessing high abrasion resistance. In the case of particularly severe mechanical action' it will be necessary to use special hard materials. The particles of all types of aggregate shall have a moderately rough surface and be of compact shape. The. combined aggregate shall be as coarsely graded as possible (grading curve close to curve A ors with gap grading., between curves B and in Figs. 1-4 of DIN 1045).

Furthermore the concrete shall be as stiff as possible, in order that there will be no concentration of cement slurry or water in the top layer. The concrete shall be kept moist for at least 7 days after placing.

In general 'Concrete with high resistance to chemical attack is required for all structural parts which will be situated below the natural ground level or the high water level or as directed by the Engineer's Representative.

Sulphate Content of Soil and Water and its Classification regarding Aggressivity to Concrete as required by the Iraqi Cement Industries

Type	Concentration of Sulphates as SO, in		Type of Cement to be used, Ratios of Mix_5 Density, Gravel of 20 mm Size is to be used.
	Soil, %	Water, parts per million	
	<0.25	< 350	Ordinary PC for reinforced concrete. Cement content shall not be less than 280 kg/cu.m concrete, w/c = 0.55 by weight.
2	0.25 - 0,6	350 - 1450	Moderate sulphate resistant cement. Cement content shall not be less than 300 kg/cu.m concrete. Water content not more than w/c = 0.55
3	0.6 - 1.2	1450 - 3000	Sulphate resistant cement. Cement content shall not be less than 330 kg/cu.m concrete. Water content not more than 0.5 by weight.
4	1.2 - 2.4	3000 - 6000	Sulphate resistant cement. Cement content shall not be less than 370 kg/cu.m concrete. Water content not more than 0.45 by weight.
5	>2.4	>6000	Sulphate resistant cement covering the concrete with a layer of asphalt or asphalt and fiberglass or the use of Alumina Cement. Cement content 370 kg/cu.m, w/c = 0.4 by weight, /(See also Clause 5505)

Note: This table can be used in case the soil is neutral (not acidic nor basic (pH = 6 - 9)).

Portland Cement cannot be used if the soil is acidic (PH = 6).

5405 CONSTRUCTION REQUIREMENTS

5405.1 STORAGE OF MATERIALS

Aggregate for concrete shall not be contaminated by other materials during transport and during storage on site. Particle aggregates shall be stored on areas covered with tightly laid wood planks, sheet metal, hard compact gravel, or other hard and clean surfaces, and in such a manner that will preclude the inclusion of foreign material. Aggregate of different sizes and different sources shall be stored in separate piles. Stock piles of coarse aggregate shall be built in horizontal layers not exceeding one meter in depth to avoid segregation. Should the coarse aggregate become segregated, it shall be remixed to conform to the grading requirements given hereinbefore.

If aggregates are stored on the grounds the bottom layer, of aggregates shall not be disturbed or used without recleaning.

Cement shall be protected from moisture during transport and storage. Bulk transporter vehicles and bins or silos for cement shall not contain, any residues of a different types, *or* of a lower strength class or of any other materials; in doubtful cases this »• should be carefully checked before filling.

Cement shall be stored immediately upon receipt at the site of the work. Cement in sacks shall be stored in a suitable weather- ¸' proof structure which shall be as airtight as practicable: floors shall be elevated above the ground a distance sufficient to prevent the absorption of moisture. Sack shall be stacked close together to reduce circulation of air but shall not be stacked against outside walls, the manner of storage shall permit easy access for inspection and identification of each shipment. Bulk cement shall be transferred to elevated airtight and weatherproof bins. At the time of use all cement shall be free-flowing and free of lumps. Cement that has been in storage so long that there is doubt of its quality will be tested by standard mortar test to determine its suitability for use and such cement shall not be used without approval.

. On small jobs, storage in the open may be permitted by written authorization from the Engineer's Representative* in which case a raised platform and ample waterproof covering shall be provided.

5405.2 PROPORTIONING

All concrete shall be proportioned by weighing, except as specified herein, and shall conform to the concrete mix requirements specified in Clause 5404 for the respective classes of concrete.

The proposals for the proportions by weight of cement, aggregates and water necessary to conform to the requirements listed in Clause 5404 shall be determined in the first instance preliminary testing made by the Contractor according to DIN 1045 Clause 7 and approved by the Engineer's Representative upon the materials to be used in the work. No concrete shall be placed until the results of the 28 days indicate that design proportions are satisfactory.

The maximum water-cement ratio listed is the maximum water-cement ratio allowed in the respective classes of concrete and includes both the water added at the mixer and the free water held by the

The minimum cement factors listed are the minimum cement content allowable for the respective classes of concrete. Cement required in excess of these minimum amounts, in order to obtain the required strength and consistency, shall be furnished by the Contractor at no additional cost to the Employer.

5405.3 CHANGES IN PROPORTIONS

If the quality control tests, as specified in Clause 5417, indicate that a change in the mix proportions is necessary, such change shal be made as directed. The 28 days compressive strength will govern in any case., and the 7 days compressive strength is regarded as an indication only. Costs for all tests shall be borne by the Contractor and have to be included in the regarding rates for concrete.

5405.4 VOLUMETRIC PROPORTIONING

Where volumetric proportioning is permitted in the Bill of Quantities or where the failure of equipment necessitates the temporary use of volumetric proportioning, the weight proportions indicated shall be transposed into equivalent volumetric proportions by weighing representative samples of the aggregates in the condition in which they will be measured.

5405.5 CONSISTENCY OF CONCRETE

Three consistency ranges are to be distinguished for fresh concrete (see Table below). Within these ranges the consistency should, if necessary, be more precisely specified by a particular value for the compaction or the flow-table spread (see columns 4 and 5 of the Table below, and DIN 1048 Sheet 1).

Table Consistency Ranges for Fresh Concrete

	1	2	3	4	5	6
	Consistency range	fine mortar	Properties of the fresh concrete on placing	Compaction index	Spread (flow table test)	Method of compaction
1	K1 Stiff concrete	somewhat wetter than 'no-slump'	still loose	1.45 - 1.26		with powerful vibrators or vigorous tamping in thin layers
2	K 2 Plastic concrete	plastic	lumpy to barely coherent	1..25 - 1.11	40	vibrating or punning *or* tamping
3	K 3 Soft concrete	1iquid	slightly fluid	1.10 - 1.04	41-50	punning, etc.

The consistency of the concrete shall be constantly supervised during concreting. The consistency test shall be performed at the time of first placing the concrete and at all times of samplina as required.

5405.6 MEASURING MATERIALS

Cement shall be measured by the sack of 50 kilos net. Unless specifically authorized by the Engineer's Representative in writing, batches of concrete shall be so adjusted that fractional sacks of cement are not required. When permitted by the Engineer's Representative in writing, the addition of fractional sacks shall be accomplished by actual weight. For this purpose the Contractor shall station a workman whose sole duty is to make such weights.

The fine aggregate and each size fraction of the coarse aggregate shall be weighed separately. Representative samples shall be taken and the moisture content determined for each kind of aggregate. The aggregates shall be stored and handled so that the moisture content remains reasonably constant during any day's run.

The equipment for weighing materials sha-11 provide convenient and positive means of determining the quantities in the concrete^ and means shall be provided for the addition and removal of small quantities of materials to obtain the exact weight per batch.

The device for measuring the water shall "show accurately the" quantity and be designed that the water supply will be automatical! cut off while water *is* being discharged into the mixer. Water shall be assumed to weigh 1 kilo per liter.

5406 MIXING CONCRETE

5406.1 GENERAL

Unless otherwise authorized by the Engineer's Representative, concrete shall be machine mixed at the site. The temperature of freshly mixed concrete shall, at the end of the mixing procedure, not exceed + 35 C -resp. during cold weather - not below + 5 C or as directed by the Engineer's Representative.

5406.2 MIXING AT SITE

Concrete shall be thoroughly mixed in a batch mixer of an approved size type, which will ensure a uniform distribution of the materials throughout the mass. For important operations spare mixers shall be on the site as ordered by the Engineer's Representative.

The mixer shall be equipped with adequate water storage and a device for accurately measuring and automatically controlling the amount of water used in each batch. Preferably, mechanical means shall be provided for recording the number of revolutions for each batch and automatically preventing the discharge of the mixer until the materials have been mixed the specific minimum time.

The entire contents of the mixer shall be removed from the drum before materials of a succeeding batch are placed therein. The materials composing a batch shall be deposited simultaneously in the mixer. No mixer having a rated capacity of less than 1-bag batch shall be used nor shall a mixer be charged in excess of its rated capacity.

All concrete shall be mixed for a period of not less than 1 1/2 minutes after all materials., including water$_9$ are in the mixer. During the period of mixing, the mixer shall operate at the speed for which it has been designed., but its speed shall be not less than 14 nor more than 20 revolutions.

The first batch of concrete materials placed in the mixer shall contain a sufficent excess of cement, sand and water to coat the inside of the drum without reducing the required mortar content of the mix. Upon the cessation of mixing for a considerable periods the mixer shall be thoroughly cleaned.

5406.3 TRUCK MIXING

Truck mixers., unless otherwise authorized by the Engineer's Representatives shall be of the revolving drum type, watertight and so constructed that the concrete can be mixed to ensure a uniform distribution of materials throughout the mass. All solid materials for the concrete shall be accurately measured in accordance with Clause 5405.6 and charged into the-drum at the proportioning plant. Except as subsequently provided, the truck mixer shall be equipped with a tank for carrying mixing water. Only the prescribed amount of water shall be placed in the tank unless the tank is equipped with a device by which the quantity of water added can be readily verified. The mixing water may be added directly to. the batch in which case a tank shall not be required.. Truck mixers may be required to be provided with means by which the mixing time can be readily verified by the Engineer's Representative.

The maximum size of batch in truck mixers shall not exceed the maximum rated capacity of the mixer as stated by the manufacturer and stamped in metal on the mixer. Truck mixing shall be continued for not less than 50 revolutions after all ingredients, including the water, are in the drum. The speed shall not be less than 4 r.p.m., nor more than a speed resulting in a peripheral velocity of the drum of 70 m per minute. Not more than 100 revolutions

of mixing shall be at a speed in excess of 6 r.p.m. Mixing shall begin within 30 minutes after cement has been added either to the water or aggregate.

When cement is charged into a mixer drum containing water or surface-wet aggregate, and when the temperature is above 35 C_3 or when Rapid-Hardening Portland Cement is used., this limit shall be reduced to 15 $minutes_3$ the limitation on time between the introduction of the cement to the aggregate and the beginning of the mixing may be waived when, in the judgment of the Engineer's Representative, the aggregates are sufficiently free from moistures so that there will be no harmful effect on the cement.

5406.4 PARTIAL MIXING AT THE CENTRAL PLANT

When a truck mixer, or an agitator provided with adequate mixing blades, is used for transportation, the mixing time at the stationary machine mixer may be reduced to 30 seconds and the mixing completed in a truck mixer or agitator. The mixing time in the truck mixer or agitator equipped with adequate mixing blades shall be as specified for truck mixing,

5406.5 PLANT MIX

Mixing at a central plant shall conform to the requirements for mixing at the site, Clause 5406.2.

5406.6 TIME OF HAULING AND PLACING MIXED CONCRETE

Concrete transported in a truck mixer, agitator, or other transportation device shall be discharged, at the job and placed in its final position in the forms within 45 minutes after the introduction of the mixing water to the cement and aggregate? or the cement to the aggregate, except that in hot weather or under conditions contributing to quick stiffening-of- the concrete, the maximum allowable time may be reduced by the Engineer's Representative. The maximum volume of mixed concrete transported in an agitator shall be in accordance with the specified rating.

5406.7 HAND MIXING

When hand mixing is authorized by the Engineer's Representative in writing, it shall be done on a watertight platform and in such a manner as to ensure a uniform distribution of the materials throughout the mass. Mixing shall be continued until a homogenous mixture of the required consistency is abtained.

5406.8 DELIVERY

The organization supplying concrete shall have sufficient plant capacity and transporting apparatus to ensure continuous delivery at the rate required. The rate of delivery of concrete during concreting operations shall be such as to provide for the proper handling, placing and finishing of the concrete. The rate shall be such that the interval between batches shall not exceed 20 minutes. The methods of ""cHFRvering and handling the concrete .shall be such" as will facilitate placing with the minimum of rehandling and without damage to the structure of the concrete,

5406.9 RETEMPERI!

The concrete shall be mixed only in such quantities as art required for immediate use .and any which have developed inset shall be tempered or remixed.

5407 HANDLING AND PLACING CONCRETE

5407.1 GENERAL

The Contractor shall submit in due time for approval by the Engineer's Representative a schedule of the proposed working procedure indicating time and sequence of concreting sections,

In preparation for the placing of concrete all sawdust, chips and other construction debris and extraneous matter shall be removed from the interior of forms. Struts, stays and braces, serving temporarily to hold the forms in correct shape and alignment, pending the placing of concrete at their locations, shall be removed when the concrete placing has reached an elevation rendering their service unnecessary. These temporary members shall be entirely removed from the forms and not buried in the concrete.'

No concrete shall be used which does not reach its final position in the forms within the time stipulated under Clause 5406.6.

Concrete shall be placed so as to avoid segregation of the materials and the displacement of the reinforcement. The use of long troughs, chutes and pipes for conveying concrete from the mixer to the forms shall be permitted only on written authorization of the Engineer's Representative. In case an inferior quality of concrete is produced by the use of such conveyors, the Engineer's Representative may order discontinuance of their use and the substitution of a satisfactory method of placing.

Open troughs and chutes shall be metal lined. Where steep slopes are required., the chutes shall be equipped with baffles or be in short lengths that reserve the direction of movement.

All chutes, troughs and pipes shall be kept clean and free from coatings of hardened concrete by thoroughly flushing with water after each run, water used for flushing shall be discharged clear of the structure.

When placing, operations would, involve dropping the concrete more than 2 meters, it shall be deposited through sheet metal or other approved pipes. As far as practicable, the pipes shall be kept full of concrete during placing and their lower ends shall be kept buried in the newly placed concrete. After initial set of the concrete the forms shall not be jarred and the ends of reinforcing bars which project shall not be strained.

5407.2 PUMPING CONCRETE

Placement of concrete by pumping will bo permitted only if specified in the Bill of Quantities, or if authorized by the Engineer's Representative in writing. The equipment shall be so arranged that no vibrations result which might damage freshly placed concrete.

Where concrete is conveyed and placed by mechanically applied pressure, the equipment shall be suitable in kind and adequate for the work. The operation of the pump shall be such that a continuous stream of concrete without air pockets is produced. When pumping is completed the concrete remaining in the pipe-line, where it is to be used, shall be ejected in such a manner that there will be no contamination of the concrete or separa™ tion of the ingredients. After" this operation, the entire equip ment shall be thoroughly cleaned.

5407.3 COMPACTION VIBRATION

Concrete, during and immediately after depositing, shall be thoroughly compacted. The compaction shall be done by mechanical vibration subject to the following provision:

The vibration shall be internal unless special authorization of other method is given by the Engineer's Representative in writing, or as provided herein.
Vibrations shall be of a type and design approved by the Engin-eer's Representative. They shall be such as to visibly effect a mass of concrete of 5 centimeters slump over a radius of at least 45 centimeters.

The Contractor shall provide a sufficient number of vibrators including replacement, to properly compact each batch, immediately after it is placed in the forms.

Vibrators shall be manipulated so as to thoroughly work the concrete around the reinforcement and embedded fixtures and into the corners and angles of the forms. In special places external vibrators may be prescribed by the Engineer's Representative.

Vibration shall be applied at the point of deposit and in the area of freshly deposited concrete. The vibrators shall be inserted and withdrawn out of the concrete slowly. The vibration shall be of sufficient duration and intensity to thoroughly compact, the concrete, but shall not be continued so as to cause segregation. Vibration shall not be continued at any one point to the extent that localized areas of grout are formed.

Vibration shall not be applied directly or through the reinforcement to sections or layers of concrete which have hardened to the degree that the concrete ceases to be plastic under vibration. It shall not be used to make concrete flow in the forms over distances so great as to cause segregation, and vibrators shall not be used to transport concrete in 'the forms,

Vibration shall be supplemented by such spading as is necessary to ensure smooth surfaces and dense concrete, along surfaces and . in corners and locations impossible to reach with the vibrators.

The provisions of this article shall also apply to precast mem- ... bers except that, if approved by the Engineer's Representative, external vibration or manufacturer's methods of vibrations may be used.

5407.4 PLACEMENT OF CONCRETE IN LAYERS

Concrete shall be placed in layers not morejthan 30 cm thick in. reinforced concrete and 50 cm thick in mass concrete except as hereinafter provided. When less than a complete layer is placed in one operation, it shall be terminated in a vertical bulkhead. Each layer shall be placed and compacted before the proceeding batch has taken initial set to prevent injury to tjie green concrete and avoid surfaces of separation between the batches. Each layer shall be compacted so as to avoid the formation of a construction joint with a preceding layer which has not taken initial set. The use of a retarding-agent is recommended, in accordance with the conditions stated in the test certificate of admixtures and if permitted by the Engineer's Representative. (See also Clause 5403.4 of this Specification.)

When the placing of concrete is temporarily discontinued, the concrete, after becoming firm enough to retain its form, shall be cleaned of laitance, and other objectionable material to a

sufficient depth to expose sound concrete. To avoid visible joints as far as possible upon exposed faces, the top surface of the concrete adjacent to the forms shall be smoothed with a trowel. Where a "feather edge" might be produced at a construction joint, as in the sloped top surface of a wing wall, an insert form work shall be used to produce a blocked out portion in the preceding layer, which shall produce an edge thickness of not less than 15 centimeters in the succeeding layer. Work shall not be discontinued within 45 centimeters of any surface face unless provision is made for a coping 45 centimeters thick, in which case, if permitted by the Egnineer's Representative, the construction joint may be made at the underside of the coping.

Immediately following the discontinuance of placing concrete, all accumulations of mortar splashed upon the reinforcing steel and the surface of forms shall be removed. Dried mortar chips and dust shall not be puddled into the unset concrete. If the accumulations are not removed prior to the concrete becoming set,. care shall be exercised not to injure or break the concrete-steel-bond at and near the surface of the concrete, while cleaning the reinforcing steel.

5407.5 CULVERTS

In general, the base slab or footings of box culverts shall be placed and allowed Jo set before the remainder of the culvert is constructed. In this case, the construction joint between the foundation slab and the walls shall be roughened.

Before concrete is placed in the sidewalls, the culvert footings shall be thoroughly cleaned of all shavings, sticks, sawdust, or other extraneous material and the surface shall be carefully treated in accordance with Clause 5409.2 and in accordance with the method of bending construction joints as specified herein.

In the construction of box culverts with small heights, the sidewalls, and top slab may be constructed as monolith. When this method of construction is used, any necessary construction joints shall be vertical- and at right angles to the axis of the culvert.

In the construction of high box culverts, the concrete in the walls shall be placed and allowed to set before the top slab is placed. In this case, the execution of the construction joint shall be done with special care all to the instructions of the Engineer's Representative.

Each wing wall shall be constructed, if possible, as a monolith, construction joints, where unavoidable, shall be horizontal and so located that no joint will be visible in the exposed face of the wingwall above the ground line.

5407.6 GIRDERS, CQLUWJS AND PILES

Concrete in girders shall be deposited uniformly for the full length of the girder and brought up evenly in horizontal layers. For box girders see Standard Notes "L" on the general drawings.

Concrete in piles shall be poured with the utmost, care and shall be thoroughly compacted, that: no cavities occur within the concrete., according to the requirements of Section 55.

5407.7 WORK DURING NIGHT TIMES

If ordered by the Engineer's Representative concreting shall be done at night time. In such case sufficient 'light shall be produced by the Contractor at no cost to the.Employer subject to directions and approval of the Engineer's Representative,

5408 DEPOSITING CONCRETE UNDER WATER

Concrete shall not be deposited in water except with the approval of the Engineer's Representative and under his immediate supervision, and in this case the consistency of the concrete and the - method of placing shall be as hereinafter designated.

If concrete for loadbearing components has to be placed under water$_5$ it should in general have a spread (in the standard flow-table 'test) of about 45 - 50 cm. The water/cement ratio shall not exceed 0.60;' it shall be lower if concrete quality or chemical attack necessitate this. For aggregates with a maximum particle size of 32 mm the cement content shall be at least 350 kg/cu.m of finished concrete.

It is preferable to use continuous gradings located approximately in the middle of the 'favourable' region (3) of Figs. 1-4. The content of ultrafine particles shall be sufficiently high (see Clause 5403.. 1).

For all other directions see DIN 1045$_s$ Clause 10.4

A tremie shall consist of a tube having a diameter of not less than 25 cms, constructed in sections having flanged couplings

fitted with gaskets. The tremies shall be supported so as to permit free movement of the discharge end over the entire top surface of the work and so as to permit rapid lowering when necessary to retard or stop the flow of .concrete. The discharge end shall be closed at the start of work so as to prevent water entering the tube$_s$ and shall be entirely sealed at all times, the tremie tube shall be kept full to the bottom of the hopper. When a batch is dumped into the hopper, the flow of concrete shall be induced by slightly raising the discharge end, always keeping it in the deposited concrete, The flow shall be continuous until the work is completed,

Unwatering may proceed when the concrete seal is sufficiently hard and strong. Ail laitance or other unsatisfactory material shall be removed from the exposed surface by scraping chipping or other means. which will not injure the surface of the concrete.

5409 JOINTS

5409.1 GENERAL

Construction joints shall be mde only where 'located on the drawing? or shown in the pouring schedule according to Clause 5407,.I unless otherwise approved by the Engineer's Representative.

If not detailed on the drawings, or in the case of emergency, construction joints shall be placed as directed by the Engineer's Representative. Shear keys or inclined reinforcement shall be used where necessary to transmit shear or bond the two sections together.

5409.2 BONDING

Before depositing new concrete on or against concrete which has hardened, the forms shall be retightened. The surface of the hardened concrete shall be roughened as required by the Engineer's Re-presentative in a manner that will not leave loosened particles of aggregate or damaged concrete at the surface. It shall be thoroughly cleaned of foreign matter and laitance, and saturated with water.

5409.3 OPEN JOINTS

Open joints shall be placed in the locations shown on the drawings and shall be constructed by the insertion and subsequent removal of a wood strip$_9$ metal plate, or other approved material and/or as directed by the Engineer's Representative. The insertion and removal of the templet shall be accomplished without chipping or breaking the corners of the concrete but chamfering of exposed edges shall be elaborated as shown on the drawings. Reinforcement shall not extend across an open joint unless so specified on the drawings.

5409.4 FILLED JOINTS

Poured expansion joints shall be constructed similar to open joints. When premolded types are specified, the filler shall be placed in correct position as the concrete on one side of the . joint is placed. When the form is removed the concrete on the other side shall be placed. Rubber, metal water stops and/or sealant shall be carefully placed, as shown, on the'drawings and as directed by the Engineer's Representative,

Bituminous filler shall be of approved material.

5410 FALSEWORK CENTERING AND FORMS

See Section 52.

5411 CONCRETE AND WEATHER

No concrete shall be placed when the atmospheric temperature is below 5 C without the written permission of the Engineer's Representative, In cool weather and during frost the concrete should., on account of retarded hardening and possible permanent impairment of its properties, have a certain minimum temperature at the time of placing. This applies also to ready-mixed.concrete. When placed, the concrete should be protected from heat loss, freezing and drying for a certain length of time.

When air temperatures are between +5°C and -3°C. the temperature of the concrete on placing must not be below +5 C. It must not be below +10 C if the cement content of the concrete is less than 240 kg/cu.m or if low-heat cements or slag-based binders ('Mischbinder') are used.

When air temperatures are below -3 C, the temperature of the concrete on placing should be at least +10 C. It should thereafter be kept at not less than this temperature for at least 3 days. Otherwise the concrete should be protected for as long as is necessary for it to attain an adequate strength.

Young concrete with a cement content of at least 270 kg/cu.m and a water/cement ratio of not more than 0.60, which is kept protected from considerable moisture access (e.g. rein), will as a rule be safe from damage due to freezing only if the temperature of such concrete, when made with rapid-hardening cement (350 F_s 450 L 450 F), has not fallen below +10°C for at least 3 days previously or if the concrete has already attained a compressive strength of 50 kg/sq.cm.

The Contractor shall supply such heating apparatus as stoves$_s$ salamanders or stone equipment, and the necessary fuel. When *dry* heat is used, means of maintaining atmospheric moisture shall be provided. All aggregates and mixing water shall be heated to temperature of at least 20 C_B but not more than 70 C_5 the aggregates may be heated by either steam or dry heat.' If permitted by the Engineer's Representative the torch method of heating mixed aggregate shall be such as to heat th:? mass uniformly and avoid hot spots which will burn the materials.

In case of extremely low temperature, the Engineer's Representative may, at his discretion, raise the minimum limiting temperatures of waters aggregates and mixed concrete.

When the shade temperature is above 35)C, special precautions shall be observed during concreting and curing.

Concreting, when the shade temperature is above 40 C_s shall preferably carried out at night (see Clause 5407.7 of the Specifications) and shall not be carried out, unless the procedure required for producing "concrete II" is applied for all reinforced concrete (also for Bn 250) and without written permission of the Engineer's Representative. - No extra payment will be made for the necessary additional measures.

5412 CURING CONCRETE

Concrete surfaces exposed to conditions causing premature drying shall be protected by covering with canvas, straw, burlap, sand, or other satisfactory material and kept moist. This covering shall be placed as soon as the concrete has hardened sufficiently to support the covering without damage. The type of covering, provided shall be that which in the judgment of the Engineer's Representative, is best suited to the conditions. If, in the judgment of the Engineer's Representative, such coverings are not necessary, the surfaces shall be kept moist by flushing or sprinkling.

If, in the judgement of the Engineer's Representative, it becomes necessary for proper curing, the Contractor shall provide a suitable pump, piping, hose, and a sufficient numberof sprinkling heads so that all forms shall be thoroughly and continuously sprinkled with water for up to 7 days after placing concrete therein. The sprinkling system shall be so arranged that the outside of all forms can be kept damp for a period of seven days after the placing of concrete inside the forms, it being the purpose of this Specification that the forms be kept damp enough so that no moisture is taken away from the concrete by the forms.

541.3 SURFACE FINISH

The surfaces of all concrete shall be thoroughly worked during the operation of placing by means of a broadtined fork or a concrete spade of an approved type. The working shall be such as to force all coarse aggregate from the surface and thoroughly work.the mortar against the forms .to produce a smooth finish free from water and air pockets or honeycomb.

As soon as the concrete has set sufficiently^ the forms shall" be carefully removed and all depressions resulting from the removal of form ties or from other causes shall be carefully painted with mortar of sand and cement in the proportion which has been employed'-'for the particular class of concrete treated. The surface film of all; such pointed surfaces shall be carefully removed before setting occurs.

As soon as the concrete has set sufficiently and the forms have been removed, the entire surface shall be thoroughly cleaned. Where necessary the surface shall be rubbed with a carborundum stone or an abrasive of equal quality to remove all form marks and projections and leaving a smooth dense surface without pits or irregularities.

5414 TREATMENT AND FINISH FOR HORIZONTAL SURFACES NOT SUBJECTED TO WEAR

All upper horizontal surfaces such as the tops of handrail posts and caps and the tops of parapets, copings, and bridge seats shall be formed by placing an excess of material in the forms and removing or striking off such excess with a wooden templet, forcing the coarse aggregate below the mortar surface. The use of mortar topping for concrete railing caps and other surfaces falling under this classification shall in no case be permitted.

The final finish for caps and railings shall be obtained in one of-the following ways, as specified.

Brush Finish:

After the concrete has been struck off, as above described,the surface shall be thoroughly worked and floated with a wooden canvas or cork float, the operation to be performed by skilled and experienced concrete finishers. Before this last finish has set, the surface shall be lightly stripped with a fine brush to remove the surface cement film, leaving a fine-grained, smooth but sanded texture.

Float Finish:

In lieu of the above, the surface may be finished with 4 rough carpet float or other suitable device leaving the surface even, but distinctly sandy or pobbled in texture.

All visible edges shall be chamfered two by two centimeters.

The above specified surface finishes are to govern in ordinary-concrete construction. When so specified, special surface finishes may be employed for ornamental panels copings and like construction In general, the method and manner-of performing this work will be fully provided for in the Bill of Quantities.

In each case the Contractor shall be required to prepare test or sample panels under the direction of the Engineer's Representative and the method and manner of finish, the choice and selection of the aggregate and other features affecting the work, shall be approved before any further work is done,-

5415 DECKSLAB AND SIDEWALK FINISH

Deckslab Finish:

After the concrete is placed and compacted, it shall be struck true to lines, grades and cross sections shown on the drawings. After the concrete has been struck to grade and cross section, it shall be floated to a smooth, even texture. Quality of workmanship shall be such that the finished work, when tested with a 4 meter straight edge, shall show no deviation greater than 10 millimeters from the required grade and cross section.

Sidewalk Finish:

After the concrete has been deposited in place, it shall be thoroughly tamped in such a manner that the coarse aggregate will be forced down and a layer of mortar about 6 millimeters thick covers the surface. The surface shall be struck off by means of a strike board and floated with a wooden or cork float. An edging tool shall be used on all edges and at all expansion joints. The surface shall not vary more than 4 millimeters under a 4 meter straight edge. The surface shall have a granular broomed or matto texture which will not be slippery when wet.

5416 PNEUMATICALLY APPLIED MORTAR

This section refers to premixed sand and cement pneumatically applied by suitable mechanism and competent operators, and to which mixture the water is added immediately prior to its expulsion from the nozzle. Overhead applications shall be made in multiple layers to prevent sagging.

The proportions of cement to sand shall be based on dry and loose volumes$_9$ and shall not be less than one to four for encasement of steel members, one to three for concrete repair or one to four and a half for special linings.

The water cement "ratio shall be maintained at a practicable minimum and not in excess of 12 liters per 50 kg of cement as placed.

The cement and sand shall be thoroughly mixed before being charged into the machine. The sand shall contain not less than 3 *nor more* than 6 percent moisture by weight.

The velocity of the material as it leaves the nozzle must be maintained uniform at a rate determined for the given job conditions to produce minimum rebound.

The nozzle shall be held in such a position and at such distance - that the stream of flowing material will impinge at approximately right angles to the surface being covered without excessive impact.

Rebound or accumulated loose sand shall be removed from the surface to be covered prior to placing of the original or succeeding layers of mortar and shall not be used again.

The forms shall be structurally sufficient and of such design that rebound or accumulated loose sand can freely escape or be readily removed. Sheeting strips should be used at corners$_5$ edges and on surfaces where necessary to obtain true lines and proper thickness.

The pneumatically applied mortar at the end of any day's work or similar stopping periods shall be sloped off to a thin edge. Before placing an adjacent section this sloped portion shall be thoroughly cleaned and wetted.

Surface to which pneumatically applied mortar is to be bonded shall be thoroughly cleaned of dirt$_3$ paint, grease, organic matter and loose particles. Absorptive surfaces shall be wetted before the application of the mortar. Concrete surface shall be roughened by pneumatic chipping or sand blasting.

Pneumatically applied mortar shall be so applied, protected, and cured as to prevent its temperature falling below 10 C, or a loss of moisture from the surface for the periods indicated below:

Where ordinary Portland Cement is used, 7 days.
Where Rapid Hardening Portland Cement is used, 3 days.

o
If the air temperature is 1.0 C or less pneumatically applied mortar shall be applied only with the permission of the Engineer's Representative,

The reinforcement when required and/or as shown on the drawings shall be adequate from the stand point: of structural requirements$_s$ and shall consist of mesh or round bars, spaced not less than 5 cm *no)* i . tl n 10 cm apart either way. The area of the reinforcement shall be at least 0.2 percent of the cross-sectional the mortar. The reinforcement shall be at least 6 mm from the Un-exposed surface of the mortar and at least 2 cm from the exposed surface.

5417 SAMPLING AND TESTING

5417.1 GENEP 1 REQUIRE! ENTS

The Contractor is responsible for the execution and interpretation of the tests specified in DIN 1048, DIN 1084 and in this Clause and for taking due account of the results of such tests in the execution of the job.

The Contractor shall include in the price for concrete the cost •f o r t h e e x e c u t i o n o f all s a *m*p l i n g a n d t e s t i n g. A11 m a t e r i a l s specified for testing and the suitable testing equipment shall be furnished free of cost and shall be delivered in time for the-tests 'as required in this Clause and as in DIN 1045, Clause 7, and/or as directed by the Engineer's Representative.

5417.2 CEMENTS, ADMIXTURES AND ADDITIVES

For each delivery of cement it shall be checked that the information on the package or on the delivery note with regard to the type, strength class and quality control (quality control mark) of the cement conforms to the particulars in the technical documents.

In the case of admixtures it shall be checked that the package is provided with a valid test mark.

All additives applied shall conform with the requirements of DIN 1045, Section 6.3.2.

5417.3 AGGREGATE

Aggregate shall be regularly checked visually with regard to its granulometric composition and other properties which are significant according to DIN 4226. In doubtful cases the aggregate shall be examined more thoroughly.

Sieve tests are necessary when the first delivery is effected and whenever there is a change-over to a different supplier. In additions they are necessary at suitable intervals for:

a) Concrete B I, if a concrete composition in accordance with Clause 5404,2 with aggregate grading in the favourable region (3) has been chosen, or if the composition of the concrete has been determined on the basis of preliminary tests.

b) Concrete B II always (see Clause 6404.3).

c) Concrete with special properties always (see Clause5404.4)

Fhe granulometric composition of the combined aggregate is to be regarded as satisfactory if the percentage passing any individual sieve does not deviate from the specified, grading curve by" more than 5% of the total weight, or by not more than 6% of the total absolute volume in the case of particle size fractions differing greatly in the specific gravity of the particles and its characteristic value for the grading or the water demand is not more unfavourable than that for the specified grading curve. In the particle size fraction 0-0,25 mm, however, the permissible' deviation must not exceed 3%.

5417.4 MIXING WATER

See Clause 5403.2

5417.5 CONCRETE TESTING

Prelimi nary Test:

The testing procedure and the manufacture and storage of these test specimens shall comply with DIN 1048.

In the preliminary tests the average value of the compressive strength 3m of three cubes made of the concrete mix, to be adopted for the actual job, shall exceed the values 3- in the table, column 4 (see Clause 5404.1) by a certain margin:

For concrete of strength class Bn 50 the margin is at least 3Q kg/sq.cm, for concrete of strength classes TJrTTcK) to Bn 250 (inclusive) it is at least 50 kg/s^cjru

In the preliminary tests the consistency of concrete B I shall be at the upper limit of the chosen consistency range (upper limit of spread in the flow table test).

Quality Control Test:

Compressive Strength: For site-mixed and ready-mixed concrete B I of strength classes Bn 150 and Bn 250, and for loadbearing walls and columns of Bn 50 and Bn 100, a series of three test specimens shall be made for:

Every 500 cu.m (or less) of concrete placed,

each important structural member and

every 7 working days on which concreting is carried out*

or as directed by the Engineer'.s Representative.

This shall be clone for each concrete strength class employed.

Of these alternative conditions.the one requiring the largest number of series of test cubes shall be applied. For concrete B II_s exept in so far as is otherwise stipulated below with regard to ready-mixed concrete, twice the number of test cube series required in the first paragraph shall be tested. Half the number of cube tests thus required may be replaced by twice the.number of water/cement ratio determinations in accordance with DIN 1048, sheet 1.

The strength tests performed by the ready-mix plant for the purpose of its own quality conctrol (see DIN 1084, sheet 3) may be reckoned as strength tests for concrete B I and concrete B II to be performed by the Contractor, provided that the concrete for making the test specimens has been taken from the construction site in question.

Strength Requirements: The strength requirements are to be regarded as fulfilled if the average compressive strength of each series, each comprising three consecutive cubes, attains at least the values stated in'the table in Clause 5404.1, column 4, and the compressive strength of each individual cube attains at least the values stated in column 3.

However, for concrete of the same composition and made in the same way, one out of *every* 9 consecutive cubes must fall not more than 20 % below the values in the table in.Clause 5404,1, column 3, at the same time, the average value of any three consecutive cubes must at least attain the values in the table, column 4.

Conversions of the Compressive Strength Test Results: If cylinders of 15 cm diameter and 30 cm height are used instead of 20 cm cubes, the cube strength |3 can, if the specimens are stored under similar conditions, be ^derived from the cylinder strength 8 as follows:

$$[\beta_C = 1.25\ \beta_{13} \quad \text{for strength classes Bn 150 and lower,}$$
$$(\beta_W = 1.18\ \beta_C \quad \text{for strength classes Bn 250 and higher.}$$

If cubes or cylinders of some other size are used, the compressive strength ratio with respect to the 20 cms cube shall be verified seprately for concrete of each composition, strength and age in the preliminary tests. This shall be done for at least six specimens of each type of specimen.

If the expected 28-day cube strength [3 α_{fi} is to be estimated from the 7-day cube strength β_7 in preliminary tests and quality-control tests, this may ill general be done on the basis of the information given in the table below'for each cement strength class.

Other ratios are allowed to be adopted, if they have been determined in the preliminary tests.

Table Coefficients for Converting 7-Day to 28-Day Cube Strength

	1	2
	Strength class of the cement	28-day cube strength β_{28}
1	250	1.4 β_7
2	350 L	1.3 β_7
3	350 F and 450 L	1.2 β_7
4	450 "F and 550	1.1 β_7

Hardening Tests:

The hardening test gives an indication of the strength of the concrete in the structure at a particular point of time and thus also gives guidance as to the formwork stripping time as determined in DIN 1045, Clause 12.3

The hardening can be determined, in accordance with DIN 1048, on test specimens or by non-destructive means.

The specimens for these tests shall be made from the concrete intended for the structural components in question and be stored directly beside or on these components and be cured in the same manner (influence of temperature and humidity). At least three specimens shall be made for the hardening test but it is advisable to make more so that if the strength determined in the test is found to be inadequate the test can be repeated later on.

In judging the results it shall be borne in mind that components whose dimensions differ significantly from those of the test specimens may attain a different degree of hardening from that of the spcimens, e.g., in consequence of differences in heat evolution in the concrete.

Verification of Concrete Strength
in the Structure:

In special cases, e.g. if no compressive strength test "results are available or if the results were inadequate or if there is some other reason for seriously .doubting the strength of the concrete in the structures it may be necessary to determine the compressive strength of the concrete by taking specimens from the structure or, if permitted by the Engineer's Representative, by non-destructive testing performed on the finished component in accordance with DIN 1048, or by both methods. In connection with such tests the age and the conditions of hardening (temperature, humidity) of the concrete in the structure shall be taken into account.

As a rule, the advice of an expert shall be sought in deciding the nature and scope of the non-destructive tests, where the . specimins are to be taken from the structure and in assessing the results of these tests.

5418 MEASUREMENT AND PAYMENT

The payment for concrete of the various classes shall include compensation for all equipment, tools, materials* falsework, forms, bracing, labor, surface finish, if finish works are not especially provided in the Bill of Quantities and all other items of expense required to complete the concrete work shown on the drawings, with the exception of reinforcement steel, metal expansion plates, or other metal incorporated in the work.

Payment will be made on the basis of the actual cubic meters, except for members which are-measured per square meter or per number (as prefabricated girders), or linear meter (as pipe culverts), within the neat lines of the structure as shown on the drawings or revised by written authority of the Engineer's Representative,

except that deductions shall be made for the volume of embedded structural steel. No deductions will be made for the volume of metal reinforcement. Unless otherwise provided in the Bill of Quantities, payment for concrete shall include payment for water-proofing, joint filler, or other similar materials shown on the drawings or called for in the Specification. Payment for pneumatic-ally applied mortar shall include compensation for all equipment/ tools, materials, labour and incidentals necessary to complete the work and shall include metal reinforcement unless otherwise provided.

55 LARGE DIAMETER CAST IN PLACE PILES

5501 SCOPE

The work covered by this section of the Specification consists in furnishing all materials,, plants equipment and labour and in performing all operations in connection with the execution of large diameter concrete piles complete, subject to the Conditions of Contract and in strict accordance with this Section of the Specification and the applicable Drawings,

5502 -MATERIALS

The concrete^ cements fine and coarse aggregate, water and additives shall conform to Section 54 of the Specification,

The reinforcing steel shall conform to Section 56 of the' Specification,'

5503 FOUNDATION SYSTEM OF PILES

The Contractor shall supply the Engineer's Representative with complete details of the.system of piling9 which he proposes to uses including a specification of the materials and method of construction of the piles. Prior approval of the Engineer's Representative shall be obtained in writing before any such piling is used, which approval shall not relieve the Contractor of any of his responsibilities.

In consideration of the important nature of the work of large diameter concrete piles, one engineer of the Contractor, specialized in this works shall be present on site during the whole time of the performance of this work. Night work shall be avoided in order not to prejudice the quality of this work. The diameters of the piles are defined as the exterior diameters of the casing. The possible enlargement of piles during the placement and compaction of the concrete shall not be considered for measurement and for enlarging the permissible load. All shall be executed in accordance with the Specification and the instructions of the Engineer's Representative.

The final length of the piles shall be determined in close coordination with the Engineer's Representative.. Piles located in the area of embankment are to be constructed after earthwork for the embankment is completed, if not directed otherwise by the Engineer's Representative.

The piles shall be executed with an approved sulphate resistant cement, and special care shall be taken with the gradation of the aggregates, and any segregation shall be avoided. The proportioning shall be strictly observed to get satisfactory consistency, which can be satisfactorily worked. During the execution, a continuous delivery of concrete shall be guaranteed in order to minimize the rehandling of concrete and to avoid damage to the structure of the concrete, in case concreting has to be executed in water, the minimum rate of cement shall be 400 kg per cu.m of concrete in the first mix, if not otherwise cR Fee ted the the Engineer's Representative,,

If the Contractor wishes to construct piles with diameter different from the one shown on the drawings, he shall submit to the Engineer's Representative for this approval detailed plans and calculations. If approval is given, to use piles with diameter "that will necessitate enlarging the foundations, the cost oP such enlargements shall be the sols responsibility of.the Contractor,

5504 QUIPf€NT

The equipment, which the Contracor wants to use, shall have the approval of the Engineer's Representative and shall guarantee during all time satisfactory conditions for the execution of the Works. The equipment shall give the maximum possible guarantees fur the following: precision of pile driving and perforation, minimum disturbance of the adjoining ground, continuity of the piles, quality of concrete. The drilling installation shall be equipped in such manner as to prevent the danger of seepage (piping) failure. The program of pile-driving operations shall be submitted to the Engineer's Representative for approval$_s$ which approval shall not relieve the Contractor of any of his responsibilities.

5505 CASING

The casing shall be completely even. Any joints shall be screwed or welded and shall be impermeable. The casing shall be placed by-an approved method.

The bottom of the casing must always be lower than the respective excavation sole of .the borehole. Care shall be taken that the surrounding ground is not disturbed more than necessary and the use of explosives will not be permitted. The casing shall be freed of soil up to its lower end. The casing shall be removed completely to ensure the required bearing capacity of the pile, unless otherwise directed by the Engineer's Representative (e. g. as a possible protection measure against concrete corrosion in certain cases of heavily aggressive groundwater or soil). Protection against aggressive water and soil is to be provided for according to DIN 4030.

5506 REINFORCEMENT

The reinforcing steel shall be fabricated into a cage and lowered into position prior to the commencement of concreting. The concrete cover olier the spiral reinforcement shall be measured ' from the outer face of the casing tube. Positive means shall be provided to ensure proper cover. A few additional bars shall be provided$_s$ extending well above the water level inside the casing^ to facilitate observation and registration of possible movements of the reinforcing steel during concreting operations.. The reinforcing steel shall be prevented from following the steel casing when this is being withdrawn,

5507 EXCAVATION

The ground on shore may be soft, with low load carrying capacity, especially during periods with high groundwater levels and water in the river. It is expected that the piling equipment will have to be located on a platform in some cases. When boring for the piles in the river, the raft must be securely held and anchored and the casing must be guided to prevent harmful movements during the execution of piling work.

Boring and excavation for a pile shall not be commenced until hours after completion of the concreting of any pile within a radius of 5,0 m center to center,

5508 BORING

The boring and pressing down of the steel casing shall be done ...without disturbing the adjacent soil and without causing hydraulic ground failure at the bottom of the hole. If a soil "plug" develops at the bottom of the casing, with a tendency to follow the casing, such a plug shall be excavated before sinking of the casing is continued. The casing shall be kept full of water or drilling mud suspension at all times* with water or suspension level inside the casing at a higher elevation than the ground or water level outside. Pumping of water into . the casing will be necessary. If excavation is done by grabbing, care shall be exercised not to create suction at the underside when lifting the grab. The excavation shall be done in such a way and with such equipment that the soil around the pile and beneath the bottom of the pile is not disturbed. Jetting is not allowed as an aid for the excavation. The bottom of the completed borehole shall have a horizontal surface.

5509 CLEAN-OUT AND CONTROL AT THE BOTTOM OF THE PILES

After the excavation has been brought down to the proper elevation$_3$ 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 casing during 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 break shall be make for a period of at least five minutes, then pumping shall bo 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's Representative. The checking shall normally be performed by the Contractor under the supervision of the Engineer's Representative. 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,, using a 50 mm Split Tube Sampler. Equipment and method of performing the tests are subject to approval by the Engineer's Representative, and the tests shall be performed under his supervision. Based upon the results of the Standard Penetration Tests$_s$ the Engineer's Representative will approve the borehole or decide that it must be sunk to a deeper elevation. In latter case, cleaning and testing shall be repeated at the new bottom elevation.

When the Engineer's Representative is satisfied that the bottom of the borehole is located at an elevation where the load carrying capacity of the soil 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 responsi-bilities.

Regardless of the pile length necessary to develop the required bearing capacity for the maximum vertical load, all piles shall have an effective embedment lengths measured from the level at which the surrounding soil is capable of effectively resisting horizontal forces, at least equal to the appropriate value indicated in the following table.

Pile Diameter in m	Minimum Embedment Lengths 1 in m for Coefficient of Horiz. Subgrade Reaction at Top of Effective Embedment Length of	
	k = 0.3 kp/cu.cm	k = 1.0 kp/cu.cm
1.2 1.5 1-,8	15 18 -21	11 13 15

Concreting of the pile shall not be commenced until written approval has been issued.

5510 CONCRETING

A retarding agent shall be added to the concrete and sulphate resistant low alkali cement shall be used, taking into account the local aggressiveness of soil' and water. The cement contest shall be not.less than 400 kg/cu.m of concrete, in case of concreting under water; the consistency shall be such that the concrete will flow evenly out of the tremie tube. Reference is made to Section 54.

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 after cleaning the bottom of the borehole, the cleaning shall be repeated.

Concreting of a pile shall be done without construction joints. Concreting shall be done under water by the tremie method. The water level inside the casing shall be kept at a constant elevation, well above ground or water elevation.outside the casing. 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 meters) 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 by accident 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.

The first 0.5 to 1.0 cu.m of concrete to be deposited in a pile may consist of grout, with a consistency and quality corresponding to the rest of the concrete in the pile.

While concreting the pile casing shall be slowly withdrawn without lifting the reinforcement out of position. The surface of concrete inside the casing shall at all times be kept at a sufficiently high elevation-above the bottom of the casing in order to prevent squeezing ground to cause "necking[11], i.e. reductions of the concrete cross section of the pile and also to prevent ground water flowing into the casing. When deciding at what distance the surface of the concrete shall be kept above the bottom of the casing, consideration must be given to the fact that the concrete area below the casing will be larger then inside the casing.

It is the sole responsibility of the Contractor to continue concreting until the surface of deposited concrete is sufficiently high above the theoretical cut-off elevation, as shown on the drawings or decided by the Engineer's Representative, to ensure that all concrete below cut-off elevation is of a satisfactory quality. Concreting shall not be discontinued until the surface of concrete i.s at least 40 cm above cut-off elevation,

When concreting of a pile is completed with the surface'the concrete more than 1.0 m below ground e"levation, a sand layer not less than 50 cm thick shall be deposited on top of the concrete before removing the nile casing.

When applicab'le, the piles shall be cut at theoretical cut-off elevation after the foundation bottom seal has cured sufficiently.*'' and after the cofferdam has been dewatered. The connecting bars of the reinforcement however shall not be damaged.

In case of broken, split or mijjja^c^jjj^e^ additional piles shall be placed at the expeliTe^lrf^tTC^troTwactor who shall also bear the cost of all special construction required due to the new situation.

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's Representative shall decide if and when core drilling is to be performed. Core drilling will be required when the concrete or irregularities during the executionof work indicate that the quality of the pile may be below the required standard. Testing of the cores shall be performed as directed by the Engineer's Representative. Independent of the requirement to drill cores and the total length of some of the piles, core drilling in the top of several piles will be required, as ordered by the Engineer's Representative. Other methods of control might be used if approved by the Engineer's Representative.

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

5511 TOLERANCES

During boring, the inclination and location of the pile will be checked by the Engineer's Representative. The location of the pile head shall not exceed 5 % of pile diameter, and not more th^JLxjTL as compared to the drawings. The inclination of the pile shalT not" exceed 1 % of the pile length below soil surface.

When these figures are exceeded, the misplaced piles are to be handled as described in Clause 5510.

5512 DAILY REGISTER

During drilling of the boreholes, a bore shall be prepared. Each layer of the encountered soil types shall be described and entered in the bore log. Observations .regarding water lass in the borehole and drilling obstacles encountered shall also be recorded and be reported to the Engineer's Representative at once.

A complete record of the construction of each pile shall be kept be the Contractor and this record shall be submitted to the Engineer's Representative as and-when required. This record shall show: the time of the start, and termination of placing casings by boring or pile drivings the lower level of the casings., the level of reinforcement, the level" of water if any, the start and the termination of concreting and any special occurrences, The forms for pile recording shall be as approved.

The quantity of deposited concrete shall be recorded and, when extracting the casing, a record shall be kept showing the elevation of the surface of concrete inside the casing before and after each lifting stage.

5513 SAMPLING AND TESTING

Sampling and testing shall be carried out in accordance with Section 54 und 56 of the Specification.

The equipment to carry out Standard Penetration Tests$_9$ when . and where ordered by the Engineer's Representative, shall be provided.

5514 PILE LOAD TESTING

The test loading shall be carried out in accordance with DIN 1054 and DIN 4014 to the directions of the Engineer's Representative, on a pile specially prepared for test loading. The test pile shall

be executed exactly as the piles for the respective structure on a place chosen by the Contractor and approved by the Engineer's Representative. The equipment must permit the loads shown in the following table, unless instructed otherwise by the Engineer's Representative:

Diameter of pile in cm	Normally applied test load +	Provided maximum test load in tons
90	440	600
120	700	900
150	1100	1300
180	1600	1700

In the immediate vicinity of the test pile,, a .boring has to be carried out by the Contractor private the load test, and the properties of the soil encountered determined in the laboratory. The Contractor shall keep a detailed record of all piles at all times and submit the results to the Engineer's Representative for approval. The Contractor shall keep a competent engineer on site, during all time of execution of pile tests. The Engineer's Representative shall have at all times access to the Contractor's ..-pile record.-

The test loading procedure has to be prepared by the Contractor -;. and approved, by the Engineer's Representative. The test program shall include the details of applying loads in relation to time, shall inform about the long-term behavior, and the necessary gauges

515 MEASUREMENTS

The unit of measurement for concrete piles shall be the linear meter,, as determined by the drawings and/or the written direction of the Engineer's Representative. The excess concrete in the shoes below the lower level of the piles, any excess diameter and the disposal of heads shall not be measured and shall be-deemed to be included in the item for concrete of piles in the Bill of Quantities

The unit of measurement for reinforcing steel shall be the ton in accordance with Clause 56 of the Specification.

5516 PAYMENT

Payment shall be made for concrete piles and reinforcing steel as measured in accordance with Clause 5515, and shall constitute full

compensation for the furnishing of all materials, plant, equipment and labour and in performing all operations in connection with the execution of concrete piles, complete, in strict accordance with this Section of the Specification, the applicable drawings and the instructions of the Engineer's Representative.

Pile load testing will be paid for as a lump sum per number of piles in accordance with the respective items of the Bill of Quantities, which payment shall constitute full compensation for all equipment, materials;, labour and all incidentals for carrying out pile load testing, as specified under Clause 5514.

56 REINFORCING STEEL

5601 SCOPE

The work covered by this Section of the Specification consists in furnishing all plant, equipment, material and labour and in performing all operations in connection with reinforcing steel, complete$_5$ subject to the terms and condions of the Contract and in strict accordance with this Section of the Specification, the drawings and the directions of the Engineer's Representative.

5602 STANDARD SPECIFICATIONS AND TEST METHODS

Concrete reinforcement shall consist of deformed steel bars$_a$ mild steel bars ribbed tor steel bars or wire mesh as indicated on the drawings and set forth in the proposal.

Reinforcing steel shall be in accordance with the German Standard Specification unless otherwise specified hereinafter.

DIN 488 Blatt 1 bis Blatt 5
Betonstahl (April 1972 und August 1974)

Sheet 1 to sheet 5
Reinforcing Steel (April 1972 and Aug. 1974)

DIN 1045 Beton und Stahlbetonbau
Bemessung und Ausfuhrung (Januar 1972)

Concrete and Reinforced Concrete Structures
Design and Construction (January 1972)

5603 MATERIALS

MILD STEEL BARS: BSt 22/34 *(I)*

Mild steel bars for reinforcing concrete structures shall consist of plain round steel bars and be manufactured by an approved process,

RIBBED TOR STEEL BARS: BSt 42/50 (III)

Ribbed tor steel bars for reinforcing concrete structures shall consist of ribbed round steel bars and be manufactured by an approved source.

WIRE MESH: BSt SO/55 {IV}

Wire mesh shall be of approved kind and quality of manufacture and no steel fabric shall be delivered on the site in rolls.

5604 CONSTRUCTION. REQUIREMENTS

5604.1 GENERAL

In general bar lists shall be prepared by the Contractor and be approved by the Engineer's Representative.

The content shall be in strict accordance with the drawings and the pertinent Specifications of this Section.

Special reference is made to hooks, splices, bending diameters, anchorage lengths and concrete cover.

5604.2 PROTECTION OF MATERIALS

Reinforcing steel shall be protected at all times from damage and when placed in the structure$_3$ shall be free from dirt, loose mill scale and 'rust scale, paint, oil or other foreign substance.

5604.3 BENDING

Steel reinforcing bars shall be cut and bent by careful, competent workmen, They shall be bent cold to templates which shall not vary appreciably from the shape and dimensions shown on the drawings. All sharp bends shall be avoided and in no case shall be of less radius than according to Clause 18.3 of DIM 1045,

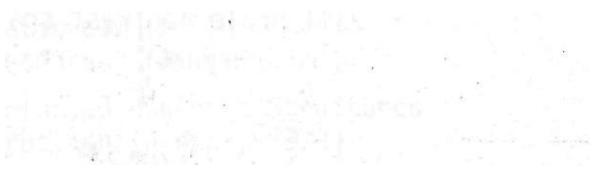
5604.4 PLACING AND FASTENING

All reinforcing steel shall be accurately placed and during the placing of concrete firmly held in the position shown on the drawings.

Distance from the forms shall be maintained by means of stay, blocks, ties, hangers, or other approved supports. Blocks for holding reinforcement from contact with he forms shall be precast . concrete blocks cr other suitable material of approved shape and dimension. Also layers of bars shall be separated by precast blocks which may be reinforced and which may have slots to receive the bars and hold them in place, The block* hall be short enough to permit their ends to be covered with concrete. The use of pebbles, pieces of broken stone or brick, metal pipe and weien blocks will not be permitted. Reinforcement in any member shall be placed, inspected and approy concrete is placed. Concrete placed in violation of this provision will be subject to removal. Reinforcing bars shall be securely wired together at each intersection in such a manner that they will maintain their exact designated position during placing of concrete.

5604.5 SPLICING

All steel bars for concrete reinforcement with a total length of below 12 m shall be furnished in the full lengths indicated on the drawings. Steel bars with splices shown on the drawings shall be spliced and steel bars with a total length exceeding 12 m may he-spliced as given on the drawings and as governed by DIN 1045, Clause 1.8.4, or as directed by the Engineer's Representative.



5605 MEASUREMENT

All reinforcing steel will be measured by the computed weight of all metal actually in place as shown on the drawings and as listed in the approved bar lists, or as ordered by the Engineer's Representative, No allowance will be made for finishers$_s$ form blocks, wire clips or other fastenings* which must be furnished by the Contractor as and where ordered by the Engineer's Representative. When laps are made other than specified in Clause 5604.5, no allowance will be made for the extra steel required, When steel is required, at construction joints which are not shown on the drawings and which are permitted for the Contractor's convenience$_s$ no allowance will be mode for the additional steel required.

t-or tne purpose cu conipirung weignr-s or reinforcing s'cee "cue followinq table shall be used;

RIBBED TOR STEEL BARS

Dia-meter in mm	Weight/ meter in kg	Area in sq.cm	Dia-meter in mm	Weight/meter in kg	Area in sq.com
6	0.222	0.283	26	4.17	5.31
8	0.395	0.503	28	4.83	6.16
10	0.617	0.785	30	5.55	7.07
12	0.888	1.13	32	6.31	8.04
14	1.21	1.54	34	7.13	9.08
16	1.58	2.01	36	7.99	10.18
18	2.00	2.54	38	8.90	11.30
20	2.47	3.14	40	9.87	12.57
22	2.98	3.80	50	15.41	19.63
24	3.55	4.52			
25	3.85	4.91			

5606 PAYMENT

Payment for reinforcing steel will be made at the price tendered per metric ton for "Steel Reinforcing Bars" in place or "Wire Mesh" in place as.the case may be. Payment for reinforcing steel shall include the cost of furnishing, fabricating and placing the reinforcement. No allowance will be made for clips, wire or other material used for fastening reinforcement in place.

57 PRESTRESSING

5701 SCOPE

The work covered by this Section of the Specification consists in furnishing all plants equipments material and labour, and in performing all operations in connection with prestressing, complete subject to the terms and conditions of the Contract and in strict accordance with this Section of the Specifications the drawings and the directions of the Engineer's Representative

5702 PRESTRESSING SYSTEMS

The Contractor shall be free to choose the prestressing system or systems$_s$ .provided they introduce no changes in the position of - the centroid of the total prestressing force over the length of the member and in the magnitude of the'.final effective [.'re-stressing force as prescribed in the drawings. The prestressing system chosen by the Contractor shall be indicated in the Tender, In all cases the following conditions shall have r,o be fulfilled

Before concreting any part of the structure destined to be presfressed^ the Contractor shall submit the full details of the method, the material and the equipment he intends to use in the prestressing operations for the approval of the Engineer's Representative.

- Said details shall comprise the constructive and operational procedure, indicate the full Specification of the prestressed steel, the devices of anchorings, types of sheaths accessories and all remaining data relative to the prestressing operations.

- The Contractor shall place at the disposal of the- Engineer's Representative, free of charge$_3$ a team specialized in the proposed prestressing method, including at least one-higher grade expert in order to furnish the necessary help and instructions during the whole construction process of the structure in question.

- The final prestressing forces indicated in the drawings represent the required stresses independently from the^ losses due to the prestressing system and prestressing material (e. g. relaxation of steel).

- If the system proposed by the Contractor requires any modification in the number, form or dimensions of the reinforcements, he shall have to present sufficiently detailed drawings and calculation for the approval of the Engineer's Representative. In all cases the indispensable condition is that the total cost of the inbuilt steel does not exceed that obtained without said modifications.

- Independently from tho prestressing system to be applied the following points have to be ensured:

  The safety of the anchorages of the prestressing tendons and their suitability for the transmission of forces to the concrete under all loads whatsoever.

  "[hat; the actual losses due to friction coincide with the calculated ones for the prestressing.

  The suitability of the proposed steel for the chosen pre-stressing system.

  Length of transmission of tho force to the concrete and minimum strength of the latter necessary for prestressing
  in systems where th-; prestressing elements are fully or partially anchored to the concrete through bond and friction.-

  The suitability of measures taken to protect prestressing tendons from corrosion not only until the final tensioning is carried.out, but also afterwards.

A certificate of official approval (agreement) for the prestressing system shall be submitted and approved by the Engineer's Representative before placing any tendons. This agreement certificate must be issued by an authorized testing laboratory. Otherwise the Engineer's Representative may order such an agreement certificate from a laboratory of his choice at the cost of the Contractor. All rules referring to this agreement certificate hereinafter are subject to the approval of the Engineer's Representative,

5703 STANDARD SEC IF I CATIONS

Prestressing steel and prestressed concrete members shall be in accordance with the German "Richtlinien fur Bemessung und AusfUhrung von Spannbetonbauteilen (Juni 1973) unter Berucksich-

tigung von DIN 1045 (Oanuar 1972) als vorlaufiger Ersatz des Normblattes DIN 4227 (Oktober 1953)".

Codeof practice for the design and construction of prestressed concrete structural members (June 1973) in consideration of DIN 1045 (edition January 1972) as a preliminary substitute for DIN 4227 (October 1953).

Moreover besides the standards noted in Clause 5402 also the following standards shall be applied to prestressed concrete .unless otherwise specified hereinafter,

DIN 1072 StraBin- und Wegebriicken Lastannahmen (November 1967).

Road and foot bridges design loads.

DIM 1075 Richtl iirien flir'die Bemessung i.ind Ausfuh-*yum* massiver Brjjcker: (August 1973).

Concrete bridges, design and construction.

Richtl inien fur das Einpressen von Zen-errc-mortal in Spnnnkanale (Juni 1.973).

Code of practice for the grouting of tendon ducts.

Vorlaufige Richtl inien flir die Prllfung bei Zulassung, Herstellung und Oberwachung von Spannstahlen flir Spannbeton nach DIN 4227 (Dezember 1.965).

Preliminary code of practice for the tests required for approval manufacturing and supervision of prestressing steel for pre-stressed concrete according to DIN 4227.

English translations of the above-mentioned Standard Specifi-cations are available through "Beuth Verlag GmbH", Burggrafen-strasse 4~7_5 1000 Berlin 30, and/or "Dorsch Consult", Postfach 210243, 8000 MUnchen 21.

5704 MATERIALS

5704.1 PRESTRESSING STEEL

Prestressing steel shall be high-tensile-strength steel wire, high-tensile-strength wire strand or high-tensile-strength steel bars as called for on the drawings or in the special provisions,

Prestressing wires should be at least 5.0 mm in diameter or for non-circular cross-sectional shape should have at least 30 sq.mm cross-sectional area. Strands must consist of not more than 7 wires and should have at least 30 sq.min cross-sectional area., the individual wires being not less than 3 mm In diameter. For special purposes, e.g. for temporarily needed reinforcement or for prestressed concrete pipe?., individual wires at least 3..0 inn: in diameter or for non-cirular section, with at least 20 "sq.n^ cross-sectional area are permissible.

Only prestressing steel and prestressing systems shall be used, which have previously been approved also by the Engineer’s Representative.

For each shipment of prestressing steel the pupplier shall furnish. The certificate of analysis shall show the all in splcitird requirements and in addition the net weight for each shipment. The certificates shall be submitted to the Engineer's Representative.

“ preliminary code of practice for the tests…” see clause 5703”

Each shipment of prestressing steel shall be identified with a metal tag$_s$ which shows the manufactures the steel quality., the dimensions, the melting number, the project number and the date.

Steel and tendons without a certificate shall not be used'and have to be removed from the site within 24 hours.

All prestressing steel shall be properly stored and protected against rust and other corrosion and damage and. shall be free of all dirt, rust$_5$ oil, grease and other deleterious substance when finally encased in concrete or grouted in the member.

5704.2 ANCHORAGES

Anchorages shall be capable of developing guaranteed minimum tensile strength of the prestressing steel, and shall facilitate the even distribution of the stress in the concrete at the end of the tendon. Provision shall be made for the protection of the anchorage against corrosion.

Anchor devices for all systems of post-tensioning must be set exactly normal in all directions to the axes of the post-t ension ed t en dons.

Accurate measurements for anchorage losses are to be made at both ends of the tendon. The losses should then be compared with the assumed losses in the post-tensioned schedule and. if necessary, adjustments made 'In the operation.

5704.3 Ducts

Ducts provided for post-tensioning tendon shall be fc.-med by means "of"' flexible metal conduit, metal tubing i: ol;her approved means and shall be stiff enough to positively maintain the de-sired profile between points of'supports during operation work. The end of the duct shall be made so as to provide free movement oT end anchorage, Ducts must be completely sealed against leakage of mortar,

Cutlet holes shall be provided at all. high points and, at both ends of each tendon and should be provided at all low points for dewatering purposes.

5705 CONSTRUCTION REQUIREMENTS

5705.1 TRANSPORTING AND' STORAGE

Stressing steel shall be shipped or transported in vehicles closed or covered by waterproof canvas to be taken upon arrival at site to the storage place prepared in advance. During transport they shall be prevented from contact with chemicals, vehicles shall be thoroughly cleaned before being loaded.

Great care has to be taken during transportation to prevent damaging of surfaces.

Tendons, prestressing steel and accessories shall be stored in a dry places free of dirt, and shall be protected against corrosive residues such as chlorides, nitrates, acids, etc. It is sufficient to cover prestressing steel with waterproof sheets. For prolonged storage sufficient ventilation must be provided to prevent condensation of water.

Welding operations are not permitted near prestressing steel, Hot sparks or welding material .falling on the tendon cause changes in the molecular structure of the steel that may lead to failure.

5705.2 ASSEMBLING OF TENDONS

Assembling of tendons shall be carried out in .accordance with the instructions of 'the agreement certificate of the manufacturers,

In addition the following has to be considered:

Before assembling, the surfaces of the prestressing" steel must" he cleaned of all rust flakes. At the same time care should be taken .to locate damaged surface spots. Cleaning can be done by hand .with the aid of burlap rags or soft steel wool or by means of an electrically operated cleaning machine; Damaged steel sections must be eliminated.

The Contractor has- to make sure that the ducts are not damaged and are free from fissures, crack, etc.

Joints shall be carefully made in such a manner that they are mortar tight. Damaged ducts have to be removed from the site.

Anchorages must be assembled with the tendons in a manner that will prevent any shift in position, neither during installation nor during concreting.

5705.3 PLACING OF TENDONS

Careless or incorrect installation of post-tensioning units can cause many difficulties during stressing and grouting operations. The Contractor shall use utmost care and never dispense with a thorough inspection before placing the concrete.

Tendons shall be supported and secured at suitable intervals to ensure that no movement of the tendons occurs during concreting operations.

Sheathing shall not be damaged during the placing of the post-tensioning units. It is therefore recommended to place the tendons in such a manner that they will keep thoir proper position from the beginning and will not have to be moved to their fins'! position by a longitudinal displacement. If, however,, a change in position'should be required, the tendon units must be raised from their support to prevent the ducts from being torn open. Position of -tendons in plan and elevation must be exactly as called for, in order to obtain th;- prescribed carrying capacity of the structural members. The use of chairs and spacer racks is necessary for this purpose. Chairs Must bo applied immediately behind all anchorages, The anchorages shell not carry the weight of a tendon. Spacer racks in gird;:,' forms should be detailed in such a way that the prestressing steel can be placed in consecutive layers without cumbersome threading,

Anchorages must be held rigidly to prevent displacemant during the placing of the concrete. This can be achieved by wiring them to the non-prestressed reinforcement or to the form work.

All post-tensioning units must be thoroughly inspected in regard to damages and errors in placing before starting the pouring of concrete.

No tears are permitted in duct work. Leaky spots must be sealed by winding insulating tape around them.

Where tendons have been fastened with wire,the ties must not throttle the duct opening.

5706 PRESTRESSING

5706.1 TIME OF PRESTRESSING

In addition to the accurate installation of the tendons the stress Induced is of great importance for the strength capacity of a structure. The prestressing operations shall therefore be carried out with precision and care by train personnel.

Concrete must not be prestressed until it is strong enough to resist the stresses associated with the transfer of the prestressing force including the stresses at the anchorages. This condition is to be regarded as satisfied if it has been shown by me n of hardening tests in accordance with Clause 7.4,4 of DIN 0^{j} ; thai the cube strength SwM has attained the values indicated in column 2 of the table over leaf.

In regard to obviating shrinkage cracks, and temperature cracks* -hand also for the sake of early stripping of form work from individual parts of a structures it- may be advantageous to apply pert of the prestress as early as possible . This-is permissible only when it has been shown by means of hardening tests in accordance with Clause 7.4,4 of DIN 1045 that the cube strength of the concrete had attained the values indicated in column 3 of the table overleaf, fn that ease the (parti1) prestressing forces of any tendon and the concrete stresses in the rest of the member must neither exceed 30. % of the prestressing permissible with regard to anchorage, nor 30 % *of-* the "permissible stresses envisaged in Clause 15of the code of practice DIN 4227 see Clause 5703 respectively. If the cube strength ascertained *by* means of the hardening tests is between-the values in columns-*2* and 3 the permissible value of the partial prestressing force may be detrmined by linear interpolation.

Approval by ih Engineer's Representative of such partial pre-sin and moving shall in on way relieve the Contractor of full responsibility for successfully constructing the prestressed members,

The concrete strength class Bn envisage, here is the strength class needed to resist'the stresses and forces (including the anchorage forces) occuring at transfer. If creep and shrinkage are not specifically taken into account for the tendons tensioned in advance so as to produce part*of the prestressat an early stage, the effect thereof should be determined by de-stressing a-few-selected-tendons and be allowed for in the further tensioning operations.

1 Bn	2 Cube strength at the time of final pre-stressing kp/sq.cm	3 Cube strength at the time of applying part of the prestress, kp/sq.cm
25	240	120
350	320	160
450	400	200
550	480	240

By no means – and this applies for all types of bridges – may the deck slab be concreted later than 6 months after concreting the prefabricated girders.

Post-tensioning will not be permitted until it is demonstrated to the satisfaction of the ?Engineer's Representative that the prestressing steel is free and unbounded in the duct.

prestressing steel is free and unbounded in the duct.

5706.2 TENSIONING EQUIPMENT:

The following general conditions shall be fulfilled, independently from the equipment used in the chosen prestressing system:

Hydraulic jacks shall be outfitted with either corresponding pressure gauges or load cell with suitable device for reading the produced elongation. This equipment consisting of jack and pressure gauge shall be properly calibrated ad the calibration chart shall be at the disposal of the Engineer's Representative.

If other types, of jacks are used, they shall be provided with duly checked and proven devices, which allow at all times an exact calculation of the force exercised by the jacks and the stress applied to the reinforcement.

Equipment used for the tensipning of tendons should, before being used for the first time and subsequently (as a rule) at half yearly intervals, be. checked in order to determine what deviations from the desired value occur when it is used.-In so far as these deviations are dependent on external influences (e.g. on the temperature as affecting oil-operated jacks), this should be taken into account.

Equipment whose error with respect to the test diagram in the vicinity of the final prestressing force exceeds + 5 % is not allowed to be used.

5706.3 ICEDURES AMD MEASUREMENTS DURING TENSIGNiNG

An accurate tensioning programme shall be drawn up. in addition to indicating the time sequence of tensioning, this programme shall contain for each tendon information on the prestressing force and tendon extension having due regard to the compressive shortening of the concrete; friction and slip.

The sequence of tensibning and lowering of falsework should be so chosen that no inadmissible stresses will develop,

All measurements performed during tensioning should be recorded by trie Contractor in writing with copy to the Engineer's Representative. If the sum of the percentage deviation from the desired (specified) prestressing force and the percentage deviation from the desired (specified) extenstion for an individual tenden…, the Engineer’s Representative shall be informed of this if the deviation from the desired prestrassing force or from the desived extension totals more than 5% for all the terdans located in a cross-section, the supervisory staff shall likewise be informed.

5706.4 TENSIONING AND PERMISSIBLE STEEL-STRESSES

The dirt and water-prevention attachments must be removed before commencement of tensionirig car shall be taken that no dirt and water can enter the prestressing ducts.

During the prestressing process it is forbidden to-stand behind jaci or under the jack so thats should, a break occur, no one will hi injure by the fiying spindle or the tendon and jack.

The elongation and/or the counter value must agree with the corresponding, manometer pressure. This check must be made for each tendon during the prestressing operation.'

The maximum .temporary jacking stress in prestressing steel shall not exceed 65 percent of the specified minimum-ultimate tensile strength of the prestressing steel.

The work force in the prestressing steel shall be not less than the value shown on the drawings. Unless otherwise specified or shown on the drawings, the average-working stress- in the pre-/ stressing steel shall be not exceed SO-- percent of the specified / mi nimum, u 111 mate tensile strength of the prestressing steel.

Work force and working stress will be considered as the force and the stress remaining in the restressing steel after all losses, including creep and shrinkage of concrete, elastic compression of concrete, creep of steel losses in post-tensioned prestressing steel due to sequence of stressing, friction and take up of anchorages and all other losses peculiar to the method or system of prestressing have taken place of have been provided for.

5707 GROUTING

5707.1 GENERAL

To protect the tendons against corrosion and to bond them to the surrounding concrete the prestressing ducts must be injected carefully with an approved cement grout. The required compostion production and handling of this grout is regulated by the German "Richtlinien for das Einpressen you Zementmortel in Spannkanale (June 1973)" - code of practice for the grouting of tendon ducts (June1973), and shall be approved by the Enginner's representative. This grout of cement mortar shall be injected in all cable ducts not later than 2 days after the tensioning has been completed and approved by the Engineer's representative.

5707.2 REQUIREMENTS APPLICABLE TO GROUT

The fluidity of the grout should be sufficient to enable grouting to be properly completed. It is determined by means of the immersion test.

The following immersion test times should be conformed to;

Immediately after mixing:	≥30 seconds
Longer immersion timer (40 - 45 sec.) should be aimed.at$_9$ 30 minutes after mixing:	in general - 80 seconds'.

The solids in the grout must not undergo more than a small amount of sedimentation. In the test the sedimentation (the difference between the initial level of the grout surface in the test receptacle and the level after sedimentation has occured) must not exceed 2 % of the original depth of the grout, a moderate amount of swelling is -desirable, No water must be found standing on the .grout specimens after 28 days.

The compressive strength of the grout, which must in any case be determined on three cylindrical specimen shall - in preliminary (suitability) tests and in quality control tests – conform to the following requirements:

7 day strength, average	225 kg/sq.cm
No individual value to be less than	200 kg/sq.cm

28 day strength, average ≥ 300 kg/sq.com
No individual value to be less than 270 kg/sq.cm

If anchorage forces have to be transmitted to the grout before it has had time to hared for 28 days, it shall be shown at the time of force transmission to it, the grout has attained at least the compressive strength which, under the special conditions of the agreement certificate are required for the prestressing system concerned.

If grouting is to be performed at low temperatures, the frost resistance of hardened grouth must be ensured. It should be verified by means of preliminary (suitability) tests. The requirement is to be considered as fulfilled if on testing the volume of 3-day old specimens which have been stored at 5°C (+1°C) until testing does not increase as a result of one freesing operation to – 20°C (+ 1°C).

Particular ttention is drawn to the frost resistance check since grout, which. is, injected into the ducts at low temperatures, should be frost-resistant even at an early age.

Grout.is,composed.of cement, water admixture and possibly additives and aggregate. The suitability of the composition and utilization properties of the initial materials shall be verified by means of a preliminary-'test.

Only cements which conform to-the following requirements are admitted

Portland cements in accordance with DIN 1164, 1970 edition, which are at least of strength class 350 F.

The cement should be supplied in bags of 50 kg and must (counted from the date of dispatch from the cement factory) be not more than 3 weeks old or as directed by the Engineer's Representative, Until it is used it should be stored in a closed shelters protected from moisture.

The water content of the grout should be kept as low as possible and be so proportioned that all the requisite properties of the grout are achieved. As a rule the water/cement ratio should not exceed 0.44.

In so far as; the requisite fluidity and" climatic conditions permit s the water content should be reduced so as to give a water/ cement ratio of less than: 0.44.

In general, drinking – water from public supplies is suitable for making grout, sea-water must not be used. If other water is used, it shall be shown that it does not promote corrosion of the prestressing steel. The chloride content of the mixing water must not exceed 300mg Cl per liter.

The sulphate content of the mixing water shall be according to clause 5103.2.

The only admixtures that may be used are grouting aids for which a valid test certificate has been issued.

The purpose of a grouting aid is to reduce the water requirement and improve the fluidity of the grout. It should contract the sedimentation of the cement, should slightly expand the freshly made grout, and should ensure frost resistance of the growth even at an early age.

Additives are finally a divided substance such as pozzlana, where as “admixtures” change the properties of growth or concrete by chemical or physical action (see DIN 1045,clauses 2.1.3.5 and 6) they are allowed to be added to the growth only if their use is expressly permitted in the agreement certificate for the prestressing system or by the Engineer’s Representative.

The additives shall comply with DIN 4226, sheet 1 (aggregate for concrete). Other additives may be used only if a test mark or an official permit has been issued, stating that their use in grout is allowed or if approved by the Engineer’s Representative.

Large cavities - e.g. enlarged ends of box-section sheet metal ducts - may be filled with suitably graded gravel above 8 mm size before they are grouted. The aggregates should comply with DIN 4226, sheet 1. Factory-made grouting compound, supplied dry, may be used only if an official permit has been issued for it and/or if approved by the Engineer's Representative.

5707.3 BATCHING, MIXING AND GROUTING

All materials used for making grout should be carefully proportioned and weighted. Furthermore the conditions stated in the agreement certificate for the prestressing system concerned must he fulfilled.

As a rule, mixing should be done in the sequence: water cement, additives (if any), aggregate(if any).

It should be completed within not more than about 4 minutes. The cement should be added slowly. Furthermore the grouting aid should be added in such a way that uniform mixing of the grout and effective action of the grouting aid are "ensured; Next the grout shall be mechanically 50 agitated that segregation and the formation of lumps are avoided. The temperature of the freshly mixed grout should, at the end of the mixing operation not exceed h 35 C or as directed by the engineer's Representative.

When grouting under high temperatures, suitable simians are to be foreseen to cool the mixing Water and if necessary the structural members.

Grouting (injecting the grout into the ducts)shall be done by means of a pump (not compressed air) which ensures uniform flow of the grout. The manifold of the pumping pressure applied and the flow velocity of the grout should be suited to the requirements of the tendons.

Before grouting is carried out, the tendon ducts shall be checked to see that they are unobstructed. Ducts which are blocked must be cleared by chiseling drilling or other appropriate means before grouting.

If the ducts are flushed with water, the water that remaing in them shall be removed with compressed air, as outlet holes provided at low points along the tendon profile will as a rule not suffice to get ride of all the water. The water used for flushing the ducts shall fulfill the same requirements as the mixing water for making the grout.

Unlined tendon ducts, i.e. formed without a sheathing, should be saturated;/with /water-Tor some hours before grouting, so as to ensure that the concrete will not absorb too much water from the grout. After this saturation of the ducts excess water should, be removed with the aid of compressed air.
Grouting must continue until a sufficient quantity of grout, whose immersion time is not less than 30 seconds, has flown out of the other end of the duct.

It must be ensured that the grout can expand in the duct and can displace any free water that may be present. In view of this requirement, openings at points of the ducts, where free water can collect and be discharged, must not be closed. Grout which has flown out of a du.ct must not be re-used,, It is not permissible to use grout which has remained unused for half n hour after it was made.

In every duct grouting shall continue uninterrupted until the duct has been-filled. Regrouting should be done only under circumstances where water segregated from the grout in large cross-sectional parts of'ducts has to be displaced by fresh grout.
As a general principles a tendon duct should be grouted from its lower end.

It must be ensured that immediately after concreting, all the ducts are cleared of any water that may have penetrated into them. This shall be done by the thoroughly blowing with compressed air. Then until grouting takes place, the ducts shall be protected against further entry or re-entry of water. Circulation of air in the ducts must also be prevented.

If protective agents are employed for temporary protection of the steel against corrosion, they shall be approved by the Engineer's Representative. It must be verified that the requisite properties of the grout and the necessary bond are not impaired.
No grouting should be done when the temperature of the structure is below +5°c.

If frost sets in during grouting, it must be ensured by appropriate measures that the temperature of the structure will not fall below +5°c within the first 5 day.

If it is unavoidably necessary to grout at air temperatures bellow +5°c, the structure must be kept sufficiently-warm for up to 5 days after; groutrig. More particularly in the part where the tendons are 1ocateds its • temperature must be maintained at not less than +5°c. The grout should be used at a temperature of not less than +5°c In these cases the preliminary (suitability) test shall be carried out at low temperature (+5oc), the frost resistance test is also required.

5707.4 TESTING OF THE GROUT FOR TENDON DUCTS

The Contractor is responsible for the execution and the interpretation of the tests specified in Clause 7 of the Code of Practice for the grouting of tendon ducts (June 1973) including the appendix to it.

The results of preliminary testing shall be submitted to the Engineer's Representative for "approval before beginning with the grouting of the tendon ducts.

5708 WORKING DRAWINGS

Before installing any prestressing steel or related material, the contractor shall submit to the Engineer’s Representative for approval not only complete details of the method materials and equipment he proposes to use in the prestressing operations but also working drawings of the prestressing outlining the method and sequence of stressing, details of the prestressing tendons and reinforcement, anchoring devices, anchoring stresses type of ducts and, if necessary, couples and hodsings and all incidentals according to the requirements of the specification.

Working drawings shall be based on the engineering drawings which "were used for the tender documents. The tender documents
contain for the prestressing steel 'the position" of-the centroid
of,the total prestressing forces the maximum permissible pre-stressing force at time = 0 and the minimum necessary pre stressing force at time t =co , i.e.' after creep-and shrinkage.
AIT prestresMng tendons are to be dimensioned within these -limits and to be arranged according to the given cehtroid position. Deviations from the given centroid position are accepted
only up to ± 1.0 cm.

It is the contractor’s responsibility to check whether the reinforcement, and in particular the bursting tensile reinforcement, is sufficiently dimendsioned for the prestressting system used by him. Otherwise the reinforcement must be modified, without extra paysment for additional reinforcement, if required (Ref. Clause 5702.

5709 ALTERNATIVES

Should the Tenderer offer a prestressing system, which does not permit the fulfillment of the conditions demanded in Clause 5708 with regard to the position of the centroid of the total pre-

stressing force and to the magnitude of the final effective pre-

stressing forces5 the Tenderer shall supply with the offer a checkable concise preliminary calculation, detailing the tendon position, prestressing system, type of tendons, number of wires or bars per tendon, area resp. diameter and quality of steel9 as sembling and type of anchorages, and the tendon forces at time
t = 0 and t =co .

It shall be quoted in the calculation which losses from friction,

shrinkage, creei and steel relaxation were taken into account. As for the rest, the German DIN Standards quoted in Clause 5703 will

apply.

If the Tenderer undertakes larger design-modifications, as e.g. modifications of the cross-section, he shall submit, besides the abb1 e 'mentioned calculation, detailed project plans sufficiently showing all modifications.

5710 SAMPLING AND TESTING

All wire, strand or bars to be dispatched to the site shall be assigned a lot number and tagged for identification purposes anchorage assemblies to be sent shall be likewise identified.

All samples submitted shall be representative of the lot to be furnished and in the case of wire or strand, shall be taken from the same master roll.

All of the materials specified for testing shall be furnished free of cost and shall be delivered in time for tests to be made well in advance of anticipated time of use.

Where the Engineer’s representative intends to require non destructive testing of one or more parts of the structure, special specifications. Shall be drawn giving the requirement details of the work.

The Contractor shall furnish for testing the following samples selected from each lot. If ordered by the Engineer’s Representative, the selection samples shall be made at the manufacturer s plant by-the Engineer's Representative.

The following lengths shall be furnished: .

For wires requiring heading - 1.5 m

For wires not requiring heading - -sufficient length to make up one parallel-lay cable 1.5 m long, consisting of the same number or wires as the cable to be furnished

For strand to be furnished with fittings - 1.5 m between near ends of fittings.

For bars to be furnished with threaded ends and nuts - 1.5 **m** between threads at ends.

Two anchorage assemblies shall be- furnished, complete with distribution plates of each size or type to be used, if anborage assemblies are not attached to reinforcement samples

5711 MEASUREMENT

All prestressing steel will be measured by the computed weight of the final installed length of tendons in place as shown on the drawings or as ordered by the Engineer's Representative no allowance will be made for related materials, labour, tools, equipment and other work necessary to furnish, fabricate, place prestress and grout the prestressing tendons including anchorages, ducts, couplers, chairs, grout, additional reinforcement and additional concrete according to clues 5708, and all other incidentals which are used on installed when completing the work by the contractor or which are order by the Enginner's representative and as specified herein.

5712 PAYEMENT

Payment for prestressing steel will be made at the price tendered per meteric ton for steel in plance according to the drawings or as ordered by the Engineer's Representative. Payment for prestressing steel shall include the cost for all related materials work and incidentals as mentioned in clause 5711.

58 BRIDGE RAILINGS AND GUARD RAIL POSTS

5801 SCOPE

The work covered by this section of the specification consists in furnishing all plant, equipment, material and labour and in performing all operations in connection with hand railings and guard rail posts. It is entirely subject to the terms and conditions of the contract and is to be executed in strict conformity with this section of the specification, with the drawings and the direction of the Engineer's representative.

In view of constriction, repair and maintenance of all hand railings and guard rails of the entire Expressway, all structural member most in their material, dimension and method of execution be executed and mounted exactly according to the drawings and prescriptions of tnis section.

Prior to the manufacture workshop drawings shall be made and subcited on time to the Engineer's representative for approval.

5802 MATERIALS

For all section material like tubes, bars, plates workshop quality structural steel shall be used with the properties required for st 37-2 according to the German standards. The data are given in section 59(DIN 17100).

The safety cable in the top rail member shall accept an ultimate load of 25 Mp minimum and reach a minimum strain at failure of 2%.

Ø16 mm giue anchors shall be provided for fixing of posts. The glue shall be two-component synthetic-resin glue. Expansion stud anchors are not allowed. Each anchor must be capable of accepting a minimum tensile force of 7.5 Mp.

The contractor shall furnish a test certificate for the planned anchor system failing this, be shall perform pull –out tests accordant to the Engineer's Representative before the latter gives his approval in case of doubt, the arrangement of these tests shall also be decided upon by the Engineer's Representative.

5803 CONSTRUCTION REQUIREMENTS

All members shall be executed in a way that permits impeccable galvanization. For perfect-galvanizing and in order to-ensure that condensation water can run off after installation, the tubs shall be provided with openings according to the drawings.

Additional openings in tubes, which might be necessary for perfect galvanizing, shall be arranged in a way that they are little visible, and do not change the bearing function. All welding works shall be executed in an expert way and under consideration of material protections. All Bering and welding work shall be completed before galvanizing, Welding seams shall be sufficiently chipped ground and cleaned to ensure sufficient bond for galvanizing. As a general principle, welding after galvanizing is not allowed, in exceptional cases, the approval of the Engineer’s Representative may be solicited for welding after galvanizing.

The base plates shall be welded according to the transverse gradient given in the plans and in such a way that the pasts are in vertical position.

The longitudinal gradient is to be taken into account either by a correspondingly incluined arrangement of the base plates or by stirms.

5804 PROTECTION AGAINST CORRDSION

All steel member are to be provided with an 30 micro minimum not dip galvanizing.

Concerning the safety cable, all individual wires, and not only the cable as a whole, shall be galvanized.

Tubes shall be completely galvanized inside too.
Welding same which were expected after galvanizing according to an approval by the Engineer’s representative, shall be treated in conformity with clause 5803, and afterwards be coated with a triple zone dust priming paint. The priming paint must be of high and durable quality and is to be approved by the Engineer’s Representative.

The fixing anchors shall be rustproof. All other connecting devices shall be anti corrosive.

5805 PLACING AND FIXING

Falsework supporting-cast-in-pi ace girders shall be released prior to placing railings, unless otherwise permitted by the Engineer's Representative.

All railings shall be carefully erected true to line and grade. Posts shall be vertical within a tolerant not to exceed 3mm in 1mm.
Steel bridge railing shall be completely reacted in the shop and checked for alightment and grade. Adjacent railings panels shall alight with each other within 3mm. Joints shall be match marked. Railings shall conform to the curvature by means of a series of short chords, from center to center of rail posts, expect that railing noted on the plants or specified in the special provisions shall be shop bent to fit the curvature.
The railing shall present a smooth, uniform appearance in its final positions.

Fixing of the railings and guard rail posts will be executed in the concrete of the sidewalks. Burring of the boreholes and gluing or the anchors must be done exactly in accordance with the manufacture’s specifications and with bias test certificates or as directed by the Engineer’s Representatives.
Between base piate and concrete surfaces of the sidwalke concretes a shim has to he applied as require.
The safety cable is to be primly anchored at the extreme posts according to the specifications in the plans and to be fixed at each post by a clamping screw. All nuts shall be spot welded to the anchor bolts.

5806 MEASURMENT

Measurement of bridge railing shall be the number of linear meters constructed and accepted in plance. Measurement of each continous rail will be made along the line of the top rail member to the out end of the rail structure assembly, and shall include all intermediate posts, rail supports and curved end elements.

The guard rail posts shall not be measured separately, but shall be deemed to be included in the relevant items for guard rails in Section 64.

5807 PYAMENT

Payment shall be made for the total number of linear meters to the nearest one-tenth (1/10) of a meter, installed and accepted complete. In place as specified and the payment there of will be made at the unit price per linear meter of the proposal for the type or types to Bridge Riling specified, such payment shall be full compensation for furnishing all materials labour and equipment, and for performing all work required for the construction of the bridge railing, including posts and fastenings all finishing welding galvanizing, painting and all other work in connection with furnishing and installing the remind compete in place. No other compensation will be allowed.

No extra payment for guide rail posts will be made. They will be paid with the relevant items of guardrails according to section 64.

59 BEARINGS AND EXPANSTION JOINTS

5901 SCOPE

The work covered by this section of the specification consists in furnishing all plant equipment, materials and labour and in performing all operations in connection with constructing and placing bearings and expansion joints compete. Subject to the terms and conditions of the contract and in strict accordance with this section of the specification the applicable drawings and the directions of the Engineer's Resentative.

5902 BRIFE DESCRIPTION

All standard bearings according to the drawings and to these specifications are reinforced elastomeric bearings (R.E.B).

As special bearings are admitted, roller bearings are expended from use.

In material and constrictions. The special bearings shall be equivalent to those bearings for which approval certificants were issued by:

Institute for bantechnik
(institute for civil Engineering)
Reinchpietsthu for 72-67
1000 Berlin30
West-Germany

All standard expansion joints according to the drawings and to these specifications are reinforced alosttomeric joints.
Special expansion joints are joints which can absorb particularly large expansions.

5903 MATERIALS

5903.1 STRUCTURAL STEEL

Structural steel for the objects describen in this section shall comply with the requirements of DIN 17100 " Allgemine Baustahle" (Steels for General ?Structural Purposes). See table Page 2 of DIN 17100.

Steel grade					Mechanical properties notched bar impact strength									
								ISO V-notch specimens		Aged DVMF Specimens 10) At + 20 °C		DVM specimens At + 20 °C		Mandrel diameter for bending test 11)
Code number	Material number	Type of de pxidation1	Treatment conditions 2	Similar steel grades according to Euronorm253	Tensile strength 4)5)kg/mm2	Yield Point 6 Kg/mm2 Minimum	Elongation 7)8) Lo=5do % minimum	Average value from 3 specimens 9) Kgm/cm2 Minimum	At α	Average value from 3 specimens	Single value	Average value from 3 specimens	Single value	
										Kgm/cm2 minimum				
St 33-1	1.0033	-	-	Fe33-0	33 To 50	19 14)	18 14) (14)	-	-	-	-	-	-	3c
St 33-2	1.0035	-	-	-				-	-	-	-	-	-	
UST 34-1	1.0100	U	U,N	Fe34-A	34 To42	21	58 (20	-	-	-	-	-	-	0,59
UST 34-1	1.050	R	U,N	Fe34-A				-	-	-	-	-	-	
UST 34-2	1.0102	U	U,N	Fe34-B3FU				3,5	+20	8	5	-	-	
RST 34-2	1.0106	R	U,N	Fe34-B3FU				3,5	+10 15)	10	6	-	-	
UST 37-1	1.0110	U	U,N	Fe37 A(Fe42-A)	37 To 45	24	25 (18)	-	-	-	-	-	-	19
RST 37-1	1.0111	R	U,N	Fe37 A(Fe42-A)				-	-	-	-	-	-	
UST 37-2	1.0112	U	U,N	Fe37 Fe42-B3FU				3,5	+20	8	5	-	-	
RST 37-2	1.0114	R	U,N	Fe37 Fe42-B3FU				3,5	+10 15)	10	6	-	-	
St 37-3	1.0116	RR	U	Fe37-C3				3,5	+0	-	-	7	3,5	
			N	Fe37-D3				3,5	-20	-	-	9	4,5	
UST 42-1	1.0130	U	U,N	Fe42 A(Fe45-A)	42 To 50	26	22 (16)	-	-	-	-	-	-	29
RST 42-1	1.0131	R	U,N	Fe42 A(Fe45-A)				-	-	-	-	-	-	
UST 42-2	1.0132	U	U,N	Fe42-B3FU				3,5	+20	8	5	-	-	
RST 42-2	1.0134	R	U,N	Fe42(Fe45)B3FN				3,5	+20	8	5	-	-	
St 42-3	1.0136	RR	U	Fe42-C3				3,5	+0	-	-	7	3,5	
			N	Fe42-D3				3,5	-20	-	-	9	4,5	
RST 46-2 17)	1.0477	R	U,N	-	44 To 54	29	22 (16)	3,5	+20	8	-	-	-	29
St 46-3 18)	1.0483	RR	U	-				3,5	+0	-	-	7	3,5	
			N	-				3,5	-20	-	-	9	4,5	
St 52-3 19)	1.0841	RR	U	Fe 52-C3	52 To 62	36 20)	22 (16)	3,5	+0	-	-	7	3,5	29
			N	Fe 52-D3				3,5	-20	-	-	9	4,5	
St 50-1	1.0530	R	U,N	Fe 50-1	50 To 60	30	20 (14)	-	-	-	-	-	-	-
St 50-2	1.0534	R	U,N	Fe 50-2				-	-	-	-	-	-	-
St 60-1	1.0540	R	U,N	Fe 60-1	60 To 72	34	15 (10)	-	-	-	-	-	-	-
St 60-2	1.0542	R	U,N	Fe 60-2				-	-	-	-	-	-	-
St 70-2	1.0632	R	U,N	Fe70-2	70 To 85	37	10 (6)	-	-	-	-	-	-	-

Note : Table continued on next page…

1) U rimming, killed (including balanced steel), &R special killed,
2) U hot formed, untreated, N normalized {see also. Section 7-3.1., and the usual ns delivered conditions according to section 7.2).
3) The comparison is based on the guaranteed minimum values for the yield point. The grades in breakers are intended for strip, plate and video flats.
4) The listed values apply to products up to and including 100m thick, for thickness greater than this only the minimum value is guaranteed. The values may lie 2kg/mm2 outside the stated limits, but in the case of steels st33-1 and st 33-2 an upper limit of tensile strength of 50 kg/mm2 must be observed.
5) In the case of strip under- 3mm thick the upper limit tensile strength may be exceeded by values up to 10% of the minimum value of tonsile strength quoted for the grade concerned.
6) The values apply to products up to 16mm thick; for thickness > 16 ≤ 40mm they are reduced by 1kg/mm2 the for thicknesses >40 ≤100 mm by 2 kg/mm2. Values for thicknesses over 100mm are subject to agreement.
7) The values apply to longitudinal, specimens from products up to 100 miu thick, or up to 50 mm thick in the case of St 52~3« For transverse specimens from plate, side flats and strip over 3 mm thick the values may be lower by 2 points in the normalised condition and by 4 points in the hot rolled condition. For' thicknesses >100 mm, or >50 ma in the case of St 52-3, the values 6hall be subject to agreement.
8) The values in brackets apply to hot rolled atrip 3 am thick. For thicknesses smaller than this the values reduce by 2 points per ma of thickness (see Section 8.4.2.2).
9) See Section 7.4.2.2. No single value is allowed under 2.0 kg m/cm . In the case of rimming steel the values are guaranteed only up to a thickness of 16 mm max.

Chemical composition in % by weight													
Ladle analysis				Check analysis				Folding		Bar drawing		Drop forging	
C [12]	P	S	N [11]	C	P	S	N [12]	Is guaranteed for the steel grades shown					
Maximum								Code number	Material number	Code number	Material number	Code number	Material number
-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	.060	.050	.007	-	0.075	.063	.009	-	-	-	-	-	-
.17	.080	.050	-	.21 .19	.10 .088	.063 .055	- -	- -	- -	Uzst34-1 -	1.0101 -	UPSt34-1 -	1.0101 -
.15	.050	.050	.007	.19 .17	.063 .055	.063 .055	.009 .008	UQST34-2 RQST34-2	1.0104 1.00109	UZST34-1 -	1.0151 -	UPST34-2 RPST34-2	1.0177 1.0178
0.20	.07	.050	-	.25 .25	.090 .080	.063 .055	- -	- -	- -	UZST37-1 -	1.0120 -	UPST37-1 -	1.0118 -
.18 [16] .17	.050	.050	.007	.22 [16] .19	.063 .055	.063 .055	.009 .008	UQST37-2 RQST37-2	1.0121 1.0122	UQST37-2 RQST37-2	1.0161 1.0165	UPST37-2 RPST37-2	1.0160 1.0182
.17	.045	.095	.009	.19	.050	.050	.010	QST37-3	1.0123	-	-	-	-
.25	.080	.050	-	.31 .25	.10 .088	.063 .055	- -	- -	- -	UZST42-1 RZST42-1	1.0140 1.0139	- -	- -
.25 .23	.050	.050	.007	.31 .26	.063 .055	.063 .055	.009 .008	UQST34-2 RQST34-2	1.0141 1.0142	UZST42-2 RZST42-2	1.0181 1.0185	- RPS42-2	- 1.0191
.23	.045	.045	.009	.25	.050	.050	.010	QST37-3	1.01.3	-	-	-	-
.20	.050	.050	.007	.22	.055	.055	.008	RQST34-2	1.0978	RZST42-2	1.0479	-	-
0.20	.045	.045	.009	.22	.050	.050	.010	-	-	-	-	-	-
.21 [22]	.045	.045	.009	.22 [22]	.050	.050	.010	QST52-3	1.0833	-	-	PSt52-3	1.0888
.25 [23]	.080	.050	-	-	.088	.055	-	-	-	ZST50-2	1.0531	-	-
30 [33]	.050	.050	.007	-	.055	.055	.008	-	-	ZST50-1	1.0533	PSt52-2	1.0539
35 [22]	.080	.050	-	-	.088	.055	-	-	-	-	-	-	-
40 [23]	.050	.050	.007	-	.055	.055	.008	-	-	ZST60-2	1.0543	-	-
50 [23]	.050	.050	.007	-	.055	.055	.008	-	-	ZST70-2	1.0633	-	-

10) See Section 7.4.2.5.
11) Specimen thickness, bending angle 1800 in each case.
12) For pelican up to and including 100mm thick or of equivalent cross-section; for thicker products the maximum allowable carbon content must be agreed.
13) For electric furnace steel antitogree contact up to 0.012% in the analysis is permitted.
14) Thin value is guaranteed only for products up to and including 25mm thick.
15) Applies to product thickness up to 30mm. for thickness over 30mm the test temperature is +20∘C.
16)for thicknesses over 16mm a carbon content of .0.20% max in the idle analysis and of 0.25% max in the check analysis is allowed.
17) RST 46-2 in supplied only in thickness up to 20mm. the atateed mechanical properties apply up to the limiting thickness.
18) The section st 46-3 is intended only for product thickness over 20 up to 30mm. the stated chemical properties apply to this thickness range.
19) In the ladle analysis the section content may not exceed 0.55% or the manganese content 1.50%.
20) This value applies to products up to 16mm thick. For thickness >16≤30 mm it is reduced by 1kg/mm, and for thickness >30≤50mm by 2kg/mm2; for thickness over 50mm the values are subject to agreement.
21) This value applies to products up to 16mm thick. For thickness >16≤30 mm the mandrel diameter is 3a for thicknesses greater than this it is subject to agreement.
22)in the case of plate over 16mm thick, and in the case of strip and wide rats in all thickness, carbon content of 0.22% in the ladle analysis and of 0.24% in the check analysis may not be objected to .
23)Approximate average value.

All steel parts, unless otherwise specified, must at least conform to steel quality RSt 37-2.

The reinforcing steel plates shall consist of steel St 50-2, St 52-3 or St 60-2 with a manufacturer's certificate. The edges of the steel plates shall be carefully treated in order to prevent notch effects.

Exposed steel parts-shall be sufficiently protected against corrosion according to clause 5905.

5903.2 ELASTOMER FOR BEARINGS

The basis of the elastomeric shall be a poly-2-chlorobutadin. The eleastomer shall have an excellent resistance to aging, to weathering, to chemical attack and to ozone.

The elastomeric shall comply with the requirements of the "provisional rules for quality control of reinforced elastomeric bearings within the framework of the manufacture's and independent quality control (rules of the specialist panel on "Bearings" of the instates for Civil Engineering Berlin).

The elastomeric shall comply at least with all requirements given in the table of clause 5903.3 for the material No. 2416 (Mechanically high quality for abrasion-proof surfaces). Column 1

5903.3 ELASTOMER, FOR STANDARD EXPANSION JOINTS

The elastomeric shall be polychloropren with excellent resistance to aging, weathering, chemical attack and abrasion. It shall be composed of the two different qualities whose properties are given in the table over leaf.

5903.4 ERIA FOR,SI ECIAI EXPANSION JOINTS

The steels used for all construction parts shall be accompanied by a manufacturer's certificate; this certificate, shall contain sufficient information to allow to correctly classify the steels in the table of DIN 17100 in Clause 5903,1 " Elastomeric parts must possess according to their functioning the minimum properties according to the table see page 5 - 95.

Table to Clause 5903.3 and 5903.4:

PROPERTIES OF ELASTOMER QUALITIES FOR STANDARD EXPANSION JOINTS AND BEARINGS

.	Quality No. 2416 Mechanically high quality for abrasion-proof surfaces	Quality No. 2413 Shear-sof t inner parts	Proof method according to DIN
A. PHYSICAL PROPERTIES			
Shore –A- hardness (SHE):	60±5	30± 5	53505
Tensile strength (Kp/sq.cm)	≥ 170	≥ 110	53504
Elongation at break (%)	≥ 450	≥ 800	53504
Tear propagation strength (kp/cm)	≥ 20	≥ 10	53515
Shock elasticity (%)	≥ 30	≥ 20	53512
abrasion (cu.m)	≥ 170	Not measurable, rubber being too	53516
Residual compressive strain 24 h Rl. (%)	≤ 10	≤ 10	53517
Residual compressive strain 24 h 70◦C (%)	≤ 15	≤ 35	53517
Shear modulus (kp/sq.cm)	10 ± 2	3,8 ± 5	53509
Burability under ozone influence 48 h 50 Pphm (step)	0	0	
Change of properties by artificial Gaining For 7 days at 70◦c.			
Short –A – hardness (SHE)	≤ 5	≤ 5	
Tensile strength (%)	≤ - 15	≤ - 15	
Elongation at break (%)	≤ - 40..	≤ - 40	
B. COMPOSITION (PERCENTAGE			
BY WEIGHT)			
Elastomer content (polychloropren)	≥ 60 P.P.W		
Soot content	≤ 25 P.P.W		
Adjuvant substance	≤ 15 P.P.W		
Ash content	≤ 5 P.P.W		

.

PROPERTIES OF ELASTOMER SEALING ELEMENTS FOR SPECIAL EXPANSION JOINTS

A) Physical Properties	
Shore-A-hardness (SHE)	63 ± 5
Tensile strength {kp/sq.cm)	≥ 110
Elongation at break *{%)*	≥ 350
Tear propagation strength (kp/sq cm)	≥ 10
Shock elasticity [%)	≥ 25
Abrasion (cu.m)	≥ 220
Residual compressive strain (24h 70◦C)*(%)*	≥ 28
Durability under ozone influence (48 to 50 pphm)	0
Change of properties by artificial aging (7 days at 70◦C)	
Shore – A – hardness (SHE)	≤ - 5
Tensile strength (%)	≤ - 20
Elongation at break (%)	≤ - 20
(Respective DIN Standard; see table above)	
B) Compositlpn	
See t it le on Page 5 - 94	

5903.5 MATERIALS FOR SLIDING DEVICES OF SPECIAL BEARINGS

The material of sliding devices must conform to the following specifications:

The sliding device consists of a carrier plate which is covered with a layer of austenitic steel in the area of travel. The sliding material is polytetra- fluorethylene (PTFE) which is contained in a recess of the steel lid. Polyoxymethylene (POM) can be used in place of the austenitic steel.

The PTFE shall be pure virgin PTFE – known as PTFE white – without additives of regained material or filler. This PTFE must be frealy sintered and not subsequently compressed. Its surface shall be clean and smooth.

The cover of the carrier shall be austenitic steel sheets which must be at least 1mm thick, be made of material x5 cr ni mo 18.10 No. 14401 – comparable to DIN 17440 – and have a surface hardness of not less than HV 1= 130 kp/sq.mm. The surface shall be homogenous with a surface roughness of R=1 mymeter.

The cover of the carrier plates may also be of acetal resin (POM) toughfalric plates for special applications. Such carrier plates consist of two layers of material bonded together, each of which must be at least 2 mm thick. The POM layer must face the sliding surface and the tough fabric, rigidly connected to the carrier plate, the opposite way.

Carrier plates with a hard-chromlum layer are not to be used.

Other parts for the sliding system are preferably made of steel st 52-3 according to DIN 17100

5904 COMSTRUCTION REQUIREMENTS

5904.1 OBSTRUCTION REQUIREMENTS

FOR STANDARE BEARINGS

All dimensions of the-standard bearings must be in exact conformity with the data contained in the drawings.

The embodied reinforcing steal plates shall be hot-bonded to the layers of elastomer.

The following design data are to be guaranteed:

- permissible shear deformation tan $\gamma = 0.7$

where

$$\tan \gamma = \frac{\text{horizontal displacement}}{\text{thickness T of elastomer}}$$

T = total thickness of all the layers
Of eleastomer in unstressed state

- permissible stress 6 = 125 kp/sq.cm
- permissible range of temperature between -30°C + 50°C and for short - term exposure + 70°C

5904.2 CONSTRUCTION REQUIREMENTS FOR SPECIAL BEARKINGS

Special bearing are:
GHH sliding line rocker bearing
(Gutehoffnungshuttee Sterkrade AG, Esslingen, Nest-Germany)
Type LGa and
Type LGe
or equivilent products.

Equivalence shall be judged according to the conditions which apply for issuing an approval certificate by the Institute for Civil Engineer in Berlin(see Clause 5900).

Bearings with a valid approval issued by this institute are considered as technically equivalent;
Dimensions of bearings must furthermore be equivalent for esthetic reasons. They may not exceed the overall dimensions given in the Drawings for height, length and width unless authorized in writing by the Engineer's Representative.

The following design data shall be guaranteed:

The permissible stresses on the sliding materials are limited by the load-carrying capacity of the PTFE. The PTFE plates may be subjected to the following compressive stresses -

- Load condition : I -

  Dead load, prestressing, shrinkage, creep and temperature : 300 kp/sq.cm

- Load condition II -

Dead load, prestressing, shrinkage, creep, temperature, live load, brake load and wind forces: 450 kp/s q cm

Provided that the above sabulated values represnte a true mean loading for every individual PTFE surface, the following edge pressures on circular PTFE plates are used:

- Load condition I 400 kp/sq.cm
- Load condition II 600 kp/sq.cm

The occurring maximum friction values under these load conditions shall be not more than

- Load condition I μ I = ≤ 0.030
- Load condition II μ II = ≤ 0.025

  At low temp (-35◦C)

The permissible angles of tilt shall be in

Longitudinal direction tanδ1 = 10 0/100

Transverse direction tan δ2 = 0

Perfect functioning and the bearing capacity are to be proved by a complete statical calculation.

The following dimensions of the supporting PTFE suface, its thickness and the size of gap between the sliding surface and the PTFE housing are imperative.

PTFE Surface Dimensions

Dimension in mm	Minimum thickness in mm	Size of gap in mm
≤ 600	4.5	+ 0.6 2. 0 -0.1
≥ 600 ≤ 1,200	5.0	+0.85 2.5 **-0.1**

A special kind of silicome grease is to be used as lubricant, which neither resinifies nor affects the sliding plates.

On each bearing, an indicateor shall be supplied to chech movements.

The sliding surface must be completely protected aginst dirt and weather.

The sliding device as well as the line rocker elements must be replaceable.

5904.3 CONSTRUCTION REQUREMENTS FOR STANDARD EXPANSION JOINTS

The joints are shock and sound absorbing, watertight systems. Their dimensions shall be in strict conformity with the drawings. All steel parts must be totally encased in the elastomer.

The joints are to be supplied in units 2 m long. Shorter units may be supplied to ma I up any length. All units shall be butted together by means of tongue and groove interlock as given if: the drawings and which Is vulcanized or fixed with a special adhesive.

All mitered joints at curbs and sidewalks shall be prefabricated and vulcanized by the manufacturer.

Sealants are to be applied according to the drawings, to be approved by the Engineer's Representative and used strictly in accordance with the manufacturer's instructions.

All joints are to be shaped according to the transverse profile of the roadway section as given in the drawings.

The anchorage of the expansion joints shall be obtained by glue anchors with a minimum diameter of 16 mm. The application and type of construction of these anchors visions given in Section 58.

For large expansion joints steel subfraffles for protection of the concrete edges are to be provided according to the drawings.

5904.4 CONSTRUCTION REQUIREMENTS FOR SPECIAL KPANSW JOINTS

The special expansion joints are to be executed with the type 641 maurer system (maurer shone, Munchen, West -Germany), or with equivalent systems which must comply in particular with the following requirements.

The system must be watertight. All parts subject to way must be easily replaceable from the roadway surface. Mobile parts must be placed on elastic bearings.

A perfect anchoring in concrete must be guaranteed.

All bolts, must and washers shall be of rustproof material.

Perfect functioning of the system must be sufficiently tested and proved by a list of reference.

The special expansion joints are to be shaped according to the roadway surface and sidewalks, and shall be conducted over the entire bridge width without interruption.

On the exterior surfaces of the sidewalks the structure shall be covered by steel plates winch allow bridge movements.

Workshop drawings must be submitted for approval by the Engineer's Representative well in time before manufacturing.

5905 RUSTPR00FLNG.

All steel parts, shall be supplied as follows:

Sadblasted; Sprayplated to a thickness of 60 to 100 mymeters coated with two layers of chlorinated rubber paint to a 40 mymeter ter thickness each, This rustproofing shall be applied to all steel surfaces not in contact with concrete or rubber.

Other methods of rustproofing may be applied if clearly defined in the proposal and if approved by the Engineer's Representative.

Steel parts protected by elastomer shall have a minimum thickness of elastomer cover» of 2mm

Any damage to the coating by handling or placing must be repaired as directed by the Engineer's Representative.

All parts for the anchoring of standard expansion joints shall be zinc sprayed with the exception of nuts and washers which shall be made of stainless steel.

In general, all bolts, nuts and washers shall be of rustproof material.

5906 PLACING OF JOINTS AND BEARINGS

5906.1 GENERAL

All items of this section must be delivered to the site clearly identified as to their type and place of installation.

All items of this section are subject to approval by the Engineer's Representative before being placed unless otherwise directed by him in writing.

All grouting shall be executed according to DIN 1045.

The accurate placing of all bearings and joints shall be approved by the Engineer's Representative before grouting unless otherwise directed by him. After grouting, the completion of the work of this section shall be finally approved by the Engineer's Representative.

All work executed on. joints and. bearings, on the site is allowed only if it is' performed by .the manufacturer's experts, or by his representatives fully authorized and trained by him.

All placing work is to be executed in accordance with the directives given by the manufacturer or by the Engineer's Representative.

5906.2 PLACING OF BEARINGS

All bearings must be identified in a way that type, size, position, direction of placing and pre-set are given unequivocally.

The bearings must be placed precisely horizontally on to a layer of cement grout whose thickness is not less than 2.5 cm. The concrete under the cement grout layer must be roughened and well soaked before the grout is applied.

The layers of cement mortar must not exceed a thickness of 5 cm when not reinforced.

R.E.B. must not have contact with grease, solvents and especially not with formwork oil before placing.

The lateral faces of R.E.B. must be entirely free to leave room for deformation.

Sliding devices of bearings shall be pre-set in accordance with the requirements.

The temporary fixing device shall consist of such material which does not cause damage to the bearing when initial displacement occur.

5906.3 PLACING OF JOINTS

Before placing standard expansion joints, the concrete surfaces shall be trowelled perfectly smooth. The required level of accuracy is ± 1 mm vertically for a length of 1 m along the gap.

The so prepared concrete surfaces shall be supplied with a quick setting rubber sealant immediately before placing the units according to the instructions of the manufacturer. The sealant is to prevent ingress of water under the expansion joint.

5907 TESTING

At the request of the Engineer's Representative, individual bearings and expansion joints shall be tested to determine whether they meet the chemical, physical and/or statical requirements as stipulated in the Specifications.

5908 MEASUREMENTS AND PAYMENTS

5908.1 GENERAL

Bearingsand expansion joints which were not properly placed or do not meet the required standards shall be replaced at the request of the Engineer's Representative and at no additional cost. The unit price shall! include all materials, equipment and labour needed for the construction, hauling and placement as well tests ordered by the Engineer in accordance with 5907 above.

The price shall especially include all grouting, fixing devices, indicators, sealants, vulcanizing as described.

5908.2 BEARINGS

Measurement and payment will be made per unit,

5908.3 EXPANSION JOINTS

Measurement and payment of all joints will be made per meter length measured along the gap at the surface of the joint from outer end to outer end.

PART SIX : M.ISCE-LLA-NE0US

61 REST HOUSES AND REST AREAS

6101 SCOPE

The work covered by this Section of the Specifications consists in furnishing all plant, equipment, material and labour and in performing all operations in connection with the construction of rest houses and rest areas complete, subject to the terms and conditions of the Contract and in strict accordance with this Section of the Specifications and the applicable drawings and the directions of the Engineer's Representative.

6102 BRIEF DESCRIPTION

The works consist of rest areas along the Iraq Expressway No. 1. In these rest areas filling and service stations are included. The location of these rest areas is indicated on the drawings.

Each rest area consists of the following:

Rest building.

A one story building with two different heights, which houses rest area facilities, i.e. restaurants and their services, i.e. kitchens, toilets … etc. It also houses the offices, rest and sleeping areas and service facilities for the working forces in the rest area and filling station. It also houses other services such as central switch board for the emergency telephone system, boiler room .., etc. The building is fully air-conditioned, serviced with cold and hot water, and shall have a fully equipped kitchen.

Service-Building.

A one story building with a mezzanine, housing vehicle maintenance and repair activities, i.e. 2 repair bays, tyre repair shop, stores and garage. It also houses services such as toilets and showers and a rest, and sleeping area for

the workers. Parts, of. it shall be air-conditioned arid it.will... be serviced-with hot and cold'water'and compressed air for the repair parts. It is faced with fair faced bricks on.the outside.

Concrete hyperbolic paraboloid sheds for the filling station.

A number of reinforced concrete hyperbolic paraboloid umbrella shell-type sheds are required over the filling station and petrol pumps. .

Filling station facilities.

The filling station facilities shall include:

Underground fuel storage tanks, the number of which, size and location are shown on the drawings, also shown on drawings are constructional details .for their installation.

These tanks shall be supplied by the Directorate for Distribution of Oil Products in the Ministry of Oil and Minerals.

Kerb side fuel pumps, the number of which and position are shown on the drawings.

These fuel pumps shall be supplied by the Directorate for the Distribution of Oil Products in the Ministry of Oil and Minerals,

Underground fuel pipes, electrical cables .., etc. all the work related to mechanical and electrical installations for the pumping station.

The Works include all the civil engineering work required for the filling station which include the housing of the fuel underground tanks, the preparation of all underground work necessary for the mechanical and electrical installation of the pumping station, the preparation of bases for the kerb side pumps, etc. The mechanical and electrical work required for the filling station shall be done by the Directorate for the Distribution of Oil Products - Ministry of Oil and Minerals. A provisional sum for this work is provided for in the Bill of Quantities.

The fuel pumps, the fuel tanks and all piping, electrical wiring for the filling station will be supplied by the Directorate for the Distribution of Oil Products - Ministry of Oil and Minerals, and a provisional sum is put aside for in the Bill of Quantities to cover the cost of this work.

Site work and external work shall include ail excavation, re-filling and grading for new structures., utilities, purification plant, water tanks, services, planting, areas*'lawn areas, and similar.

All earthwork for the preparation of site area shall be made in accordance with the drawings and Section 22 of these Specifications, its payment is not included in the lump sum for the rest area but in the relevant items of earthwork.

The pavements outside of the buildings and the surface drainage of these paved areas will be paid with the relevant items of the Bill of Quantities and shall not be included in the lump sum.

For each rest area a water treatment plant with settling tank, filtration plant and elevated water tank and a purification plant shall be installed as part of the lump sum.

The power supply shall be provided by diesel generator sets located behind the service building, which also shall be used for the road lighting of the rest area. These generator sets are not included in the lump sum.

General specifications for all sections.

Generally where specifications have been issued by BS, ASTM, DIN or VSM for mechanical equipment and by VDE for electrical equipment, forming part of the works, such equipment or material shall be used in conformity with and tested in accordance with the recommendations contained in the latest issues of the specifications applying thereto, except where otherwise specified or agreed to in writing. Other standard specifications can also be used when equivalent to the above stated.

The works'shall also include any additional work ordered by the Engineer's Representative and the ancillary necessary for the efficient and safe conduct of the work.

6103 CONCRETE AND MASONRY.

6103.1 WORK GENERAL

For concrete work all applicable clauses of Part Five shall be observed.

The dimensions of foundations are based on a permissible soil pressure of approx. 1.0 kg/sq.cm. If the subsoil conditions allow a reduction of the dimensions and/or depths of the foundation, these reductions shall be based on subsoil investigations to be performed by the Contractor, and approved by the Engineer's Representative.

ALT required additional calculations and drawings shall" be supplied to the Engineer's. Representative and approved- by him before beginning the works.

6103.2 SAMPLES AND TESLS

The Contractor shall submit the required numbers of masonry units for the approval of the Engineer's Representative and perform all necessary laboratory testing. All tests shall be in accordance with the latest B.S. or ASLM standards or equivalent, and to the standards and limits put down by the Iraqi official laboratories whenever applicable.

For concrete work the Contractor shall perform test specimens as often as directed by the Engineer's Representative. Special attention is drawn to Clause 5417.5

6103.3 CONCRETE WORK

The following concrete classes shall" be used:

Bn 50 - for soling layers

Bn 150 - for footings, foundations and floor slabs, for reinforced and/or lean concrete.

All concrete beneath the ground level shall be made with sulphate resisting cement.

Bn 250 - for all other reinforced concrete structures above ground floor level,

For reinforcing ribbed tor steel bars and/or wire mesh according to Clause 5603 shall be used. The concrete cover shall be a minimum of 20 mm, where sulphate resisting cement is used "the cover shall be 35 mm or in particular cases as directed by the Engineer's Representative. All reinforcement and formwork shall be approved by the Engineer's Representative prior to concreting, this approval shall not relieve the Contractor of his responsibilities.

All columns, beams and soffits of slabs shall have exposed concrete finish to the satisfaction of the Engineer's Representative. Triangular fillets shall be inserted to form chamfered corners,

6103.4 BRICKS

Clay bricks shall be of the best quality available in the country and from the Government Factories or other approved factory. All bricks shall be sound, hard, clean, non porous, yellow, well formed, square and thoroughly burnt. They shall be wire cut, machine made, and of uniform size, colour and texture, and shall be manufactured from clay containing not more than 2 % of soluble salt.

Hollow bricks, where specified, shall be obtained from approved manufacturers and shall be the best of their kind.

All bricks which will be exposed in the finished work shall be of the highest quality obtainable, and carefully selected to be free of cracks or any other imperfection and shall be uniform in texture. All exposed brick work shall be subject to the approval of the Engineer's Representative before being installed.

Overburnt bricks shall be used in work below ground level and as specified on the drawings. All clay bricks shall be soaked in water for one hour before use.

Where specified on the drawings, cement bricks shall be obtained from the Government Factory, the colour of the exposed surfaces of the bricks shall be as specified on drawings and approved by the Engineer's Representative.

6103.5 CONCRETE MASONRY UNITS

Concrete masonry units shall consist of concrete blocks of standard sizes and shapes. All concrete blocks must comply with the latest B.S. specification or approved equivalents.

Blocks shall have regular rectangular shape and perpendicularly aligned holes. The total volume of voids shall be 20 to 35 percent of the total volume of each block. Holes shall be symmetrically, arranged as to the two horizontal central lines of the block. The thickness of solid parts between holes and exterior surfaces of the block shall not be less than 3 cm.

Concrete blocks shall be free of any deleterious matter that will stain plaster or corrode metal and shall be adequately cured before use. They shall include the closers, jambs and other shapes required by the construction work.

The blocks shall be made from concrete containing at least 250 kg. cement per cubic meter aggregate. The maximum size of aggregate shall not be more than 1 cm and shall have a uniform grading.' The crushing strength of the blocks shall be at least 40 kg/sq.cnr over the gross area of the base for

a stress-parallel to the axis of the holes. All the blocks shall' be. cast in metal, moulds and vibrated, and shall be cured" for. a- least 7 days, and to the satisfaction of the Engineer's Representative.

Blocks shall be scored at mid point to simulate 20 cm x 20 cm face. The score shall be 1 cm.wide at the block face and 1 cm deep, with joint bevelled front to back.

Units shall be sound and free from cracks or other defects that would interfere with proper setting or impair the strength or permanence of the construction.

External corners of the blocks shall be square and free from chips. All blocks shall have a maximum linear shrinkage not exceeding 0.20 % as measured by the British modified method.

6103.6 WALL REINFORCEMENT AND METAL TIES.

Longitudinal reinforcement to be placed in horizontal masonry points when used shall be fabricated from steel wire, zinc coated before prefabrication, longitudinal wires shall not be lighter than 4.5 mm nominal dimension. Longitudinal reinforcement shall be of a standard manufacturer approved by the Engineer's Representative. Width of longitudinal reinforcement shall be as recommended by the manufacturer,

Wall ties for mechanically securing outside face of a masonry wall to a masonry inside wall, shall be non-corrosive, galvanized steel lugs, not lighter than 4.5 mm nominal dimension.

A minimum of four ties per square meter shall be used. The ties shall be specially manufactured to suit the conditions shown on the drawings, so that in all cases they shall be fixed normally to the face of the wall and shall be embedded at least 8 cm into each skin' (the outside leaf and the inside leaf).

Wall ties for mechanically securing masonry to conrete beams and columns.shall be corrugated and galvanized sheet metal, dovetail type 2.5 cm wide not less than 0.3 cm thick, to be used as dovetail inserts in the concrete on one side and to be embedded at least 8 cm into the masonry on the other.

6103.7 BUILDING MASONRY WORKMANSHIP

All masonry shall be laid plumb, true to line, with level and accurately spaced courses and with each course breaking joints. with the course below. AIT bricks or blocks shall- be well bedded, the edges butted and the internal joints thoroughly filled with mortar.

The bri.ck.br block must be Wetted before being built.into the work to prevent absorption of moisture from mortar. No broken or half bricks or blocks shall be used except as closers.

The whole of the masonry work shall be executed in the manner with joints uniform and not exceeding 1 cm in thickness. Brick work shall be carried out in uniform manner and no portion shall be raised more than 80 cm above another at any time.

In the external brick walls, which consist of two skins, it shall be bonded together with four galvanized metal ties as specified above.

All openings in the external double skin brick walls shall have the external skin with return bricks properly wrapped around the vertical edges of the internal skin and tied to it in the same manner as specified above.

The outer skin shall not return round the top part of the openings and the brick above the opening shall be supported on a lintol of galvanized steel angle of a size appropriate to the condition or as shown on drawings. The galvanized steel angle shall be securely fixed to the concrete beam or supported onto the brick wall according to the particular conditions.

In the bottom part of theopenings in the external double skin brick wall except in door openings, the outer skin brick wall shall return round forming a sill with the use of the bricks on edge as on drawings.

All damp-proof courses and flashings in walls shall be of qualities conforming to the latest B,S. or equivalent.

The Contractor shall guarantee the complete watertightness of the damp-proof courses and the watertightness of the external masonry work and shall provide everything necessary to achieve this. Any leak and consequential damage are to be made good at the Contractor's expense to the satisfaction of the Engineer's Representative.

6103.8 SETTING AND BUILDING-IN

The Contractor shall build in all items occurring in any type of masonry construction shown and/or specified to be furnished under this specification, and/or the Engineer's Representative. All built-in work shall be accurately placed, securely held in position, and located as directed.

The Contractor shall set and build-in all items of miscellaneous iron,, steel such as lintols, seat .angles, sills,, frames, sleeve inserts:, anchors,, sleeves for pipe railings ... etc. where shown or directed, to be built in the masonry. Unless otherwise specified, the Contractor shall set and build in anchors and bolts required for attaching, the work of others to masonry.

6103.9 CLEANING AND POINTING

Bricks or concrete blocks to be used for fair face work shall be selected, sharp edged, and of qualjity good enough to be used for fair face work in addition to other items in this specification. The work shall be performed in as clean a manner as possible, removing excess materials and mortar droppings promptly from connecting or adjoining work before its final setting.

6103.10 EXPOSED WORK

All joints of exterior exposed masonry shall be pointed as work proceeds and shall be of the recessed type as shown an drawings The bed joints shall be finished 5 mm in depth from the smooth surface of the works. After the face masonry shall be pointing, brush cleaned, taking care the surface. not to damage

The surface masonry blocks and brick work shall be thoroughly cleaned, and left free from mortar ins *or* mortar splashes sta with tight mortar joints After cleaning the surfaces throughout. shall be rinsed with clean water.

6103.11 CONTROL JOINTS

Control joints in masonry concrete block and brick work for relieving contraction and other stresses shall be made by pro viding vertical separation through the wall thickness. Vertical separation shall be made by placing building felt continuously in the joint on one side and the cor^ at the joint shall be filled with mortar; horizontal reinforcement if existent shall be interrupted at that joint. The joint shall be watertight completely.

The placing, of control joints shall be at approximately 15 m center to center unless shown on the[drawings. The position-of control joints shall be co-ordinated, with the position of ex-pansion jo.i.nts on .the building.

6104 MORTAR

6104:1 DELIVERY AND STORAGE

The Contractor shall deliver cement, lime, juss and other manufactured materials in unbroken bags, barrels, packages, or other approved suitable containers, plainly marked with manufacturer's name and brand.

The materials shall be delivered and handled in a manner to prevent inclusion of foreign materials and damage of materials by water or breakage. The materials shall be delivered in ample time to facilitate inspection and tests.

The material subjject to damage by elements in their original unbroken packages or containers shall be stored in a manner to prevent damage and permit identification.

Perishable materi bis shall be stored and protected in watertight structures on floors raised approximately 30 cm above adjoining level, for short i able htervals of time, cement may be stored on suit-tfbrms suitable raised platforms when covered with waterproof tarpaulins.

Aggregates shall be stored in clean bins, scows, or platforms having hard, cleaip surfaces. Foreign materials shall be excluded from stored aggregate. Aggregates of different kinds and sizes shall be placed in different stock pile
The Contractor shall remove from site any material that damaged material and any maternal that shall not fulfill the test requirements of this specification.

6104.2 WATER

Water shall conform to Clause 5403,

6104.3 CEMENT

Cement shall conform to Clause 5403. Standard Portland cement shall be used, fresh stock approved by the Engineer's Representative. Only one brand shall be used in the exposed work of the entire project. For works below ground level, unless otherwise specified by the Engineer's Representative, sulphate resistant, cement shall be used.

6104.4 LIME

Hydrated lime sh.al 1 "conform to the requirements of ASTM ' C-207 Type S. or equivalent.'

6104.5 SAND

Sand (fine aggregate) for general use im mortars and setting beds exceeding 1.25 cm thickness shall conform to the latest issues of ASTM C-33 or equivalent.

Sand (fine aggregate) for general use'in mortars, grouts, and setting beds 1.25 cm or less in thickness shall conform to the latest issues of ASTM C-144 or equivalent.

Fine aggregate for use in mortars at joints less than 0.65 cm thick shall have not less than 100 % passing a 2.5 mm (No. 8) sieve, 95 % passing a 1.25 mm (No. 16) sieve, and not less than 20 % nor more than 40 % shall pass a 0.3 mm (No. 50) sieve.

Tests mentioned in the relevant standards shall be carried out on all types of cement, lime, and sand by the Contractor's laboratory or an independent laboratory at the Contractor's expense. The results of the tests shall be turned over to the Engineer's Representative.

6104.6 ADMIXTURES

Water-repellent admixture for mortar may be used. The admixture shall be a paste compound and shall increase the workability of the mix and promote proper hydration without accelerating the setting action. Compounds shall be used in proportions and manner prescribed by the manufacturer and shall meet with the approval of the Engineer's Representative.

6104.7 CEMENT MORTAR

Mortar for laying all units shall be composed of Portland cement, hydrated lime, and sand, and shall conform to ASTM standard C270 Type N or equivalent.

It shall be proportioned as follows:

Portland cement (Sulphate Resistant Cement for sections below ground level):	1 Volume .
Sand:	4 Volumes'

The grading of the.sand shall be within.the limits given below.:

Sieve Size	mm	Percentage by Weight
3/16"	4.80	100
No. 7	2.50	90 - 100
No. 14	1.25	70 - 100
No. 25	0.68	40 - 100
No. 52	0.28	5 - 70
No. 100	0.15	0-15

An addition of 5 kg of hydfated lime may be added per 50 kg of cement to make a more workable mix.

Mortars shall be mixed on an approved mechanical batch mixer in which the quantity of water can be accurately and uniformly controlled.

For work requiring only small batches of mortar or grout, however, or when specifically approved by the Engineer's Representative, mortar may be mixed by hand. Hand mixing shall be done on a tight metal or wooden- platform in such small quantities as may be required. Hand mixed mortar shall have the required plasticity before used in the work.

The mixing time shall not be less than 5 minutes, approximately 2 minutes of which shall be used for mixing the dry materials and not less than 3 minutes for containing the mixing after the water has been added. The quantity of water shall be in such a manner to suit the moisture content of the sand and to result in satisfactory workability of the mix and producing the required plasticity.

Partially set mortar *or* mortar which has been worked up or has been mixed for a period longer than half, an hour shall not be used in the work.

Mortars for poured grouting and poured fills shall have increased quantity of water to produce the consistency required for pouring the mix, and shall be stirred continuously to prevent aggregate segregation.

Mortar for pointing shall by prepared with dry consistency to produce mortar sufficiently plastic to be worked into joints.

When mortar is to be coloured, it shall be mixed as specified, except that when quantity of colouring required to be used amounts to over 2 percent by weight of cement specified, cement

volume specified shall be increased for particular mix by volume equivalent to that of added colouring. After "exact amount required has. been determined, dry. pigment or other col ouri-ng. shall be weighed or dry mixed, into each sack measure.of cement before cement is introduced into mixer,

6104.8 JUSS MORTAR

Juss mortar shall be used with clay bricks in places specifically indicated on the drawings, and above damp proofing course.

The juss shall be of the best available quality. It shall be stored in proper manner avoiding dampness and when used shall be properly mixed with the right proportion of water to produce a workable mix.

Juss that has been damaged due to dampness or being not new *or* for any other reason shall be rejected by the Engineer's Representative.

The juss shall conform to Clause 6106 of this specification.

6104.9 EXPANSION JOINTS

Expansion joints shall run through the roof and walls of the building to the ground level.

Expansion joints between two concrete faces or brick faces shall be formed where indicated on the drawings and shall be made with 1.0 cm thick "Flexcell" *br* other approved jointing material. The jointing material shall be kept back from the face by 2.0 cm and the recesses formed shall be primed and sealed with an approved mastic sealing compound.

The jointing material shall be.compressible and resistant to weathering and extrusion. The mastic sealing compound shall be strongly adherent to concrete and sufficiently extensible to accommodate joint movements at low temperatures without cracking, and does not become so soft as to lose its characteristic in hot weather.

Some expansion joints shall incorporate a rubber waterstop which shall have an ultimate tensile strength of not less than 2000 lbs per square inch (141 kg per sqicm,) and have an elongation at break of not less than 250%.

ATI sealants in joints subject to water-and water pressure shall be'of a type and used, in such a manner that they will not deteriorate following prolonged immersion in water, and the Contractor will be required to produce a guarantee from the manufacturer that the material is of such- quality.

Before the joint sealing compound is applied to a[1].joint, great care should be taken to remove all- sand and other foreign .matter, and the exposed surfaces of the joints shall be prepared in accordance with the manufacturer's instructions. Unless modified by the Engineer's Representative, the manufacturer's recommend-ations regarding the application of joint sealing compounds shall be rigidly adhered to.

All expansion joints shall be watertight. All cutting of joint filler to shape shall be carried out either by the manufacturer before delivery or by the Contractor on site, but in either case all such work shall be carried out with extreme care to ensure that the cut sheets of joint filler are of the correct size to permit proper sealing of the joints.

6106 PLASTERING

6106.1 CEMENT RENDERING

Surfaces to be rendered shall be free from grease and shall be thoroughly cleaned with wire brush soaked in water for at least 24 hours before the coat is applied. Surfaces of reinforced concrete columns and beams shall be chipped and humidified so as to increase adhesion of the cement coating.

The coats of rendering shall be composed of cement and sand mix in the ratio 1:3. An addition of 5 kg of hydrated lime may be added per 50 kg of cement to make a more workable mix. The cement used shall be in accordance with Clause 5403. The sand shall be hard, durable, clean, free from adherent coatings such as clay. The grading of the sand shall be within the limits stated below:

mm Sieve, Size		Percentage by Weight Passing B.S. Sieve .First Coat	. Finish.Coat
4.80	3/16"	10	100
2.50	No. 7	90 - 10	90 - 100
1.25	No.-14	70 - 10	90 - 100
0.68	No. 25	40 - 80	55 - 100
0.28	No. 52	5- 40	5 - 50
0.15	No. ,100	0 - 10	0 - 10

The above grading of sand for the- finished coat, may be mode-fled to suit certain texture finishes.

Two. coats of cement rendering shall be applied. The'first coatshali be applied to the clean wet surface,by means, of a trowel, and be .siightly .combed- with a wire or wooden-scratcher. It shall be kept moist with a. fog spray for two days, and then be; allowed to dry out.

The finish coat shall not be applied until the first coat has been seasoned for 7 days. Just before the application of the finish coat the first coat shall aqain be wetted evenly with fog spray. Where cement plaster with a smooth trowelled finish is specified or indicated on the drawings, the finish coat shall first be floated to a true and even surface then trowelled in a manner that will force the sand particles into the plaster, with a final trowelling to leave the surface burnished smooth and free from rough, areas, trowel marks, checks, and other blemishes. In all other areas where a smooth finish is not specified, the finish coat shall be floated to a true and even surface with a uniform texture, and it shall be given specific colours as approved by the Engineer's Representative. It shall be made up of two.volumes of near white sand and one volume of coloured cement. Sand shall be so graded that approximately 90 % lies between the 0.63 and 0.3 mm (Nos. 25 and 52) sieves.

The finish coat shall be kept moist with a fog spray for at least 2 days, and thereafter shall be protected against drying until it has been properly and thoroughly cured. The total thickness of rendering shall be not less than 1.5 cm. All adjacent surfaces of the finished work which could be stained or damaged shall be adequately masked..

6106.2 CEMENT LIME PLASTER

All surfaces to be plastered shall be free from grease, oil, loose material, etc., and everything which may interfere with the adhesion of plaster work, and shall be thoroughly cleaned with wire brush soaked in water. Surfaces of reinforced concrete columns and beams shall be chipped and humidified.so as to increase adhesion of the. cement coating.

The cement and sand shall conform to the description above.

The lime shall be of pure calcium: carbonate, .properly burned, and shall be stored upon arrival at the site in dry sheds with raised floors and water proof walls and roofs. Any lime found to have been damaged-as a result of exposure to moisture or air during transit or storage will be rejected. The hyd-rated lime shall conform with ,ASTM C-207, Type S or equivalent.

A preparatory coating of 1:1 sand cement slurry shall first be applied to the clean' wet surface by vigorous' brushing and immediately strippling with a banister brush- or simfTar to

form a closed textured key. This "preparatory coat shall be - allowed to harden thoroughly for 3 to 7 days, depending, on weather conditions. During this'period it. may be necessary, to Tightly." spray the coating with water to prevent rapid curing,

Plastering shall then be carried out in three-coat work, with mortar of 1 volume Portland cement to DIN 1164, 2 volumes hydrated lime to DIN 1060 or to B.S. 89, 8 volumes'sand to DIN 1179 or to B.S. 1199.

The first coat shall be about 0.8 cm thick, and shall be so applied to maintain maximum adhesion and coverage. It shall then be combed with a wire brush or wooden scratcher to provide a key for the second coat. A minimum of 4 days interval shall be allowed before the application of the second coat.

The second coat shall also be 0.8 cm thick and shall be applied to obtain a plain surface with all the internal angles plumb and square. It shall be keyed to the first coat and left for a minimum of 4 days before the.application of the finish coat.

The finish coat shall be applied as thinly as possible with a maximum thickness of 0.5 cm, and shall be brought to a smooth trowel finish and allowed to dry.out to a uniform colour.

The total thickness of the finished plaster work shall be not less than 2 cm.

All cracks, blisters and other defects shall be cut out to a rectangular shape with edges undercut to form a key and shall be finished flush with faces of surrounding work.

The whole of the plaster work shall be brought to a smooth even surface ready for decoration.

6106.3 JUSS PLASTER

All surfaces to be plastered shall be prepared as specified above.

The juss shall be pure calcium sulphate from the mechanical juss factory in Baghdad or of equal approved quality, and shall be delivered to the site in sealed bags. All underburnt or overburnt juss shall be rejected and the Contractor shall provide facilities for each batch of material to be checked and tested on the site to the satisfaction of the Engineer's Representative. The juss shall be kept in proper sheds on site exactly as described for lime above.

A preparatory coat, of 1:1 sand cement slurry shall be applied to the clean, wet'surface by vigorous-brushing and immediate strippling with a banister brush in order to form a close textured key.

Two coats of juss' shall "be applied-. The first coat shall be . applied, evenly and.with, sufficient material and pressure to form a good .bond .with-:the underlying surfaces.. The. surface shall then" be rodded and floated to a.true even plane, then . roughened slightly, with a stiff bristled brush.,

The second coat of smooth white finish shall be applied by trowel as soon as the first coat is firmly set and before it is dry. (If the first coat is thoroughly dry, it shall be wetted evenly by brushing or spraying). As the finish coat sets and shrinks, it shall be thoroughly and uniformly packed and compressed by heavy scouring with trowel. The material shall be allowed to shrink between scouring .operations, and additional water shall be brushed on as required. The scouring shall be continued until a smooth dense surface is obtained. Total thickness of plaster shall not be less than 2 cm.

6107 PAVING AND FLOORING

6107.1 GENERAL

All pavings outside of the buildings, e. g. roads, parking areas, footpaths, shall be performed in accordance with Part 3 of the Specifications and as shown in the drawings. This pavements will be paid with the relevant pavement items and are not included in the lump sum of the rest area.

The ground under all paved areas within the buildings shall be levelled and compacted to 98 % of the modified AASHTO density.

On this compacted earth a layer of 8 cm concrete Bn 50 shall be poured. The surface of the concrete shall receive a damp proof course as shown on the drawings.

Where tiling is to be used a concrete layer of. 10 cm thickness of concrete Bn 150 shall be laid. The surface of this concrete shall be in level and shall be combed with a wire brush to receive the tiles. On this base the tiles shall be laid as indicated on the drawings and described in Clause 6108.

6107.2 CONCRETE FLOORING

Where a concrete floor finish is specified for the concrete floor slab, the top 2 cm of the floor slab must be made of cement screed, smoothly and evenly surfaced and formed into pattern when required by the Engineer's Representative.

All floor slabs are-t.o be concreted in any case over a damp . proof coarse 1 aid', on .8 cm. thick 1 ean co.ncrete blinding of Bn-.50.

Roof slabs surfaces shall be floated and trowelled as necessary to provide a sufficiently smooth surface free from objectionable irregularities and suitable for application of,membranes, insulation or roofing material, as required.

6107.3 LIQUID HARDENER

Liquid floor hardener shall be applied to exposed interior concrete floors, and separate cement topping finishes, which shall be exposed in the completed work. The manufacturer's certificate of materials compliance and application directions shall be submitted to the Engineer's Representative for approval.

Solution shall be applied generously to cured and thoroughly dried concrete floors in at least two applications in strict accordance with the manufacturer's printed directions until no more will be absorbed.. Encrusted salts shall be removed by mopping with clean water after last application has dried for not less than 72 hours.

6108 FLOOR AND WALL TILING

6108.1 GENERAL .

The work in this section includes the provision and installation of terrazzo tiles, cement tiles, ceramic tiles,.etc., including all necessary special shapes and trim pieces, as indicated on the drawings and in the specification,

The Contractor shall submit samples of all types of tiles to be used in the works to the Engineer's Representative for approval and before the delivery of the material on the site, any tiles with chips, cracks or any other defects shall not be used on the job.

Where required, the Contractor shall submit shop, drawings., of terrazzo.tiles,, cement tiles,- etc., showing details of construction, anchorage and setting.. Colour offloor cement tiles, floor terrazzo tiles and wall ceramic tiles shall be specified :. on the drawings or they shall be. chosen by the Engineer's Representative on the submission of. samples by the Contractor in the case of no specification of colours on the drawings.

Floor, skirting and corner tiles shall be flawless, sharp edged, and without cracks. The upper and side surfaces shall be perfectly flat, finely grained, and colours approved by the Engineer's Representative.

Well soaked tiles shall be laid with 1:3 cement mortar used to fix the tiles, and the tiles shall be well laid and levelled and shall be grouted with a 1:1 cement mortar. Joint widths shall be kept to a minimum.

As soon as the floor tiles are laid, they shall be protected with a 2 cm thick layer of saw dust or sand, which shall be removed upon completion and the tiles shall be thoroughly cleaned.

Sand for setting floor beds and base coats for walls shall be well graded, passing 2 mm (No. 8) sieve with not more than 5 % passing a 0.15 mm (No. 100) screen. Sand for grouting shall be screened to pass a 0.5 mm (No. 30-mesh) sieve with not more than 5 % passing a 0.15 mm (No. 100-mesh) screen.

6108.2 CEMENT TILES

Cemet tiles shall be the best grade product of a local manufacturer with strength characteristics and appearance as approved by the Enigneer's Representative. The cement tiles shall be of a uniform size not less than 20 x 20 x 2 cm thick. The upper 0.5 cm of the tiles shall consist of a mixture of fine sand and cement (the quantity of cement being at least 650 kg. per cubic meter of sand) with a colouring material added. The upper surface shall be homogeneous and smooth and shall have a colour approved by the Engineer's Representative. The lower part of the tiles shall be a mixture of cement and sand, the quantity of cement being at least 450 kg. per cubic meter of sand. The tiles shall be made by means of a hydraulic press developing compressive force of at least 200 tons.

6108.3 TESRAZZQ TILE'

Terrazzo tiles shall be first grade tile of the mechanically compressed type. Tiles shall be 25x25x2.5 cm in size, unless otherwise indicated on the drawings, well shaped with straight edges, perfectly flat, free from defects which affect appearance or serviceability.

The upper 7 mm shall consist of a mixture of approved marble chunks and coloured cement at a ratio of 650 kg. per cubic meter of chunks. The Tower part shall be a mixture of cement and sand; the quantity of cement being at least 450 kg. per cubic meter of sand.

Marble aggregate exposed on a given surface shall be of amounts to provide exposed aggregate equal to approximately 70 % of the total surface. .

Marble chips shall consist of 50 % of the pieces of which the minimum dimension exposed shall be 1.5 cm and the maximum dimension exposed shall be 5 cm, 30 % shall be made of pieces of which the minimum dimension exposed shall be 6 mm and the maximum dimension exposed shall be 1.5 cm, and-20 % shall be made up of marble screedings.

Cleaning compound for cleaning of terrazzo shall be an approved neutral chemical cleaner free from acids and strong alkalis or other material that will affect the colour or otherwise damage the terrazzo.

Colour pigments shall be pure mineral oxides ground finer than cement or pure lampblack carbon.

Expansion joint filler shall be foam plastic or any equivalent joint material, of proper thicknesses.

Sealing of terrazzo work shall be of a nature to produce a waterproof film, seal moisture, and not yellow the terrazzo or leave a tacky finish.

Mortar colour pigments shall be of high purity, chemically inert, unfading, alkali-fast mineral oxides, finely ground specially prepared for use in cement and lime mortars. Used as per manufacturer's printed installation directions. Colours shall be as selected by the Engineer's Representative.

6108.4 GLAZED CERAMIC^ WALL.TILING

Shall' be. glazed' earthenware complying with the. current B,S. (or. approved equal),, and shall be of a uniform size approximately 15x15x0.5 cm'thick. They shall be homogenous, flawless, sharp edges, and free from cracks. The upper surface . and sides shall be perfectly straight and flat.

The tiles shall be backed first with a coat of 1/3 cement mortar (to act as a foundation' coat) not less than 6 mm in' thickness. The first coat shall be scratched or deeply scored, A second layer shall be set by trowelling on the first coat or to the back.of tile, and immediately the tile shall be floated.

Joints shall be straight, level, perpendicular and of even width not. exceeding 1,5 mm. Vertical joints shall be maintained plumb for the entire height. All joints shall be grouted with a 1:1 sand cement mortar using white cement, *or* with added colour according to the colour of the tiles.

The Contractor shall include for all necessary core tiles, angle heads, core heads, internal heads, core base, spacing trims, etc. Only first quality glazed tiles shall be employed.

6108.5 TERRAZZO TREADS, TERRAZZO TILES AND CEMENT TILES .

Lightweight concrete fill or concrete fill below setting beds, as indicated on the drawings, shall be installed according to Part Five of this Specifications.

Setting beds for treads and tile shall be composed by volume of one part gray Portland cement to three parts dry s.and, or four parts damp sand, to which not more than 10 percent of hydrated lime by volume of the cement may be added and mixed with minimum amount of water necessary to produce a workable mass. Setting beds thickness shall be as' indicated, but- in no case less than 20 mm thick. Water repellent admix may be added in accordance with manufacturer's recommendations to all mortar for use at cement tile set over roofing membrane, or the fill above same. Setting beds shall~not be laid over concrete until end of curing period, as specified in Part Five, to allow time for initial concrete shrinkage to take place.

Setting beds for treads and.tiles shall be installed with their respective surfaces screeded and tamped to true planes, level or pitched to drains as required by the drawings. Retampering of mortar will not be permitted. Tiles shall be laid" out with a minimum of cut units. Base pieces shall be installed over.full . back beds of mortar.

A 6 mm wide approved joint-filler strip shall be provided between tile flooring and fixed vertical surfaces where indicated. Expansion joint.filler shall be. similar to type specified. above.

Joints between tiles shall be of uniform width. Fractional changes in dimensions without varying the uniformity of joint width will be permitted.

Tile shall be cut with a suitable cutting tool and rough edges shall be rubbed smooth. Cut misfits shall be replaced with properly cut units. Straight edges shall be accurately set to the lines established, and reset at suitable intervals to keep the joints parallel over the entire area. Units shall be. laid to the straight edges. Cut units shall be kept to a minimum.

Tile installed over exterior concrete slabs shall be provided with a continuous joint-filler strip the full thickness of the setting bed a maximum of 6.5 mm on centers both ways. A similar 1.2 cm wide strip shall be provided one tile back from face of fixed vertical surfaces.

Unless otherwise specified, only as large an area of setting bed shall be spread at one time as can be covered with tiles before the mortar has obtained its initial set. Surplus, mortar shall be removed, and the setting beds shall be spread, tamped to force out air pockets, and screeded to a true plane, sloped to drains or levelled as shown on the drawings.

As soon as the setting beds for the terrazzo tile, and cement tile has set sufficiently to be worked upon, a dust coat of dry Portland cement, not more than 1.6 mm thick, shall be . sprinkled over the surface and lightly worked with a steel trowel. Laying shall begin as soon as the moisture, not free water, has penetrated the dust coat, A thin skin coat of neat Portland cement grout shall betrowelled or brushed into the backs of treads and tiles immediately before laying. Treads and tiles shall be laid on the freshly prepared setting bed while the surface" is still plastic and the tile then tamped into the mortar to ensure solid bedding to the exact slope or level of finished floor surface.

Expansion joints shall occur directly over the joint filler strips called for in setting beds of.exterior installation, and shall be 1.2 cm wide continuous, and shall be.the full thickness of the tiles. Joint backing and puring-grade sealants •willbe installed-''as specified below.

When the installation has hardened sufficiently,. misplaced treads and tiles shall be repositioned and'reset., and damaged or defective treads and tiles shall be replaced. A,thick creamy slurry (semi-fluid mixture) of neat waterproofed white Portland cehient and a-minimum amount of water.shall be brushed over the floor installations until all joints are thoroughly filled. The surface. Of the floor shall be every gently rubbed

with a wood block' to' bring'surfaces to true planes* excess. slurry, shall be removed,, and-the surface: s-ha/ll be rubbed with burlap, to., clean the tiles, and finish, the joints-. Th.e Contractor, at his. own option, ˙may add fine-white, sand to the pointing grout, up to a proportion of one part white Portland to two. parts' fine white sand. If coloured pointing grout, is specified, cement colour shall be added as directed by the Engineer's Representative.

All finished tile and tread work, except cement tiles-installed on sand beds, shall be covered with waterproof paper'with all joints lapped at least 10 cm, and the laps tape-sealed or held down with.planks or other weights, and allowed to damp cure for at least.72 hours before foot traffic is permitted. Alternate methods of curing may be employed by the Contractor upon approval by the Engineer's Representative. Curing materials shall be non-staining.

Terrazzo treads and tiles shall be finished in the shop after proper curing by machine grinding to a true even surface, using various grades of abrasive stone as required. After the first grinding, grouting shall be done thoroughly with the some cement and colour composition as specified. Grout shall be of the consistency of thick cream, and shall be brushed over the floor to eliminate all trapped air and also to thoroughly fill the surface for final grinding.

The grouting shall be removed by grinding not less than 72 hours after application.

The grit-or other abrasive used in the grinding machine for later stages of grinding, shall be of grain or fineness that will give the surface a honed (very smooth) finish.

Surfaces which cannot be properly worked by machine.shall be rubbed by hand.

6108.6 INSTALLATION OF CERAMIC WALL TILE

Setting beds for tile shall be applied to concrete block or brick work. Setting beds shall be composed by volume of one part Portland cement, to one-half part hydrated lime, to four parts dry sand, or five parts damp sand, mixed with the minimum amount of water necessary to produce a workable mass. It shall be applied in sufficient quantity and with sufficient pressure to cover well the entire area and form a good key, and brought out flush with temporary screeds or guide strips so placed as to give a true even surface at the proper distance from the. finished face of tile. Setting beds shall not be less than 1.25 cm nor more than 1.9 cm thick.

Joints shall be straight, level and perpendicular, and of uniformv width' throughout. Vertical joints "shall be. plumb.. for the entire height of the tile work. Each tile shall be brought to a true level and plane surface by

applying uniform pressure under, a straight-edge or rubber-faced block. Damaged or improperly set tiles shall be replaced.

Tile shall- be thoroughly soaked in clean water and drained so that no free moisture remains on back of tile, prior to setting.

Wall tile shall be set by trowelling a skin coat of neat Portland cement on the setting bed or by applying a skin coat to back of each tile unit and immediately floating the tile into place.

Immediately after a sui-table area of tile has set, joints shall be grouted full with a plastic mix of neat Portland cement. If desired, the Contractor may add fine, white grouting sand up to an amount equal in volume to the Portland cement. Joints shall be wetted before application of the grout. Maximum grout shall be forced into the joints by squeegee., brush or finger application. Joints shall be tooled slightly concave to the edge of the cushion, and excess grout shall be wiped from face of tile. No mortar shall be allowed from setting bed to show through the grout. Grout shall be roughened and replaced immediately if any depressions that appear along the face of a grouted joint once the surface has been cleaned. Joints between tile and plumbing fixtures or other built-in items shall be pointed with white caulking compound, as approved be the Engineer's Representative. Colour of grouting and caulking shall match the colour of the tile.

After grout is thoroughly set, .the tile shall be sponged and washed thoroughly, diagonally across joints, and polished with clean dry cloths. Acid cleaners will not be permitted.

Joints shall be kept continuously damp for a period of at least 72 hours after applying grout.

6109 PROTECTION, WATERPROOFING & THERMAL INSULATION

6109.1 TERMITE PROTECTION

All buildings must be protected against termite attack. An approved mixture of .poisonous materials must be used according to the manufacturer's instructions and with the approval of the Engineer's Representative,

6109.2 CAULKING AND. SEALING

All exterior and interior joints- in 'connection with masonry-, concrete, door frames, etc., control and expansion joints and all other junctures of materials of like or dissimilar character, requiring sealing, for weather tightness *or* to'permit movement, and all interior joints .and fixed joints, requiring caulking for dusttight and sanitary conditions of the building construction.

All joints greater in depth than the thickness of sealing and caulking compound as specified shall be backed up with extruded form material or any approved alternative. All expansion type fillers, and concrete paving and concrete floor joint work shall

be as specified under other sections of the Specifications.

The Contractor shall submit for the approval of the Engineer's Representative, before commencing application, samples of all sealing'and caulking materials to be used on the job together with the standard pressure gun tubes to be used for interior and exterior caulking and samples of the joint backing material.

Before proceeding with the" work, the Contractor shall install a sample for the approval of the Engineer's Representative of each type of work on the job.

All material shall be delivered to the site in their original containers with unbroken seals, and bearing their identity labels. For each class and type of work, one type of material shall be used throughout the work.

Exterior caulking shall be used in exterior joints except as otherwise indicated on the drawings or specifications. It shall be one part and of approved standard. Colour of exterior caulking compound shall be white or concrete gray or other standard colour, as. shown on the drawings and approved by the Engineer's Representative.

Pouring grade sealant shall be two parts hard set and shall be used for all joints in roof tile and other locations indicated. Colour shall be white or concrete gray, as selected by the Engineer's Representative. The sealant shall meet approved __. ' standards.

Gun grade sealant shall be used at all transverse building expansion joints and other locations indicated, and shall be two parts soft set, gun grade, colour shall be white or concrete gray as selected by'the Engineer's Representative. The sealantshall meet approved standards.

Inerior caulking compound shall be used at .all interior locations including inside faces of metal windows and metal louver frames, except.where other sealant is indicated. And it shall be used for bed caulk'ing of perimeters of hollow metal work, for caulking of exterior metal thresholds, and for other

locations indicated. Interior caul king compound shall be a synthetic resin-type compound, and-Shall "meet the.approved standards. Colour shall be selected by the Engineer's Representative from munafucturer's standard colours to match the interior colours.

All primers used in the preparation of the substrates shall be.of approved non-yellowing type furnished or recommended by the manufacturer of the sealing and caulking materials. The primer shall be checked for yellowing, dirt pick-up and compatibility with the substrates. The Contractor shall submit to the Engineer's Representative samples of primers with manufacturer's certification for its use with the sample of the sealing and caulking materials, for approval.

Bach-up material shall be expanded polyethylene foam or equivalent approved by the Engineer's Representative. The-back-up foam shall be extruded round bars or plank types as required to properly suit the caulking materials.

Surface to receive caulking shall be clean, dry and free of oil, dust and loose particles. Joints shall be wire brushed full^depth in concrete, masonry, mortar or plaster to obtain firm, clean surface. Metal surfaces shall be cleaned with wire brush to remove any scale or other deposits and wiped clean with a mild, non-staining solvent. Other surfaces shall be cleaned by methods approved by the caulking manufacturer.

Mortar joints shall be raked where caulking is to be used as the jointing material.

Continuous lengths of compressible plastic foam joint backing shall be' installed where indicated, or where required to form proper joint depth. Except where otherwise specified, depth of caulking where synthetic resin caulking compound is used shall.be between one and three times the width of the joint, but in[1] no case shall the depth exceed 2.00 cm. Where other. types of compound are to be used, the depth of caulking at joints.not exceeding 1.25 cm in width shall be approximately the same as the width, while the depth of caulking at any joint exceeding 1.25 cm in width shall be approximately 1/2 width of the joint.

Under no circumstances caulking compound is allowed to be placed in direct contact with asphaltic or bituminous materials.

All porous surfaces to receive caulking or .sealing compounds shall be primed, in accordance with manufacturer's printed priming instructions. Only surfaces to receive two-part sealant require priming.

Apply caulking only to clean dry surfaces,.and only when the ambient temperature is 5 C, or higher, at the .time of application.

Application, shall be in strict accordance, with manufacturer's printed application instructions, -subject to the following limitations:-

Caulking shall be applied with pressure guns of type approved by the Engineer's Representative, having nozzle of size to fit-into joints, and material shall be driven with sufficient pressure to fill all voids. Full perimeters of each opening in exterior walls and roofs 'shall be caulked and sealed in continuous beads. Expansion and control joints shall be caulked in continuous, uninterrupted, full length beads. Superficial pointing with a thin bead of compound will not be acceptable. Where use of pressure gun is impractical, hand guns may be used upon the Engineer's Representative's approval.

Exterior metal thresholds and exterior hollow metal rough bucks shall be set in full beds of compound. Excess compound shall be cleaned and joints shall be'pointed.

All finished caulking joints shall be pointed and coved neatly and uniformly smooth and free of wrinkles, waves, sag-lines and other imperfections.

The Contractor shall provide a written guarantee as specified herein, and to include the following requirements as "Standards of Performance" for the sealing work as shown or indicated on the drawings and as specified herein: .

1) No adhesive or cohesive failure in joints or recesses, where movement is under -a maximum of 30% as defined by ASTM Standards for rubber testing, elongation methods.

2) No crazing developing on the surface of the material exposed to the outside.

3) No staining of adjacent surfaces by primer or sealant.

4) No puncture, abrasion or tear failures in self levelling sealant.

5) No excessive dirt pick-up, chalking or colour change on surface of cured sealant.

6) No increase or decrease in Shore A durometer in excess | of .25% of readings taken one month after sealant has cured

6109.3 MOISTURE PROTECTION, WATERPROOFING & DAMPPR00FING

The provisions and' installations of dampproofing, as- shown or indicated on the drawings and as specified herein, shall be applied.

Before commencing with the work,' all surfaces to""which work of .this section is related, shall- be carefully examined and report'shall be done in writing'of .a.l 1 defects, which-would interfere with the. proper application or performance of such work, to the Engineer's Representative. Commencement of application of materials shall be deemed to constitute acceptance of the- surface.

Necessary repairs shall be made to defective surfaces, including, but not limited to, removal of projections which-might punc^ ture the work of this section. Large voids and cavities shall be filled with masonry mortar, as specified under Masonry, after first wetting the void or cavity and slushing with skin coat of neat Portland cement grout..

Membrane waterproofing shall be applied over concrete roof deck and insulation and vapor barrier membrane in constant temperature and humidity rooms as indicated on the drawings.

Coated Base Sheet for built-up membranes shall weigh'approximately 2.1 kg per sq.meter.

Asbestos finishing felt for built-up membranes shall be asphalt impregnated, perforated, asbestos felt weighing at least 3.66 kg per. sq.m, meeting or exceeding AS1M D-655.

Steep asphalt for built-up membranes shall meet or exceed AS1M Specification D-312, Type C or equivalent. -r

Samples of all materials used in waterproofing shall be submitted with manufacturer's data to the Engineer's Representative for approval.

Built-up roof membrane and built-up base flashings shall be applied in strict accordance with manufacturer's printed instructions.

The' concrete surface at supported slabs scheduled to receive the water.proofing membrane and all concrete roof areas not scheduled to receive rigid roof insulation shall be covered with'a single layer.of coated base sheet intended to serve as a cleavage plane, laid dry, without-asphalt, as shown on the drawings. Over this apply the built-up roofing membrane.

Floor areas under.the precast terrazzo tile setting bed in the constant temperature and humidity rooms shall also receive this membrane.

Vapor barrier membrane at constant temperature and humidity rooms shall be carried up the adjacent walls to a minimum height of 20 cm.

Built-up roofing membrane shall be.applied over entire combined surface, of base sbeets and:.concrete slab, hot steep asphalt ' shall be applied at the rate of not less than..1.2 ..kg per s-q. meter per layer of felt. Starting-at one edge a 0.46 meter wide asphalt saturated asbestos felt starting strip shall be put into place. Over this sheet, a 0.914 meter wide sheet of felt shall be hot mopped in place and lapped 0.50 m with- the next sheet; From then on, each sheet shall be laid to.allow 0.43 m exposure on the preceding sheet, hot mopping each into place as the work progresses.' Over the entire surface, third layer of asphalt saturated asbestos felt shall be applied,, fully mopping into place, and lapping each sheet 5.0 cm over the preceding one.

PVC flashings at pipes and vent stacks shall be built onto the roofing membrane as recommended by the materials manufacturer.

Lightweight filling on setting beds or as on drawings shall be done and roof tile shall be installed as soon as practicable , and this work must be carefully coordinated and timed with the work of those trades. If delay is inevitable, roofing shall be applied only as far as two-ply felt application. Then when work is ready to continue, third ply of hot mopped felt shall be applied after carefully cleaning, .patching, and otherwise preparing the original two-ply installation to receive the remainder of the membrane.

Extreme care shall be taken to assure that steep asphalt is applied at temperatures within the limits specified by the manufacturer, and that tfre maximum allowable temperature so stated is not exceeded.

Membrane applied at supported slab areas shall have membrane turned up the abutting walls a mimimum of 20 cm or as on the drawings.

6109.4 BUILDING WITH ADDED EARTH ROOF INSULATION

Concrete slab surfaces must be repaired, cleaned, made free from loose materials, pockets, etc.

Approved form of heat insulation shall be used in one layer approximately (5) cm as on the drawings.

The surface under waterproofing membrane should be primed with asphalt primer conforming to ASTM D41.

Waterproofing, membrane of three layers of. asbestos felt hot mopped with steep asphalt at the rate not less than 1.2 kg. per sq.m par layer of.felt. Asbestos felt should be aspah'lt. impregnated weighing at least 3.66 kg per sq.m or comply
with ASTM D-655. or'equivalent.

"Roof insulation of selected clean earth sloped towards 'the drains must be laid over the insulation, then, concrete- roof paving shall be applied,

6109.5 CONCRETE ROOF ELEMENTS

Concrete elements (slabs, skirting* corners) are to be precast with special care. Waterproofing compound should be added to the concrete mix..All those elements should be absolutely watertight. In certain areas of the roof where precast elements cannot be used, cast in place may be employed with the approval of the Engineer's Representative or as on the drawings.

Precast concrete slabs should be of a size 80 x 80 x 4 cm.

Proportion of cement to aggregate is to be 1:3. Aggregate size will be of 8 mm and Habbaniyah sand should be used. The specification of materials should be according to the specification of materials used in structural concrete.

Slabs should be with sharp edges, right angles, free from cracks and the difference of their horizontal distances should not be more than 5 mm and 2 mm for its thickness.

When drying the slab at a temperature of 37°C and emerging it in water for 48 hours and weighing it, then the increase in weight should not be more than 1 - 1/2 % of its weight when dry.

Required load to break the slab should not be less than 700 kg.[1] when loading gradually at a speed of not more than 10 kg./sec. and loads are acting along the middle line of the slab of 5 cm thick, and the slab is supported on points in the direction of the line of loading and the distance between points of supports is 45 cm.

Concrete elements should be taken from moulds before having 70 % of required strength of concrete.

Setting bed of 2 cm thick dry clean river sand must be laid under the precast elements.

Precast concrete elements (slabs, skirting, corners) are to be laid floating on the sand bed. All elements will have a special edge profile so that, when laid, they form between each other or with the parapet wall (at skirting) a joint of about .2 x 2 cm. The slabs are to be laid properly so.that the resulting joints will be equal and in straight lines that.will divide the roof into a- regular checkerwork. The surface of the slabs will be smooth cement finish.

The joints must-be perfectly dry and all dust, loose' particles to be removed. The surface of the joints should receive a preliminary impregnation of a special primer. (PrimoigoT)' or equal applied with a.thin brush.

After drying, The joints are filled with a special mastic (Mastigas or equal) and pressed with hot appropriate tools.

6109.6 WALL AND FLOOR WATERPROOFING

To each wall, which is to be built upon another wall or on a floor that has not been made impervious to the passage of moisture from the ground, a damp-proof course shall be provided in such positions that it will exclude moisture from the ground from any part of the wall.

AIT walls shall be damp-proofed for their full thickness with

triple-ply bituminous felt of approved type, or as shown on the drawings.

The felt shall be laid over a layer of concrete Bn 50, not less than 8 cm thick, the upper surface of which shall be levelled and smoothed and shall be hard enough and clean before the felt sheets be laid. Lapping of not less than 15 cm shall be used and the lapped edges shall be well attached by a bitumen or other suitable material to be approved by the Engineer's Representative. A second layer of concrete Bn 150 mix of not less than 15 cm thickness shall be laid over,the sheets. A damp-proof material in liquid or powder form, ap proved by the Engineer's Representative, shall be added.

A vertical damp-proofing of bitumen mastic or any membrane . treatment of approved type shall be applied to the outer face of all walls that are in contact with the ground on one face (to a level of 30 cm above the highest water table) and a fair face finish on the other. The bitumen mastic or membrane shall be protected with 12 cm brickwork with cement mortar 1:4.

Where vertical damp-proofing with bitumen mastic is required, all joints shall be well raked out and surfaces shall be made free from dust. The mastic shall be applied in panels 60 cm wide in alternate strips, with chamfered edges, the infilling strips over-lapping the first by 5 cm. A second coat shall be applied in a similar manner, the panels being placed centrally over the joints of the first coat.

A horizontal damp-proofing, of bitumen mastic or, membrane treat ment of approved type shall be used under all floors, which are below the finished ground level unless otherwise shown on the drawings. The damp-proofing shall be laid over a layer of

concrete Bn.50, the thickness of which is indicated-on the-drawings.

Approved damp-proofing materials and flashings shall be used for the roofs. The Tenderer shall specify the kind of materials he intends to use in his tender with the name of the maker and the method of laying.

Bituminous Felt: The base shall consist of a mixture of close-textured and absorbent fibres, saturated with bitumen, coated with oxidized bitumen and surfaced with talcum or fine sand.

Bitumen Mastic: Shall be composed of one part by volume of sand, one part by volume of cement, with 14% by weight of grade 40/50 bitumen, as supplied by the Iraqi Administration of Government Oil Products Distribution or equally approved quality. The sand! and cement shall be mixed on a tray and brought up to a tempe-rature of 175-200 C, the mix being turned over continuously I during heating.

The bitumen shall be simultaneously heated in a separate boiler! to a similar temperature and the cement-sand mix added, and the whole kept at this temperature for half an hour whilst being i continuously agitated by stirring.

Any other substitute to the water proofing material mentioned above such as metallic plaster, waterproofing flintkote treat ment, etc., may be used provided that the applications shall be made in accordance with the manufacturer and approved by the Engineer's Representative.

Waterproofing where required, the concrete shall be water- j proofed with a compound mixture. The compound shall be used in ' strict accordance with the manufacturer's instructions.

Concrete damp-proof course in wall shall be used as shown on j the drawings. The concrete shall be waterproofed with a mixture | of approved waterproofing compound used in strict accordance j with the manufacturer' instructions. The concrete D.P.C. shall j be reinforced.

6109.7 RIGID ROOF INSULATION

Below, the provisions and installation of all rigid insulation on concrete roof slabs as indicated on the drawings and as specified herein, are described.

Samples of insulation material shall be submitted to the Engineer's Representative for approval.

The roof insulation ".shall.-be applied over the waterproofi.ng membrane, it shall. be.5.cm thick as on the drawings„and' shall be of waterrepellent and damp proof material.

6110 METALS

6110.1 STRUCTURAL STEELWORK

All structural steel work shall comply with the Specifications of B.S. or approved equal.

All rivets, bolts, nuts, studs, lock nuts, and washers shall comply with B.S. Specifications or approved equal.

All materials, before being assembled, shall be straightened and freed from twist.

The erection clearances of cleated ends of members connecting steel shall not be greater than 2 mm at end, unless approved by the Engineer's Representative.

Cutting may be effected by shearing, cropping, or sawing. Gas cutting may only be used when specifically authorized in writing by the Engineer's Representative.

All holes in built-up sections shall be drilled through the whole thickness in one operation. Holes through more than one thickness qf material shall preferably be drilled after the members are assembled and tightly clamped together. If the holes are punched separately before assembly, they shall be punched 3.2 mm less in diameter than the required size and then reamed to the full diameter. The maximum thickness of material to be punched shall not be greater than 16 mm.

Holes in connection angles and plates, other than pillar splices, may by punched full size through material the thick-Lenses of which does not exceed 16 mm. No hole shall be formed by a burning process.

Rivets shall be machine driven. Riveted members shall have all parts firmly drawn and held together before and during riveting. Machine riveting shall be carried out wherever practical. All loose, burned or otherwise defective rivets shall be cut out and replaced before the structure is loaded. No straightening of build-up parts of the frame work shall be allowed after riveting.

Washers shall be tapered where necessary to give the heads and nuts of bolts a satisfactory bearing. Every bolt- shall be provided "with" a washer under the nut so that no part of the threaded portion of the bolt is within the. thickness of the parts bolted.

A temporary erection of a frame-work shall be made at the workshops and each piece shall be marked clearly, both by identification and by painting before delivery.

Surfaces, which are to be held in contact by riveting, shall be painted with-,one coat of red lead paint before assembly and the parts brought together while the paint is still wet. The structural steel must be painted with one coat of rustproof paint at the workshop and then receive two coats of oil paint at site.

6110.2 SHEET METAL WORK

Below, providing and installing all sheet metal work shown on the drawings and as specified herein including closures, covers, diaphragm, flashing, etc., is described.

Shop drawings of all work shall be submitted, showing sizes, details, joints, methods of installation, fastenings, and all other pertinent data to the Engineer's Representative for approval. Do not commence fabrication or installation until the Engineer's Representative's approval has been obtained.

6110.3 MATERIAL

Sheet copper shall conform to the requirements of ASTM B5 for composition and to ASTM. B125 for finished sheets. All sheet copper shall be cold rolled (Cornice temper) except where otherwise indicated.

Sheet copper, where it is concealed or exposed to view on the inside, shall be approximately 0.55 mm nominal thickness where not specifically noted otherwise.

Sheet aluminium shall be of 3003-H14 aluminium alloy not less than 16 gauge (1. 52 mm-.), as indicated, on the drawings.

Screws, bolts and other accessories used for. fastening copper, shall, be copper *or* brass. Fasteners for securing aluminium shall be of 2024 aluminium' alloy or stainless steel.

Solder shall conform to ASTM B32, 60% pig lead, 40% block tin. At lead coated copper it shall be 50% pig lead and 50% block tin.

Flux shall be muriatic acid killed with zinc or approved brand of soldering paste.

Sheet metal work, not indicated to be of copper or aluminium, such as closures, shall be galvanized sheet steel of gauge indicated on the drawings.

Samples of all materials used shall be submitted to the Engineer's Representative for approval.

6110. 4 INSTALLATION

Surfaces to be covered with sheet metal shall be in even plane, smooth, dry, sound and free from defects of all kinds. Dirt, rubbish and other foreign matter shall be cleaned off before application work is started.

Workmanship shall be equal to the highest standards of the trade. Workmanship in copper shall be in accordance with' "Suggested Specifications for Sheet Copper Work and Modern Sheet Copper Practices", as published by the American Brass Company or equivalent.

For copper work to be soldered, tin edges on both sides of the copper sheets shall be tinned for a width of 4 cm, soldering slowly with well-heated coppers, heating sheets thoroughly. Ample solder shall be used and sweated through the full seam width, applying!2.5 cm of evenly flowing solder per seam. Allow no fastenings to show in face of finished work. All major component shall be secured with sheet metal cleats.

Work in substantial workmanlike manner shall be constructed [and installed. Ample provision for expansion and contraction shall be made. Completed work shall be watertight. Work formed < - in shop shall not be flattened or altered for convenience of) ' shipping. Where sheet metal abuts or members into adjacent. l materials, the juncture shall be executed in a manner satis- factory to "the Engineer's Representative.

To all copper surfaces embedded in, *or* otherwise in contact with, concrete' or masonry, shall be applied one heavy. brush coat of bituminous paint before installation,

Roofing trade shall be furnished with fully fabricated flashings for pipes and vents projecting through roof membranes, for incorporation into the work.

Upon completion of sheet metal work, all exposed surfaces shall be thoroughly cleaned, removing exposed flux, and neutralizing soldered joints shall be removed by washing with a 5 to 10 percent solution of washing soda,, followed by a thorough rinsing with clean water.

6110.5 TREATMENT OF IRONWORK AND STEELWORK

All cast ironwork, unless otherwise specified or directed by the Engineer's Representative, shall be coated with an approved bituminous solution immediately after manufacture.

All steel and wrought ironwork, except reinforcing steel and unless otherwise specified or directed by the Engineer's Representative, shall be galvanized to the approval of the Engineer's Representative.

Galvanizing shall be carried out after all fitting, chipping, filling and drilling has been completed, and the whole of the metal shall be evenly covered.

The Contractor shall include in his prices for cast iron, wrought iron and steel work, the cost of coating or galvanizing as specified above.

6110.6 MISCELLANEOUS METAL WORK

A list of major miscellaneous metal work items is described here. This list is for the Contractor's convenience and to set standards. Omissions on the list do not .relieve- him of the responsibility for providing all miscellaneous metal items necessary for the complete job as shown or implied on the drawings.

Samples are required of all items specified under this Section. No work shall be installed until approval has been received in writing.

Shop drawings are required for all installations under this clause. No work of this clause shall- be delivered to the. site until shop drawings have been finally approved for the item in question.

Measurements in the , field shall be verified as required for work fabricated to. fit job Conditions:

Before starting work, adjoining work on which work is in any-way dependent shall be examined for perfect workmanship and fit. Such corrective work to adjoining work shall be done as may be necessary to make work in all respects perfect.

The Contractor shall obtain measurements at the buildings, and not from scale drawings, for constructing or *fabricating* all items which are to be fabricated elsewhere, and as required to make all parts of the work fit accurately together and to meet the existing conditions at the project.

The Contractor shall be fully responsible for the accuracy of such measurements and for the proper fitting of this work into the 'project.

The work under this Section shall be completely coordinated with the work of other sections. Both dimensions and work of other trades, which adjoin materials of this Section, shall be verified before the installation of items herein specified.

The Contractor shall obtain all necessary templates and patterns required from other trades for the proper execution of the work of this Section, and shall furnish to other pertinent trades all items included under this Section that are to be built into structural or other work of other sections, and supervise and be responsible for the proper location and installation of such built-in work.

Structural steel shapes shall be rolled from new billets. Such steel shall be made by the open-hearth process.

Castings shall be of best quality soft gray iron, entirely free from defects impairing strength, durability or appearance.

All workmanship must be first-class in all respects, and any members not presenting a finished and workmanlike appearance will be rejected. All finished members shall be free from twists, bends or other distortions and open joints.

All members shall be true, to length so that assembling may be done without fillers except .where, same are required as detailed. There shall be no projecting edges or corners where different members are assembled. All coping, blocking and mitring shall be done with care.

The AST.M Standards referred to below shall be those of the American Society for Testing Materials, and are published

in "Compilation' of ASTM Standards in Building Codes", available through the ASTM.

Materials used in this work shall meet the requirements hereinafter specified. Gauges for plate and sheet iron or steel are the minimum acceptable.

All structural steel shall conform to the requirements of the ASTM Standard Specifications for Steel for Bridges and Building, Designation A7 or A36, current edition. Rivet steel shall conform to ASTM A141 or equivalent.

All details and connections shall conform to AISC Specifications. Shop connections shall be riveted or welded. Welds shall conform to the requirements of approved standards. Filler metal shall conform to the current applicable ASTM Specification or equivalent. Connections shall be as detailed.

Structural steel shall be in accordance with Section 58 and/ or 59 of this Specification.

Bearing plates and clip angle anchors shall be provided for all steel beams bearing on masonry or concrete, unless otherwise noted.

Iron castings shall be of good quality, strong,-tough, even-grained cast iron, free, from scale, lumps,, blisters, sand holes, and defects of every nature, which would render them unfit for the service for which they are intended. Castings shall be at least Class 25, conforming to the ASTM Standard Specifications for Gray Iron Castings, Designation A48-48 or equivalent.

Steel pipe shall conform to ASTM A53 or equivalent, full standard weight, galvanized- for-exterior work.

Wrought iron in forms other than pipe shall conform to the ASTM Standard Specifications for Rolled Wrought Iron Shapes and Bars, Designation A207-39, or the ASTM' Standard Specifications for Wrought Iron Plates, Designation A42-55 or equivalent or shall be approved corrosion-resistant metal.

Steel bo-lts and nuts shall conform to ASTM B6 or equivalent.

Other materials required shall be of highest commercial quality and shall comply with the applicable requirements of applicable ASTM Specifications or equivalent and as hereafter specified.

All -materials shall be new.

6110.7 CONNECTIONS, FITTINGS AND DETAILS

All details and connections shall be. Carefully made and fitted and special care shall be exercised to produce a thoroughly neat and workmanlike appearance. All projecting corners shall be clipped and all filler pieces shall be made flush.

All lugs, clips, connections, rivets, bolts, etc., necessary for complete fabrication and erection shall be provided.

All items that are to be built into or anchored into the masonry *or* concrete shall be completely fabricated and shall be complete with bolts, anchors, clips, etc., to engage with adjacent construction.

Field connections shall be bolted unless otherwise noted or specified. Shop connections shall be riveted or welded unless otherwise noted or specified.

There shall be no burning in the shop or field without the permission of the Engineer's Representative. If consent is given, burned members, shall be finished to an acceptable appearance, which shall be the equal of a sheared finish. Burning of shapes to length in the shop shall be done with a standard flame cutting machine.

Burning of holes will not be permitted in the shop or in the field.

6110.8 PAINTING

Priming paint shall be a product of a manufacturer approved by the Engineer's Representative, and shall meet the following specifications:-

Pigment	-Not less than 60% by weight *on* paint
	Read Lead Not less than Metallic Aluminium 55% by weight . 7 inc. Dust on paint.
	Remainder: Suitable extenders..
Vehicle	- Linseed oil/tung oil/100% phenolic resin varnish. Oil length not less than 5:1.
Non volatile content	- Not more than 20% by weight.
Hard drying time.	- Not more than 16 hours.
Finish	- Red, metallic and opaque eggshell.

6110.9 FABRICATION AND INSTALLATION

.Items" shall be .fabricated in time, to avoid all delays "to job, delivered at job at such time as required for proper coordination. Work shall be fabricated and erected in thorough, workmanlike manner.

Work shall be true to. detail, with clean, straight, sharply defined profiles. Metals shall have smooth finished surfaces unless otherwise specified.

Joints shall be made as strong and rigid as the. adjoining sections-. Welded joints shall be continuously welded, unless otherwise permitted by the Engineer's Representative. Face of welds shall be dressed flush and smooth. Exposed joints shall be close fitting. Jointing shall be made where least conspicuous. Jointing of plain surfaces shall be prohibited except be welding and grinding or as otherwise directed in the field. Moldings shall not be used. All joints shall be welded except where other connecting means are indicated or permitted by the Engineer's Representative.

Weights and strength of connections and accessories shall be adequate to safely sustain and withstand stresses and strains to which they will be normally subjected.

All cutting, punching, drilling and tapping shall be done which is required for attachment of other work coming in contact with miscellaneous metal work where so indicated or where directions for same are given prior to or with approval of shop drawings.

All necessary cutting, drilling and fitting shall be done which is required for installation of miscellaneous metal work. Drilling, cutting and fitting shall be executed carefully. Work at job shall be fitted before finishing, if necessary, for correct installation.

Work to be built in with concrete or masonry shall have suitable provision for anchorage and shall be provided with suitable anchors, expansion bolts or other devices as required for proper anchorage. Where anchoring devices are to be built into masonry or concrete, they, along with suitable templates, shall be provided to the necessary trades in ample time to ensure proper installation of such devices.

Items that are anchored to concrete shall be securely fastened to the forms in such a manner as to prevent their displacement during the placing of the concrete. Items anchored to masonry shall be adequately braced and supported while masonry is being erected, and supports shall not be removed until masonry is fully set..

All supporting .members, fastenings, framing, hangers, bearing brackets,-straps, bolts, angles, and. the like, shall 1 be installed as -required to set and connect work, rigidly and properly to structural steel, masonry, or other construction.

Except where otherwise specified for a particular work item, or where work is required to be built in, secure to masonry with expansion shields and bolts, toggle bolts, or powder actuated fasteners. Fastening to wood plugs in masonry is not permitted.

6110.10 SHOP AND FIELD PAINTING

All ferrous metal work, other than galvanized metal and cast iron shall be painted before delivery or exposure to weather, with one full, coat of protective paint. Galvanized work that it is not to receive other finishes shall be touched up. Aluminium surfaces to be in contact with cement, masonry, mortar or dissimilar metals shall be painted with one coat of primer. :

Paint shall be as specified or may be baked-on rust inhibit-r, ive shop coat provided such shop coat has proved performance characteristics at least equal to those of materials specified herein. If this type of paint is used, samples shall be provided for examination and test before delivery is made., :

Paint used for touching up galvanized work shall be aluminium paint mixed as follows:-

Aluminium pigment	1 kg.
Aluminium paint	4 It.

Pigment shall conform to ASTM D962, Type II, Class B or equivalent. Vehicle shall be specially prepared varnish for mixing with aluminium pigment to,produce aluminium paint.

Surfaces to be 'painted shall be thoroughly cleaned of scale, dirt and rust. Steel scrapers', wire brushes, and blast shall be. used or other equally suitable tools or methods. Oil and grease shall be removed with benzene or other suitable solvent.

Paint shall be kept well stirred while it is being applied. Paint shall .not be used after it has caked *or* hardened. Paint shall be worked into joints and corners. Paint shall not be applied to damp surfaces nor when ambient temperature is below 5°C.

6110. 11 ANCHORS AND BOLTS

Ail miscellaneous bolts and anchors for fastening items of this. Section to wood, steel, concrete, or masonry., and in other places indicated on the drawings shall be provided. Sizes, kinds and spacing shall be as shown on the drawings or as specified. All anchors, bolts, nuts, washers, or spacers, in exterior concrete or otherwise used on the outside of the buildings, shall be galvanized.

6110.12 VERTICAL STEEL LADDERS

Vertical steel ladders, which shall be used in overflow chambers, sumps and other similar positions, shall be constructed of 5 cm outside diameter steel pipe rails and 20mm outside diameter steel rungs spaced approximately 25 cm . on center welded to the rails. Vertical rails shall be reinforced where necessary by carrying 15 mm restraining rods symmetrically along length of ladder and at same heights .in each rail.

Bottoms of ladder rails shall be welded to pipe sleeves solidly anchored.

Tops of ladder rails shall be bent at right angles to direction of travel and welded to a 1x10 cm steel plate anchored to rough channels. The ladders shall be galvanized after manufacture.

6110.13 METAL HAND RAILS

All stairs, landings, platforms, overflow chambers and manholes shall be provided with hand rails consisting (unless otherwise specified on the drawings) of vertical steel posts and two-rail type handrail.

The posts shall be steel pipes having a diameter of four centimeters, embedded at least 10 cm in the ground concrete and spaced at not more than 1.8 meters centre to centre. The posts shall be not less than 80 cm above finished floor levels.

Two equally spaced horizontal steel pipes of about 4 cm diameter shall be welded to the posts. Pipe railings shall be rigidly erected, neatly and accurately formed in graceful curves and bends at all turns.

The pipes shall be thoroughly cleaned after assembly and galvanized.

Rectangular and round tubular railings shall be fabricated of black steel tubes, of approved sizes or as shown on drawings,

and conforming to ASTM A53 in weight,, strength,, and composition. Pipe sleeves for installation of posts into concrete and/or terrazzo shall he supplied. Bearing plates for balusters where indicated on the. drawings shall be supplied and spacer bars, expansion shields, and flathead screws for fastening or rectangular balusters where required by the drawings shall be supplied and installed.

All metal brackets and metal balusters for wood and metal handrails, as indicated, shall be supplied and installed, mounting bolts and bars for the handrails shall be furnished. Installation of the wood handrails will be under section Carpentry and Timberwork.

6110.14 GRATINGS

Metal frames and grating shall be furnished and installed which are able to support a live load of 500 kg per sq.m. at locations called for in the work. Gratings and frames shall be rectangular pressure locked grid type made up of flat bars on edge and spacer bars, all. securely enclosed with a heavy flat bar or angle set in frame of angles and zees as detailed. Gratings shall be galvanized after fabrication and shall be removable.

6110.15 METAL LOUVERS

Blade-type aluminium louvers in exterior masonry walls and in aluminium window frames as indicated on the drawings.
Frames for louvers shall be formed from extruded aluminium of appropriate gauge. Corners shall be accurately mitred or coped and sol idly welded to form units into complete frames. All welds shall be ground smooth to provide flush, smooth exterior surfaces.
Reinforcements of angles and blade braces shall be provided, spaced approximately 1 m apart, for units of 2 m length or, more, where not otherwise shown.

Wire birdscreens and frames forlouvers without air filters shall be provided in exterior walls. (Where fans occur at interior face of louvers, screen shall not be provided under this Section.) Frame shall be aluminium, standard folded type, mitred and welded at corners. Screen cloth shall be 6.5 mm mesh, 16 gauge (1.52.mm) galvanized steel. Screen frame, shall be secured, to louvers by use of sheet metal non-corrosive screws.

6110.16 THRESHOLDS.

Aluminium thresholds shall be extruded 6063-75 alloy aluminium of shapes and sizes indicated on the drawings. Aluminium thresholds shall have at least 8 mm. wall thickness.

Unless specifically shown as being cast into concrete, thresholds shall be securely fastened by expansion bolts set in concrete or by countersunk non-corrosive screws to steel straps set in concrete as detailed on the drawings. Double row of fastenings alternately spaced 30 cm apart shall be provided. Thresholds to door jambs shall be scribed. Hollow-bottomed thresholds shall be set in full beds of caulking in coordination with work described under Caulking and Sealing above.

Steel angle and channel thresholds shall be of appropriate sizes and shapes or as indicated on the drawings and shall be either cast directly into concrete with: welded anchors attached or secured with countersunk, non-corrosive screws to steel straps set in concrete as detailed.

6110.17 SHIP LADDER

Inclined steel ship ladders shall be provided in location and to details shown. Ladder shall be fabricated with steel channel stringers and 6 mm steel checkerplate treads.

All parts shall be properly reinforced as required to support a live load of 700 kg/sq.m in addition to the dead load, uniformly distributed with a safety factor of four, and shall be of welded construction, except that rivets of bolts may be used where welding is. not practicable. Screws or screw type connections will not be permitted.

All carrying angles and brackets for treads and landings shall be welded on to stringers. Treads and landings shall be riveted or welded on.

6111 CARPENTRY AND TIMBER WORK

6111.1 GENERAL

This part shall describe the furnishing and installation of all carpentry and timber work and certain related items, shown' on drawings and as specified. The Contractor shall submit samples for. the approval of the Engineer's Representative of the material to be used in this Section and of typical finished wood elements used in the work.

Finish carpentry material's-will only be accepted When delivered dry arid-shall not be stored in the buildings or installed until after the concrete, and plaster work in the building, have been completed and dry conditions- prevail. Storing shall insure proper drainage, ventilation and protection from the elements and .in a manner to prevent warping and other deformation.

6111.2 ROUGH CARPENTRY

Wood for rough carpentry work, such as blocking, nailing Strips, etc., shall be local or imported softwood (coniferous), rough-sawn four sides, easily worked, certified by the producer or by an approved testing laboratory (all costs of tests and reports to be borne by the Contractor) to have a modulus of elasticity of at least 1.400.000 psi (98.433 kg per sq.cm). Wood shall be free of excessive amounts of knots, splits, shakes and wanes and shall take nails firmly and without splitting.

Toxic Treatment: All wood nailers, blocking and other wood work in contact with masonry, or which will be inaccessible in the completed work, shall be treated in accordance with the manufacturer's direction, in an approved, non-staining, preservative solution, providing positive control against attack by rot and insects, as approved by the Engineer's Representative.

Where treated members are cut, exposed surfaces shall be given heavy brush applications of the preservative approved for the particular member.

The Contractor shall furnish all items of rough hardware such as spikes, nails, screws, bolts, toggle bolts, anchors, and the like, necessary for the execution of the work, and provide washers for all bolt heads and nuts, except that for bolt heads or nuts bearing on steel, washers are required only at slotted holes.

All. wood furring and grounds shall be provided and installed as required to install all finish items' throughout the work, and as required to prepare for plastering.
The Contractor shall furnish glavanized metal nailing plugs to the masonry trade for securing all furring, grounds, nailers, trim and the like to masonry; and shall direct the setting of same.

6111.3 FINISH CARPENTRY

The Contractor shall prepare shop drawings for all finish car- pentry and millwork items and submit them to the Engineer's

Representative for approval prior to fabrication or erection on such items.

Shop drawings shall indicate the materials and species,' thicknesses, sizes of parts, construction, fastenings, blocking, clearances, assembly and erection details and necessary connections to work of other trades.

Unless otherwise directed, millwork, wood doors, and finish carpentry items shall be made termite-proof prior to shipment. It shall be submitted to the Engineer's Representative for approval of proposed method of termite-proofing such items. Materials used for termite-proofing shall not produce appreciable staining or discoloration and shall be compatible with finishes specified under Painting and Finishing section. Sufficient quantities of the approved preservatives shall be kept on the job during the work for treatment of cuts.

6111.4 MATERIALS

Lumber and finished woodwork throughout shall be of sound stock, thoroughly seasoned, kiln-dried to a moisture content not exceeding 19% for rough carpentry, and 12% for finish, and surfaced four sides, except as specifically designated for items hereinafter.

Work to be finished in paint shall be free from defects or blemishes on surfaces exposed to view that will show after the second coat of paint is applied;

All interior hardwood veneers and solid hardwood items will receive natural wood finish unless otherwise directed.

Hardwood for finish carpentry and millwork shall be clear, select, finish grade teak, free of knots or other visible defects.

All wood to be used shall be subject to the approval of the Engineer's Representative in regards to quality, appearance and workability.

Wood handrails shall be milled of teak hardwood to indicated profiles, and grooved- and drilled for attachment to metal support brackets. Metal support brackets and bolts will be furnished and installed under Miscellaneous Metals section. Attachment of handrails to support brackets will be included as part of the millwork. .

See under doors and windows in this Specifications.

Timber to be used for gate's, platforms and planks shall be solid hardwood, thoroughly seasoned, kiln-dried to a moisture content not exceeding *11%* and surfaces four sides. It shall be sound, free from sap;, shakes, large, loose or dead knots

and other defects. All timberwork to be used as part of the structure shall be treated with an approved preservative situation
. All timber to be used, shall- be subject to, the approval of the Engineer's Representative..

6112 DOORS, WINDOWS, GLASS AND GLAZING, HOLLOW METAL WORK AND HARDWARE

6112.1 DOORS, GENERAL

The sizes and numbers of doors specified for the various buildings shall be considered the mimimum required. Shop drawings of doors, including the method of hanging doors on frames, shall be submitted for the written approval of the Engineer's Representative before beginning of fabrication.

The hardware shall be of best quality as specified below, and . all locks will be arranged under a master and sub-master keyed system.

Samples of sections of typical doors showing method of construction and finish shall be submitted by the Contractor to the Engineer's Representative for approval.

All doors shall be properly manufactured and properly assembled and shall not have improper contacts, leakage from rain, sand *or* dust and admittance of undue amount of air.

Shop drawings for work under this section shall be submitted, showing sizes, details, method if installation, hardware, anchors and fastenings and all other important data to the Engineer's Representative for approval. Fabrication and installation shall not commence until the Engineer's Representative's approval has been obtained.

6112.2 METAL DOORS

For doors with hollow section frames flush or glazed, steel or
aluminium refer to Clause 6112.13 Hollow Metal Work of this
Specification.

All steels doors and frames shall be made of

mild steel welded without deposition of metals and properly reinforced. Corners shall be of welded construction with, all joints face welded and ground smooth, walds must bear the full strength of the section and all joints in face occurring over reinforced members.. All steel doors shall be-double-plated..

After assembly, all metal shall, be thoroughly cleaned of rust, oil and grease, and- given a coat of an approved rust resisting metallic primer with filler as required. Doors and frames shall be painted with two coats of an approved oil paint, the colours of which shall be according to the instruction of the Engineer's Representative.

Main members shall be designed to carry the dead loads with an extreme fibre stress not exceeding- that allowable for the type of steel used. Exterior doors shall be designed to resist a wind load of 75 kg/m . Deflection under the above wind load shall not exceed 1/120 of the span.

Shop drawings .of. doors, including the method of hanging doors on frames, shall be submitted for the written approval of the Engineer's Representative before beginning ,of fabrication.

The dimensions of each sliding or siiding-folding door shall be according to the drawings. Doors shall be double or single sliding or sliding-folding type, as specified* and shall be double-plated, consisting of mild steel plates welded to mild steel angle iron or channels framing and bracing. The leaves of sliding and sliding-folding doors shall be hung from wheel ball bearing handers operating in an overhead corrosion resisting track of adequate size fixed by brackets to the lintels or beams. The doors shall also be provided with corrosion resisting floor channel and guides, stops, handles, hasp and staple and bolts for fastening track brackets and other hardware to walls. All doors under this item shall be fitted with a tower bolt an one side and a locking arrangement on the other, and push and pull handles on both sides.

Doors, when required, shall be equipped with small hinged pass doors for use by pedestrians.

Weather proof and dust proof doors shall be fitted with weathering fabric inserted at the sides, top and bottom. Weathering shall be carried around at leading edge to act as wiper.

All double-leaf hinged doors shall be double-plated, consisting of 1.5 mm mild steel sheets welded to iron framing and shall be well braced. The frames shall be of a suitable section to provide "sufficient rigidity. The hinges shall operate on bush bearings' and shall be strong and durable. The door shall be fitted with

best quality flush type tower bolts from the inside, door checks (closers) and shall have locking arrangement of the best quality from outside.- Lock set shall be with dead bolt operated from outside by key, inside by thumb turn and it shall be provided with fixed knobs or lever handles on both sides (as specified).

The Specifications of this type of door shall be similar to

the double-leaf hinged doors above, except that no to.wer bolts, only one door check (closer) and one handle .on each side shall be required.

6112.3 STEEL SWINGING DOORS

All steel swinging doors shall be double-plated with stiles and rails formed from 1.5.mm thick or heavier steel sheets, into rectangular tubes with integral rebates; intermittently welded inside the rebates for structural rigidity. Stiles, . top rails, centre rails and bottom rails shall be of suitable section to provide sufficient rigidity.

Door corners shall be mitered, reinforced, continuously face-welded and ground smooth; centre rails shall be continuously face-welded to stiles and ground smooths

Doors shall present the same appearance, an both sides except that glazing bead and glazing stop screws - if any - shall always' be on the inside.

Frames shall be formed from at least 1.5 mm thick steel with suitable section to ensure rigidity. Frame corners shall be mitered. Hinge jambs mortised for hinges, lock jambs mortised for lock strike with mortises projected by metal plaster guards.

Jambs shall be flush with finished floor, with floor anchors attached to jambs with bolts, to set on the finished floor,
or 2.5 cm below the finished floor.

Patented rubber door silencers shall be furnished for strike jambs of single doors and for frame heads of double doors.

Frames shall be prepared for attachment .of all required hardware screw holes shall be reinforced. No hardware ,shall be attached to frames with self-tapping or sheet metal screws.

Hinges shall be extra heavy duty, cast malleable double acting heavy duty hinges of an approved quality.'

Doors shall be supplied with heavy duty double acting floor closers of an approved quality and make.

All Hardware shall be of a quality approved by the Engineer's Representative and shall be furnished and installed by the door manufacturer, and shall conform to Hardware below.

6112.4 SHOP FINISH OF METAL DOORS

Finishes of metal doors and door frames shall be. as specified in Section 6112.13, Hollow Metal Work, and in this Section of the Specification.

6112.5 WOODEN DOORS

All doors shall be flat, smooth-faced and shall be fixed properly in position. Each door shall be fitted with best hinges, handles and locking arrangements as specified in Section 6112.14 Hardware, of this Specification.

For thickness, sizes, and general characteristics refer to the Door Schedules and drawings.

Flush wood doors shall be solid core type with flush face veneers on both sides, of quarter sliced teak, kiln-dried; approximately 1.0 mm thick, of finish grade, sanded smooth to receive natural finish. Face grain of veneer shall run vertically.

Cross banding shall be thoroughly kiln-dried hardwood, 1.5 mm thick, extending the full width of the door and laid with the grain running at right angles to the face veneers.

Cores shall be built up of low density softwood blocks of varying lengths and kiln-dried to moisture content of 6 percent.

Edge bands shall be of kiln-dried hardwood of same wood as face veneers, side edge bands single piece of 20 mm thick-ness, top and bottom bands of two pieces or 20 mm thickness each. Aluminium edging shall be provided where indicated on the drawings. '

Cross banding members shall be attached to the cores, and face veneers arid edge bands laminated on with 100 percent waterproof film phenolic resin glue. All laminations shall be by the hot plate process.

Where penetrations of doors occur, provide 20 mm matching hardwood (teak) edge bands around entire opening.

Plywood doors shall be made of soft wood with solid core, flush faced and the finished thickness shall not be less than 5 cm. Frames shall be solid, of 12 dm x 5 cm hard wood unless otherwise indicated. The doors and frames shall be painted with two. coats of oil paint according to the instructions of the Engineer's Representative; where Formica Finish is specified on drawings, doors shall be faced with formica sheating, colour as on drawings.

Airtight and watertight doors shall .be provided and' instailedat the locations indicated on the drawings.

Air and water tightness shall be secured by using rubber lining or approved equal to minimize air infiltration.

Teak doors shall be made out of selected, well, seasoned teak planks not less than 5 cm finished thickness and according to the drawings. Teak doors shall be sandpapered and twice oiled and shall be finished in wax.

Frames shall be solid 15 cm by 6 cm, rebated and once chambered, unless otherwise stated on drawings.

6112.6 METAL WINDOWS, GENERAL

This section includes providing and installing all metal windows and related accessories and hardware, as shown or indicated on the drawings or specified herein.

Shop drawings for all work under this section shall be sub mitted showing sizes, details method of installation, hard ware, anchors and fastenings, and all other pertinent data to. the Engineer's Representative for approval. Fabrication or

installation shall not commence until the Engineer's Re- presentative's approval has been obtained.

A sample of each type of window specified, complete with

frames and hardware shall be provided. Only approved samples

may be used on the job.

Work installed under this section will not receive paint or

other finish other than that specified. The Contractor shall

assure that windows are properly protected during shipment and site-handling so as to prevent damage to the shop finish,

and shall be responsible for all damage to finishes during

such operations.

6112.7 WINDOW-MATERIAL

Window frames shall be. constructed of mild steel section or aluminium as on drawings of such dimensions as to ensure absolute rigidity,

In the case, of steel, the-windows shall be, welded the full length of the section and the frames shall be sand blasted and metallised and shall receive two "coats of oil paint the colour of which shall be according to the instructions of the Engineer's Representative. Aluminium windows shall have anadized finish as specified.

All metal windows shall have rubber strip lining and a perfect fit so as to be compteley waterproof and dustproof after glazing and shall be capable of withstanding a wind pressure of 75 kg/m , without excessive deflection. All openable panels should be supplied with fly screens non-corrosive metal of on approved make and shall be provided with Z-section frame. Such items should be installed in such a manner so as not to interfere with the proper operation of the window, but shall nevertheless fully prevent the entry of insects.

The hardware shall be of best quality and shall not be affected by fumes and gases producted by the processings

The glass panels shall be uniformly transparent, without bubbles, reflections, or any other defects originating from blowing, flattening or cutting up. Dimensions and thicknesses shall be according to the size of panel. The surfaces shall be flat and parallel.

The putty used for fixing the glass panels shall be of a type specially prepared for use with metal frames and shall have to be approved by the Engineer's Representative.

Window and rolled sub frame sections shall be solid sections of hot-rolled, new billet steel, with integral weathering and two point contact, at least for all ventilator members. Combined weight of frame and ventilator section shall be not less than 5.90 kg per lin m (unequal leg sections). Frame members shall be one piece sections with equal or unequal legs. All corners shall be fully mitered and electrically welded, with all welds neatly ground smooth and cleaned off. Aluminium windows shall be of extruded section of approved weight, gauge and tensile strength minimum 22.000 p.s.i. and shall have anadized finish.

Inward projecting ventilators shall be hung on spring loaded, non-ferrous shoes sliding in each jamb and heavy steel or aluminium as on drawings securely riveted to vent and frame. Projected vents shall have 'spring catch for hand operation.

The Window Contractor shall furnish all anchors, attaching screws, coupling screws and other fastenings, and access soirees necessary for the complete and workmanlike installation of work

under this /Section; .Al 1 miscellaneous items shall be hot-dipped-galvanized in the case of steel and anadized in the case, of aluminium.

Seal ing. compound for sealing of metal-to-metal joints shall be approved sealant in tape or pumpable form approved by the Engineer's Representative.

6112.8 SHOP FINISH

Steel windows, steel mullions, screen frames and all miscellaneous ferrous metal items included as part of the work, or used in conjunction therewith, shall be hot-dipped galvanized. Galvanized coating shall be between 000.045 and 000.061 kg. per sq.cm in weight. After cooling, windows shall be passi-vated by dipping in a bath of chromic acid to provide an even, bright finish, Which will not be shop or field painted, but will permit proper adhesion of caulking, sealing and glazing compounds.

In the case of aluminium windows the finish shall be clear anadized, which is oxide coatings obtained by immersing the aluminium alloy in an electrolytic bath, using an electrolyte such as sulp-hun'c or. otfrer acid. The surface is converted into aluminium oxide as an integral part of the metal. The anadized finish shall have a minimum coating thickness of 0.02 mm and a minimum coating weight of 5.5 mg per sp.m.

6112.9 INSTALLATION OF WINDOWS

Installation of all windows shall be in strict accordance with the final approved shop drawings and shall be done by the window manufacturer or an experienced, authorized representative of the manufacturer, approved, by the Engineer's Representative. The Contractor shall be responsible for the window openings, and shall make all necessary modifications to them in order that they will properly receive the windows, provided always that such windows are fabricated to sizes and details shown on the shop drawings. No site cutting', welding or drilling of windows will be allowed without express, written consent of the Engineer's Representative.

All' windows and accessories shall be erected plumb, straight, square;., level and at their proper elevation, plane .and location in alignment; with other work. All fixed items- shall be ' securely and neatly anchored into place.

The window installer shall perform all window-to-window, window-to-mull ion, and louver-to-window sealirig, as required to provide a thoroughly watertight installation, using approved sealant used in tape or pumpable form as required by the particular conditions of the job.

All operating sash and hardware shall be carefully adjusted and the opening and closing movements of all windows shall be free from twist and rattle. All moving parts shall be oiled and greased.

Materials shall be handled carefully to keep free from scratches, dents, abrasions and other defacements. Minor defacements deemed acceptable by the Engineer's Representative shall be touched up as soon as practicable, by use of high zinc content (85% solids minimum) zinc or,zinc dust primer, of matching colour as approved by the Engineer's Representative.

6112.10 ADJUSTING AND CLEANING

When so directed, after the work of various trades is completed, including glazing, the Contractor, shall inspect and adjust all sash installed under this specification. He shall leave the installation in good weathertight operating condition and shall clean his installations to the satisfaction of the Engineer's .Representative.

6112.11 ALUMINIUM DOORS AND WINDOWS'

Specifications for aluminium sections shall be that of the Architectural Aluminium Manufacturer's Association.

All sections to be used shall be of extruded type unless otherwise stated. A minimum tensile strength of the sections shall be 22.000. p.s.i. and.a minimum section thickness of 1.55 mm.

The sections to be used in- the work, shall have, the tensile strength and the thickness necessary.-for .structural rigidity, and resisting wind pressure of 75 k.g/m without-excessive deflection.

The joints may be mechanical or welded; in either case they shall be airtight, watertight and structurally sound.

Plated or coated hardware must be insulated from aluminium; aluminium to aluminium contact between hardware parts of members that move against one another is not permitted. All materials used in conjuction with aluminium alloy, including glazing beads shall be compatible with it.

The finish for all aluminium items to be used in this work shall be anadized finish. The thickness of the anadized coating shall be type NA-2A not less than 0.02 mm, and weighing 35 mg per square inch, as a minimum.

Finished aluminium products shall have transparent protective coating of methacrylate-type lacquer, resistant to mortar and plaster.

6112.12 GLASS;AND GLAZING

This part includes the provision and installation of all glass and glazing work, mirrors, stainless steel shelves and certain related items as shown *or* indicated on the drawings and as specified herein.

Samples of each type of glass and mirrors and glazing compound shall be submitted to the Engineer's Representative for approval

The material shall be the best available and of international standard. Any glass chipped, cracked, scratched, broken or permanently stained, itched, or damaged in any way prior to the acceptance of the building by the Employer, shall be replaced at no.additional cost to the Employer.

Putty shall- be of a type specially, prepared for use with metal windows, and of a make approved by the Engineer's Representative.

Thickness of glass shall be in accordance with size of door and window panels and shall conform to approved standards.

6112.13 HOLLOW METAL WORK

This section covers the provision and' installation- of all hollow metal work in accordance with the- drawings and/or as specified herein.

Sample sections of each type of aluminium door, door frame, glazed frame, frame anchors, weather-stripping and hollow metal sills shall be submitted to the Engineer's Representative for approval.

The Contractor shall submit fully detailed shop drawings for approval. Shop drawings shall show all details of construction and installation and no work shall commence until they have been approved in writing.

High quality workmanship shall be required in the fabrication and installlation of hollow metal-work.

All frames and doors shall be properly reinforced at vital points as necessary for alignment, rigidity, and for all hardware.

All frames and doors shall be prepared to receive the hardware for the door in that particular location.

Material for exposed parts of hollow metal work shall be first quality anadized aluminium. Gauges shall be such as will produce substantil construction and that finished surface will be smooth and level and will remain so under normal use, but in no case shall the metal be lighter than the gauges specified herein.

Door frames shall be of unit type, mitered and welded. All parts of door frames shall be No. 14 gauge (1.90 mm) material unless otherwise noted on the drawings. All frames shall have grout holes and shall be fabricated of wind, plumb and true. All door frames for use in masonry walls and partitions shall be furnished complete with adjustable steel "T". masonry anchors, 3.8 cm x 30.5 cm x .32 cm thick unless otherwise shown, three (3) per jamb.

All hollow metal doors shall be flush type of sizes and thickness noted with louver openings where shown.

Doors shall be fabricated of approved thickness for both internal and external conditions.

Solid door panels shall be aluminium for external doors and teakwood, aluminium or formica for internal doors as shown on' drawings and door schedule. Doors that are completely wood in aluminium frames shall have an all round aluminium section edge finished, flush with the surface of the door.

6112.14 WEATHER STRIPPING

All exterior doors shall be weather stripped. Weather-stripping shall be applied continuously to head and jambs, and shall extend across, and interlock with threshold. Sill weather stripping for out-swing doors shall be bronze hook strip type. Sill weather stripping for in-swing doors shall be bronze door bottom type.

The Contractor shall set all hollow metal frames accurately in correct position and location, shall thoroughly brace and stay, and maintain in plumb position until frames are held permanently by other construction. Each jamb shall be secured at sill by means of two concealed bolts in the clip at floor or curb.

Doors shall fit closely without binding and shall be fully in contact with the stops at all points. Doors shall not strike the floor or thresholds at any point of their swing.

Hardware shall be installed and adjusted to function properly and left in good working order at completion of the job.

The Contractor will be held to have examined the general Specifications, all plans and detailed drawings; to provide hardware for any and all openings (whether listed in this Specification or not). The Contractor will assume responsibility that all hardware will properly fit the material to which it is attached.

The Contractor shall submit samples of hardware for doors and windows in the job to the Engineer's Representative for approval.

All items of hardware shall include hinges, locks and latches, lever handles, locks, push plates and pulls, door closers, kicking plates, door bumpers, flush bolts where necessary, and shall be of international standard approved by the Engineer's Representative.

Hardware shall have the following finishes: Door closers, shall have metallic aluminium" spray. All other hardware shall be dull chromium plated.

6113 FINISHES

6113.1 PAINTING

This section includes the provisions and application of all paints and finishes which includes all enamels, paints, emulsions, stains, varnishes, sealers, and other organic or inorganic coatings,, including those used as prime, intermediate and finish coats. Surfaces listed in the schedule of finishes shall receive the surface preparations and number of coats prescribed. Colours shall be as selected by the Engineer's Representative or as on drawings and schedule.

The Contractor shall inspect all surfaces on Which paint or finish is to be applied. He shall withhold the painting or finishing of surfaces not in satisfactory condition to receive paint or finish until such conditions are corrected.

If any dirty, rusty, scale, greasy, damp, scuffed surfaces, or conditions otherwise detrimental to the formation of a durable paint film, are painted over, both the removal of the paint and repainting the affected area shall be done by the Contractor without additional, cost to the Employer.

The Contrator shall protect the finished work from damage and shall make sure not to cause damage to the work of others during his operation.

The Contractor shall prepare for approval, samples of his work on actual materials to be painted, previously installed at the job site, as directed by the Engineer's Representative. All finished work shall be equal in quality and character to the approved samples.

All oil paints, enamels, water paints and pentalites shall be obtained from approved manufacturers, and shall be subject to such tests and analyses ,as may be thought proper by the Engineer' Representative 'Each of the paints, shall be ready made in shades to be chosen by. the Engineer's Representative.

No exterior painting shall be done in damp, rainy or frosty weather, and no painting shall be done on the interior of the

building-until same has thoroughly dried-out. A-l-1. .painting shall be done in temperatures, and in weather of sufficiently low humidity to produce, good durable work.

The surfaces to be painted or otherwise finished, shall be cleaned of all dirt, rust, oil or other foreign matter, and shall be dry before painting.

Woodwork unpaiting surfaces should be brushed down and rubbed down with waterproof sand paper. Defects in the woodwork revealed by the cleaning process shall be made good with hard stopping and brought forward to a level surface.

Countersunk holes and cracks in wood surfaces shall be filled with putty. Putty shall be tinted to the shade of the finish coat, and shall be sanded smooth after hardening.

Cement and plaster surfaces should be left to dry out thoroughly -and mature before painting is attempted. Efflorescence due to salt crystalling on the surface should be removed by repeated brushing until it no longer forms. No washing should be attempted.

Joinery should be primed before assembly: all members to be inserted in cement or brick should be primed before fixing. Proper application of the priming should, be well brushed into secure maximum penetration and provide a good key of subsequent coats.

Painting and finishing materials shall be mixed and applied in strict accordance with manufacturer's direction for the particular material and coat to be applied. Reducing, when required, shall also be done in strict accordance with the recommendations of the manufacturer for the particular material and coat.

High quality workmanship will be required. Where more than one coat of material is specified, the prime coat or the first coat over the prime coat, as the case may be, shall be applied as soon as the work is in condition to receive it, and thereafter no coat of mate- rial shall be applied without change of colour unless otherwise directed by the Engineer's Representative. No succeeding coats shall be applied until the preceding coat is thoroughly dry.

Paints shall be factory manufactured and delivered to the job in unbroken containers, which shall show the designated name, for- mula, colour, manufacturer's directions, and name of manufacture Job-mixed paints will not be permitted.

Oil paints shall be of ready mixed paints, consisting of pigments ground .in refined linseed oil and adjusted to the necessary working qualities with driers and thinner's.

All oil paints shall-be washable, water repellent* "decorative, flat or glossy finish for application in interior and exterior surfaces, such as matured cement and. plaster, wood metal *or* brick, the preparations must be described as resistant to alkali, fumes, heat, cold and moisture, and are stated to be unaffected by condensation as well as non-flaking. Two coats work at least in either flat or gloss finish to be applied.

Pentalite sh all be of ready mix plastic and coating shall be with a base made pigments of high opacity in medium of plastic the coating emulsion, should be immune to attack by alkalis, sent in new which are pre-concrete, renderings and plaster, it strongly to must adhere surfaces which are free of oil and should provi grease. The coating de a tough, durable satin scrubbed whe finish, which can be safely n. cleaning down. All with suitabl surfaces must be smooth treated e and approved coat of paint mus of filling material. Three coats t be applied on left to dry the surfaces and each coat must be before the other coat is applied.

Rustproof paints shall be of ready mixed paints, water repellents, anti-acids and corrosive agents such as lactic, sulphuric and phosphoric acids, and are impervious to petrol, lubricating oils, clorine, etc., and of bitumen render properties, especially suitable for the painting of exterior iron and steel surfaces, dissolved in drying oil with the addition of driers and thinners.

Weatherproof decorative paint must be made with a base of white Portland cement, and in a powderform for mixing with water, tanacious and elastic properties shall enable it to adhere to surfaces particulary suitable for application to cement rendering, brick, asbestos cement, etc. It shall be waterproof, protective and giving a hard, durable and washable surfaces which resist abraisbn.

The following items shall not be field painted:

Mechanical and electrical equipment with factory finish coatings, except where such equipment is located outside of rooms set aside specifically for the housing of such equipment (mechanical and machine rooms).

Chrome plated, stainless steel, aluminium and other non-ferrous surfaces* unless specifically directed by the Engineer[1]s Representative.

Factory finished metal toilet compartments and steel cabinet's.

Pipes pipe coverings, duct work, conduits* etc., except where exposed in the finished work.

Exposed sheet metal work at roofs.

Fire alarm devices that are factory painted red.

Precast concrete work.

6113.2 FURRING, LATHING AND PLASTER SUSPENDED CEILING

Below, the furnishing and installing of all furring, lathing and plastering work and .all suspended ceilings in the works, as shown or indicated on the drawings and as specified herein, are described.

Specifacations for plastering are described above. Samples of items to be used shall be submitted to the Engineer's Representative, for approval.

Runner and furring channels shall be hot or cold rolled steel, hot-dip galvanized. The minimum weight of channels shall be as follows:

Size mm (Nominal)	Kg per linear meter	
	Hot-rolled	Cold-rolled
50	1.87	-
40	1.63	.71
20	.45	.45

All channels, ceiling anchors, hangers, corners beads, plaster stops, .metal lath, ceiling and wall clips shall be of the best quality appropriate in size and type to the work, and shall be approved by the Engineer's Representative.

6113.3 APPLICATION

Suspended ceilings., and furred walls in rooms and spaces noted in the Finish Schedule and/or as indicated on the drawings shall be installed. Where not otherwise shown, or required for special f conditions, the suspension system shall consist of 40 mm runner channels and .20 mm furring channels suspended by hanger wires for lath and plaster ceilings or timber seilings. Provisions .

for access panels recessed-lighting and other fixtures in. ceilings shall be made and for supplementary reinforcement members required .by special conditions indicated on the drawings or required by field conditions. Wall, furring shall consist of standard furring channels installed horizontally and vertically, and spaced- off the wall with resilient furring clips at locations called for in the details. All cuts and abrasions of galvanized coatings shall be painted with approved aluminium paint.

Hanger wires shall be spaced not over 1.22 m apart in either direction, unless otherwise indicated or approved. Flat steel hangers shall be bolted with 10 mm galvanized bolts and nuts to anchors of same section set in concrete where used for suspension system. This work shall be coordinated with the spacing requirements for ducts and fixtures.

Runner channels shall be spaced not over 1.22 m apart, unless otherwise indicated or approved. Each hanger wire shall be wrapped twice around runner channels and secured by at least three turns around itself.

Furring channels shall be spaced not over 40 cm apart, unless otherwise indicated or approved. Furring channels shall be secured with wire clips. At points where use of clips is impracticable because of insufficient working space, channels may be saddle tied with two strands of No. 16 gauge tie wire giving three twists.

Horizontal furring channels shall be spaced at 1.50 m on centres, where resilient furring clips are used horizontal channels shall be located in grooves of clips and wire tie with No. 18 gauge wire channels to clips. Vertical furring channels "Studs" shall be spaced at not over 0.60 m on centres, securing firmly at top and bottom. Vertical channels shall be wire tied to horizontal furring channels with No. 18 gauge galvanized wire.

Metal lath shall be installed for all ceiling and walls noted on the finish schedules and/or indicated on the drawings to be plastered. Lath shall be applied in a manner to provide a finished plastered surface true to line, level, plumb, and square without excessive thickness of plaster. The long dimension of the lath shall be at right angles to the direction of the supports. Sides and ends of sheets shall be lapped not less than 3.8 cm and all lath shall be secured to supports at 15 cm intervals with one strand of tie wire,

Casing beads, and- plaster .stops .shall be installed atedges and perimeters, of plaster work, where indicated or reasonably implied from the drawings. Bead shall be continuous, straight and uniform.-forming perfect miters at corners with plaster surfaces and shall be securely fastened to the base material.

Timber suspended ceilings shall be teak wood toungued and grooved strips positioned in the manner and pattern shown on the drawings . These strips shall be. of sufficient section and sizes that would provide them with the necessary rigidity..

The timber suspended ceiling shall be fixed to the supporting furring channels in a secure and durable manner. Fixings shall not be exposed.

Timber wall lining shall be teak wood toungued and grooved strips positioned in the manner indicated on drawings. These strips shall be of sufficient section and size that would provide them with r the necessary rigidity. The timber wall lining shall be fixed to the supporting furring channels in a secure and durable manner. Fixings shall not be exposed.

The Contractor shall submit shop drawings for the timber wall lining, and timber suspended ceiling to the Engineer's Representative for approval.

6113.4 SUSPENDED CEILING PUTTY COAT FINISH PLASTER

The scratch coat shall be applied with sufficient force to form good keys in the lath. The brown coat shall be applied, straight-end to a true surface and left rough, ready to receive the finish coat.

The finish coat shall be a putty coat finish, applied over the

firmly set brown coat. Moisten the brown coat if completely dry, before applying the finish coat. The smooth white finish shall be applied with a trowel in two (2) thin, even layers the second following the first immediately.

The 'application shall be in one continuous operation for each individual ceiling area. As the finish coat sets and skrinks, it shall be thoroughly and uniformly packed and compressed by heavy scouring with trowel. The material shall be allowed to shrink -between scouring operations, and additional water shall be brushed on as required.

6113.5 SUSPENDED CEILING CEMENT' PLASTER

The' scratch""-coat shall "be-full and thick, and shall be applied with sufficient force to form good keys. The scratch coat shall be cross scratched upon attaining its initial set, and shall be kept damp with a fog spray.

The brown coat shall be applied after' the scratch coat has set, but not less than forty-eight (48) hours after the application

of the scratch coat. The brown .coat shall be lightly scratched' and broomed, and shall be kept moist with a fog spray for two (2) days, and then be allowed to dry. Incorporate expansion joints in an approved pattern.

The finish coat shall not be applied until the brown coat has cured for seven (7) days, nor, in the case of exterior work, until the work of all trades whose construction would damage the plaster is completed. Just before application of the finish coat, the brown coat shall be moistened uniformly with a fog water spray. The finish coat shall be thoroughly and uniformly compressed into place by heavy scouring with a trowel and floated to a true and even sand finish in a uniform texture approved by the Engineer's Representative. The finish coat shall be fog water sprayed to prevent cracking and crazing from rapid drying.

Plaster work over metal lath shall be 3 coat work, 1.9 cm min. total thickness.

Plaster work over masonry shall be a 2 coat work, 1.9 cm thick min. total thickness.

6113.6 PATCHING AND CLEANING

Plaster work containing cracks, blisters, pits, checks or discoloration, shall not be acceptable. Such plaster shall be replaced with new .plaster. Patching of .defective work will be permitted only when approved. Such patching shall match existing similar work in texture and colour, and damage during work on the timber wall linings and suspended ceiling shall be made good using approved wood filler as necessary. Final finish shall then be applied as specified.

Access doors in plastered and/or timber suspended ceilings shall be provided where necessary and shall be approved by the Engineer's. Representative.

6114 UMBRELLA TYPE. HYPERBOLIC PARABOLOID; SHEDS

6114. 1 GENERAL

This clause covers the construction of reinforced concrete hyper' bolic paraboloid sheds for the filling station part of the rest areas and other related work indicated on the drawings.

For all structural parts especially concrete, reinforced concrete, reinforcing steel, the relevant sections of the Specification Part Five shall govern.

6114.2 FINISH

The work shall have exposed concrete finish. It shall be constructed so as to form smooth concrete surfaces to the profiles as indicated on the drawings without movement or deflection. Forms shall be easily removable without damaging plated concrete, and shall be accurately spaced and fitted with tight joints when joints in forms for concrete shall be exposed in the finished work. They shall be so located and constructed as to impart no visually distinguishable effect to the concrete surface.

All concrete surfaces in view in the finished structures shall be finished with a smooth rubbed finish. Surfaces shall be made smooth and uniform and free of form patches$_s$ fins, protrusions, bulges, form railing dimples, edge grain marks. Pockets and voids shall be cleaned. The structures shall be painted with approved paint as specified.

6114.3 .JOINT SEALANT

Joint sealant shall be provided where indicated on the drawings. Sealant shall be compatible with the approved joint filler ma- terial. Colour of sealant shall match the finish concrete surfaces unless otherwise indicated. Joint surfaces and filler material shall be clean and dry when sealants are applied. Sealant j and filler materials shall be approved by the Engineer's Rep-resentative.

6114.4 WATERPROOFING .

The roof to the structures shall be weatherproofed, it shall be given three coats of flintkote or an approved equal.

6114.5 RAINWATER

Each umbrella type hyperbolic paraboloid shall have a-.80 mm "diameter approved rainwater pipe through the supporting columns as indicated, on the drawings. The roof outlet shall be well laid to insure watertight edges and to ensure the easy movement of rainwater down the pipe.

The bottom outlet of the rainwater pipe shall discharge 10 cm above finished ground level from the side of the column as shown on the drawings.

6115 UNDERGROUND FUEL TANKS AND ACCESSORIES

6115.1 GENERAL

This clause covers the installation of a number of 10,000 gallon steel underground fuel tanks, and their accessories according to the detailed drawings, and the requirements of the Administration for Distribution of Oil Products.

6115.2 EXTENT OF THE WORK

The Contractor shall do all the civil and constructional work involved in the installation of the underground fuel tanks and other miscellaneous items related to them, such as constructional and civil work for the necessary piping, the bases for the kerbside pumps, the manholes to the fuel tanks, the loading sumps and other related items. The mechanical and electrical work required for the filling station will be done by the Directorate for Distribution of Oil Products - Ministry of Oil and Mineral's. The fuel tanks, the kerbside pumps and all piping and electrical wiring for the installation of the filling station will be supplied by the above named Directorate.

6115.3 CONSTRUCTION

The installation of the tanks shall be done, in a maximum number of two tanks in one construction unit with a joint separating it from the adjacent unit as shown on drawings. The installation of the tanks shall be in accordance with the drawings, the requirements of the Directorate for Distribution of Oil Products and the directions of the Engineer's Representative.

The tank housings shall, be of concrete which is absolutely tight against leakage of fuel. In addition, the Contractor. Shall provide damp proofing, courses and/or membranes -to ensure the tightness of the construction.

6115.4 COORDINATION OF THE WORK

The Contractor shall coordinate his work with the mechanical and electrical work, which will be done by the Administration for Distribution of Oil Products. The Contractor shall make all civil and constructional work necessary for the installation of electrical and mechanical work, and shall make all work required by the work of the Administration for Distribution of Oil Products.

The Contractor shall coordinate the work of this Section with the work of the roads and external paving areas in the rest areas. All the installation of the underground tanks and all the underground pipe work shall be done prior to the construction of the roads and the external paving and landscaping.

6116 EQUIPMENT FOR REST HOUSES

6116.1 GENERAL

This clause consists of the supply and installation of the equipment herein specified for the rest areas and filling stations. In the following Clauses it is dearly stated whether the supply is included in the lump sum for the rest area or is included in the provisional sums stated in the Bill' of Quantities.

Shop drawings necessary for the installation of the equipment shall be submitted to the Engineer's Representative for approval

The equipment shall be the best of its kind and of international standard, and shall be approved by the Engineer's Representative

The Contractor shall coordinate the work of this Section with the work of other sections.

6116.2 KITCHEN EQUIPMENT

Heavy duty cooking range with replaceable cast iron' solid top, even, heavy insulation, stainless steel side panels and doors, temperature controls, approximately 900 x 900 x 850 mm - total loading 20 kW - 1 No.

Toaster and griller on 915 mm stand with toasting rack with cool type handles, removable drip and. crump tray, removable cast top for food warming, approximately 500 x 420 x 280 mm - total loading 3 kW -.1 No.

Deep fat fryer with thermostatic controls, stainless steel sides and doors, steel drain pan and filter basket, capacity 20 kg of chips per hour, approximately 450 mm wide, 750 mm deep, 850 mm night, total loading 9 kW - 1 No.

Electric griddle plate for frying and grilling with flat frying surface of uniform temperature, thermostat, automatic regulation, drip pan, stainless steel finish, pilot lamp, approximately 450 x 450 x 250 mm - loading 3 kW - 1 No.

Equipment shall be suitable for operation on 220 V, 50 Hz, 1-Phase or 220/380 V, 50 Hz, 3-phase power supply.

The supply and installation of all above named kitchen equipment shall be included in the lump sum for the rest area.

6116.3 FILLING STATION EQUIPMENT

Kerbside Pumps: A number of kerbside pumps shall be installed in the filling station as shown on the drawing. The supply and the installation of these pumps shall be done through the Administration for Distribution of Oil Products - Ministry of Oil and according to their requirements.

Fire protection equipment: The work under this Specification shall meet with the approval of the Baghdad Fire Brigade and approved international standards and the Administration for Distribution of Oil Products - Ministry of Oil. Shop drawings for fire protection work shall be provided by the Contractor for approval.

Chemical' fire extinguishers: Fire extinguishers shall be of the pressurized dry chemical type for Class A, B, C fires, complete

with a charge of chemicals and gas bottles and ready for use. The cylinder shall, have, a durable red finish with printed operating instructions, with horn and. hose .combination and quick, acting . valve placing. They shall be of two capacities, 12. kg and 2.kg. .

OT the 12 kg extinguishers there shall be not less than 15 Nos. in Type A rest area, and 20 Nos. in the Type B rest area. Of the 2 kg capacity extinguishers there shall be not less than 5 Nos. in the Type A rest area, and 6 Nos. in the Type B rest area.

Wheeled chemical fire extinguishers: Wheeled engine for fire extinguishing shall be of the multi-purpose dry chemical type, effective on all common types of fire (A, B, C). Powder shall be non-toxic, non-abrasive, non-freezing, safe to use on live electrical fires, LP gas and greases. The engine shall be complete with solid rubber-tired wheels, nitrogen cylinder, 15 m long hose, control and shut off-nozzle, cylinder shall have red finish. Engine shall have a capacity of 50 kg fully charged and ready to use.

There shall be "not less than 4 Nos. of the wheeled engine extinguisher in the Type A rest area and 6 Nos. in the Type B rest area.

The Contractor shall coordinate the supply and installation of items under chemical fire extinguishers and wheeled engine fire
extinguishers with the Administration for Distribution of Oil Products.

The supply and installation of kerbside pumps are not included in the lumps sum. In a provisional sum of the Bill of Quantities
the costs for kerbside pumps and for the supply of all fire-extinguishers are included.

6116.4 AIR.COMPRESSOR

The Contractor shall supply and install one electric motor-driven air compressor with necessary accessories.

The compressor shall be of a 7.5 kW power, and shall have a capacity of 340 liters/minute, and an operating atmospheric pressure of S - 10 bar.

The compressor shall meet approved standards and shall be approved be the Engineer's Representative.

Costs for supply and installation are included in the lump sum.

6116.5 . ELECTRIC WATER HEATERS, ETC.

The Contractor shall, supply and install the required number of , electric-water heaters with al 1. accessories, as shown on drawings with the required capacity, as specified.

The Contractor shall supply and install the required number of electric water coolers with accessories, as shown on drawings and as specified.

The Contractor shall supply and install the required number and type of pumps, as shown on the drawings and as specified.

The costs shall be included in the lump sum.

6116.6 ELECTRIC GENERATORS

The Contractor shall coordinate the supply and install the required number and type of generators, as shown on drawings and/ or specified.

The supply shall be in accordance with the relevant Prime Cost Item in the Bill of Quantities. Installation including earthwork, foundation, wiring, switchboard and all .incidentals shall be included in the lump sum.

6116.7 TOILETS & ACCESSORIES

Samples of toilet accessories and all miscellaneous specialty items shall be submitted to the Engineer's Representative for approval, as well as the relevant shop drawings.

Toilet accessories shall be heavy duty sturdy type, suitable for public use in such buildings, and of a high quality international standard, and shall include soap dispensers, toilet paper holders, paper towel cabinets, waste, paper receptacles, mop hangers, mirrors, coat and hat hooks, ashtrays.

All costs for supply and installation shall be included in the lump sum-.

6116.8 PROVISIONAL SUM

A provisional sum is allocated for the necessary movable furniture and miscellaneous equipment which shall include table's, chairs, cupboards, office furniture, beds, benches, modular shelves, carpets,. curtains, kitchen cupboards and fittings, freezers, refrigerators, kitchen and dining- cutlery, plates, pots, pans, as well as the complete outfit of equipment and tools including overhead crane etc. for the workshop.

6117 PLUMBING 6117.

6117.1 SCOPE 'OF WORK

The work described in this part of the Specifications includes the furnishing, installation and completion of cold water, hot water, rainwater, soil, waste and ventilation pipe systems, and other sanitary fixtures and equipment, all. as described later. in this Specifications. All works should follow the best applicable clauses of B.S., ASTM or DIN standards, all as approved by the Engineer's Representative.

The Contractor shall furnish all plant, equipment, labour, and material required for completion of the work as directed by the Engineer's Representative, whether specifically mentioned or not

6117.2 SPECIFICATIONS AND DRAWINGS

Any work called for on the drawings and not mentioned in the Specifications, or vice versa, shall be performed as thoroughly as set forth in both.

The approximate desired location and arrangement of piping, fixtures and equipment are shown in diagrammatic form and must be followed as closely as possible, consistant with structural and space requirements; proper adjustments shall be made to secure the maximum headroom, a neat arrangement of piping, accessibility and to avoid interference with other phases of work.

6117.3 MATERIALS

Before any material, fitting, or equipment is purchased, the Contractor shall submit for the Engineer's Representative's approval a complete list in duplicate of all materials, fitting, or equipment to be used in the work. The Contractor shall also furnish other detailed information, which might be asked for concerning some of the items. When certain makes and models of equipment are specified, they indicate the shape, style, and class of material required. Other makes may be accepted if they are considered as good substitutes by the Engineer's Representative; otherwise, the same makes shall be supplied.

Approval of materials will-be based *on* manufacturers published data. Any material, fitting and equipment. 1isted, which are net in-accordance with the Specifications requirements may be rejected. The Contractor shall furnish a statement giving a complete description of all points where the equipment he proposes to furnished does not comply with the specifications. Failure to submit such a| statement will be interpreted to mean that the equipment meets all requirements of the Specifications.

The Contractor shall make early arrangement to import all materials or fittings which may not be available on the local market, and no requests will be considered for extension of time or change of material due to the Contractor's failure to make such arrangements.

6117.4 PIPES

Pipes used for the distribution of water within the building shall be screwed galvanized steel pipes. PVC or copper pipes may be used only where permitted; they shall conform to the requirements of the applicable standards.

Cast iron pipes shall be of the plain standard weight spiget and socket type, unless specifically stated otherwise, painted inside and outside. All fittings shall be similar to the pipes in every respect. High pressure cast iron pipes shall be used where required.

Lead pipes shall be milled to a uniform thickness and texture and be free from cracks or other defects, to hold the full | weight and pressure required.

Asbestos cement pipes shall conform to B.S. or equivalent. Asbestos cement pipes of respective type produced in Iraq may i also be used if they meet load and pressure requirements. The pipes shall have an internal acid-resisting coating.

6117.5 JOINTING OF PIPES

Galvanized steel pipes are jointed with screwed socket to remove any burr from the ends of pipes after screwing.

A jointing compound shall be used together with few strands, of fine hemp. Compounds containing redlead must not be used. Any .threads exposed after jointing should- be painted, or-in the case of underground piping, thickly- coated with bituminous or other suitable composition to prevent corrosion. In some cases, steel piping may also be jointed with screwed flanges of wrought iron or steel. Flanged joints should be made with pointing rings of best quality smooth, hard, compressed fibre board, not less than 2 mm thick, and of such width as to fit inside the circle of bolts. The rings should be smeared thinly with graphite paste.

The nuts shall be carefully tightened in opposite pairs until the joint ring is only just sufficiently compressed between the flanges to ensure water tightness of the joint under the desired water pressure.

Cast iron spigot and socket pipes shall be jointed to each other with tarred, spun yarn packing in half the depth of the jointing space, while the other half of the socket shall be filled in with molten lead, properly caulked and finished.

Lead joints for all purposes should generally be of the kind known as wiped joints. Connections of two lengths of lead pipes to each other shall be made by belling out the end of one pipe and slipping in the other pipe in the manner of a socket and spigot joint, and forming a lead-burnt joint around the top lipped edge , of the spigot.

Lead to cast iron socket connection shall be made by jointing a brass ferrule or sleeve to the lead pipe by means of a wiped soldered joint. The joint between the ferrule and the socket is then made by inserting a hemp or yarn gasket and caulking with molten lead or lead wool. When connecting a lead pipe to the outlet of a soil or waste fitment a brass liner with screw thread at one end shall be introduced. The liner is jointed at plain end to the lead pipe by means of a wiped soldered joint, care being taken to leave clearance room for manipulation on the brass coupling nut which completes the joint at the fitment end.

Asbestos-cement pipes of the spigot and socket type are jointed to each other by use of a gasket of tarred yarn caulked to about 25 mm in depth and filled in and jointed with 1:2 cement-sand mortar. Sewer simplex joint consists of an asbestos-cement sleeve, same as the pipe to be jointed, and two rubber rings, which are rolled in position between pipes and sleeve, assuring a tight flexible coupling. Joints similar to the simplex type may be accepted. after approval by the Engineer's Representative.

6117.6 INSTALLATION

Service, pipes shall be laid; as shown on the drawings.. Piping outside buildings should be laid underground, with a cover, measured from the topjof the pipe to the surface of the ground of not less than 0.40 im, except where they are surrounded with concrete or embedded Hn foot-paths.

All pipework should be done so that the piping could be accessible for inspection, replacement and repair. Uncovered pipes shall be supported by tietallic clips tightened firmly but not so as to bite into the pipe. Clips should be placed at approximately center-to-center distance equal to-twenty times the outside diameter for tubes running horizontally, for pipes 22 mm diameter or less.

This center-to-center diameter for tubes abo cally, clips should be diameter of the tube in the wall after suidistance shall be twelve times the outside above 25 mm. Whenever pipes are running verti- provided at centers twenty five times the part. All clips and brackets shall be placed e interposition of wooden battons.

All visible parts shall be painted with two coats of oil paint. If pipes are to be hidden in walls or ceiling, they shall be taped by tar paper and covered with cement mortar before plaster ing with lime mortar.
When it is necessary for a pipe to pass through a wall or floor, for a sleeve should be fixed for the pipe to pass through so as to allow freedom for expansion and contraction and other movement.

No pipe shall be laid so as to pass through any sewer drain or e cesspool, or any manhole connected therewith. Draw-off taps and seated located stop valves shall be in the places shown on the drawings, and, wherever required for the proper control and draining of all piping branches and fittings.

The work shall be carefully laid out in advance of any other Did connection so as to avoid cutting through the construction afterwards. Exact roughing in dimensions shall be determined after approval of contractor’s samples by the Engineer's Re- presentative.

All required connections shall be provided for even when not shown on the drawings. If any cutting should be necessary, this i shall be done only with the written permission, of the Engineer's Representative, and shall be carefully done, and all damages to building, piping be. resulting from such cutting, shall be repaired by skilled personnel at the Contractor's, expense.

Pipe openings shall be closed with caps or plugs temporarily. during installation. Soil and waste fitments shall be tightly covered and protected. At the completion, of the work, the fittings, traps, etc. shall be thoroughly cleaned and delivered ready for use

Cast iron pipes laid within the building, under or through walls, or under roads shall be completely surrounded with concrete 0,10 m thick all around. In other locations, they shall be encased in concrete, as stated above when they are at more than 1.0m depth below ground level, and shall be bedded on 0.10 m concrete layer and haunched with the same concrete at less depths. Special supports shall be provided as directed for pipes inside pipe channels.

Fixing of cast iron pipes on walls shall be done with stout cast iron holder bats having a tail built into the wall.

The flattest gradients at which pipes may be laid shall be as follows:

100 mm diameter pipes at 1 to 90

150 mm diameter pipes at 1 to 150

200 mm diameter pipes at 1 to 200

Larger gradients shall be provided wherever possible.

All horizontal pipes except those burned under slabs or in the ground, unless otherwise indicated, shall be supported by solid or splitring hangers of steel or malleable iron with pipes solid rod hangers, the lengths of which shall be adjustable. The hangers shall be spaced not more than 1.5 meters for cast iron pipe, and not more than 3 meters for steel pipe.

Solid rod hangers shall be 6 mm for steel pipes up to and including 50 mm, and for cast iron pipe up to and including 100 mm, 10 mm for 65 to 90 mm steel or copper, and cast iron pipe larger than 100 mm, '15 mm for 100 to 150 mm steel or copper pipe, and 15 mm for lines larger than 150 mm. Where hanger rods are longer than 45 cm, provide lateral bracing at each fourth hanger.

Under concrete floors, the hangers shall be hung from steel or iron inserts cast in the concrete at a distance not less than 150 mm from the bottom of a beam. Pipes which pass through more than two floors shall be supported from the building structure at each floor (except lower floor) through which they pass.

All exposed vertical pipes shall be secured to the building structure at intervals specified for hangers for horizontal pipes.

6117.7 MANHOLES

Manholes shall be provided at all bends or changes of 'slopes,, as shown, on the drawings. They shall be built with yellow brick, precast concrete blocks, reinforced concrete, or precast concrete elements as described in Clause 4412.

Manhole bases shall be formed of concrete Bn 150 made with sulphate resisting cement and shall have a thickness measured under the channel of at least 0.15 m, or as shown on the working drawing.. All manhole bases shall have channels with semi-circular inverts and walls rising vertically to the same height as the top of the outgoing pipe then benching shall be formed on each side of the channel with concrete sloping at 1:6 towards the channels. Both the channels and the benchings shall be finished off to a smooth hard surface 1:1 cement mortar not less than 1 cm thick. In all cases bricks or blocks shall be built with 1:3 sulphate resisting cement mortar. Both inside and outside surface of brick made manholes shall be rendered in two equal coats to a total thickness of 2 cm with 1:2 sulphate resisting cement-sand mortar. All surfaces which may be exposed to sewage water shall be painted with a double bituminous coat.

All manholes shall be covered with air-tight covers of reinforeced concrete$_9$ checker plate or equivalent. The permissible load of the covering shall be minimum 6 tons, but in all trafficed areas 25 tons.

The tentative dimensions of the manholes as shown on the drawings have to be verified accordingly, so that the maintenance and perfect cleaning of all entering pipes is possible. In relation of the depths of the manholes the dimensions have to be chosen. Values are given in B.S. 556. The approval of the Engineer's Representative shall be obtained.

6117.8 FLOOR DRAINS OR GULLIES

Gullies shall be made of glazed ware or cast iron bedded on and surrounded with a minimum of 0.15 m concrete. Trapped gullies shall be in one piece with or without inlets to receive waste pipes pouring into it shown in the drawings, and as specified and with required grating. Waste pipes shall discharge beneath the gully grating and above the water line of the trap with tight connection and with no possible leaks outside the gully.

6117.9 TESTS

The service piping system shall be tested hydraulically at a pressure of 5 kg/ sq. cm, unless different test pressures are specified. The test shall be conducted at Contractor's expense, the pressure being maintained for several hours as required, without showing any signs of leakage, injury *or* other defects. When the piping work is complete, it shall be slowly and carefully charged with water allowing all air to excape and avoiding all shocks of watter hammer. The service shall then be inspected under working conditions of pressure and flow. All piping and fittings shall be checked over for satisfactory supports and protection from damage.

Soil waste pipes: The work shall be inspected during installation and upon completion according to the directions of the Engineer's Representative. Care should be taken that all work, which is to be encased or concealed, is tested before it is finally covered. Soil waste pipes shall be tested for gas and for hydraulic performance.

Smoke test may be applied at the foot of the pipe by pumping smoke into the installation with the aid of a smoke machine, when the smoke emerges from the top of the ventilating pipe, a plug should be inserted at this point and sealed with a small quantity of water.

Water test may be applied be charging with water the pipe to be tested. It is .necessary to seal all openings affected by the test and provide support to the plugs.

The water test shall be applied before the appliances are connected and may be carried out in sections so as to limit the static head to 3.0 meters.

Discharge tests shall be made for all the soil and waste fitments singly and collectively. Obstruction in any of the pipe lines should be traced and the whole system examined for proper hydraulic performance, including the retention of an adequate water seal in each trap.

6117.10 SANITARY FITTINGS

European water closets pans shall be made of white vitreous china, provided with "S'' or "P" traps. The seat shall be made of plastic and fitted with hinged cover of the same material as the seat. Seats should be flat on the underside and fitted with two or three solid rubber buffers to avoid damage to the pan and to reduce noise. The flush tank shall be of 11 liters capacity, low level, and of the same material and colour as those for the pan. Included are supplying and' fixing of plain toilet roll holder with spring roller.

Bidet shall be made of materials as specified for European water closets, and of design consistant with this closet. Bidet shall have 32 mm diameter chain waste and chromium plated trap supply fittings with ascending spray, hot and cold taps to spray, hot tap only to rim 15 mm diameter and as required in the drawings.

Eastern (squatting) type water closets shall be made of white vitreous china with 100 mm diameter cast iron trap. The outlet shall be in the back of the pan, which shall have an integral flushing rim. The pan shall be provided with a squatting plate, with foot rests forming a part of the plate. The flush tank shall be high levels, 11 liters, cast iron painted, with galvanized pipe and pulling chain. Price is to include 15 mm chromium plated water tap.

Urinals shall be made of white glazed fire clay and of the stall type, with automatic flushing cistern of the same material and with stainless steel flush pipes, raised foot treads, drain outlet, and partitions. Urinals shall be 60 cm wide center to center, 105 cm high.

Wash basins shall be made of vitreous china, white colour, with pedestal of the same materials, with slot overflow and clip securing pedestal to basin, mixer fitting comprising 15 mm, pillar type, combined hot and cold valves with supply nozzle to basin and 32 mm waste. All fittings shall be chromium plated.

Showers shall consist of white glazed fire clay shower tray, 800 x 800 x 175 mm, with corner outlet, 40 mm waste fitting with plug, chain and stay, 15 mm mixer fitting comprising hot and cold valves and low pressure shower rose. All fittings shall be chromium plated, price to include supplying and fixing 15 x 15 cm tongue lipped soap holder with hand grip.

Sinks shall be of stainless steel, with moulding all around and grooved, drainer, overflow combined to waste-with plug and chain.. Sinks may be of single or double drainer, or of single, or double, b.owl as specified. Single drainer sink shall be reversibleahd. can be installed with bowl at right or left hand side of drainer.

Sinks may be of white glazed fireclay where required, with drain fitting, supply supports, and sizes as specified on drawings. A combined 15 mm chromium plated mixer fitting wall tap assembly with swiveling outlet nozzle shall be supplied and fixed as required and approved. Special type of mixer shall be supplied when required by the Engineer's Representative.

Exact types and sizes of the above sanitary fittings will be decided by the Engineer's Representative. Therefore all necessary samples, shop drawings and catalogues have to be supplied before the installation.

6117,11 EXPANSION AND CONTRACTION

All piping subject to expansion and contraction shall be installed with expansion bends, swing joints made up of fittings or other approved methods or device. Branch lines, from lines subject to expansion and contraction shall have swing joint at point of connection with the main.

6117.12 INSULATION

All hot water, tempered water, and hot water return lines and cold water lines on roof exposed to weather shall be insulated, except for small pipes burried in walls or under floor tiles, which shall be surrounded with fine grade vermiculite cement mixture as instructed by the manufacturer. Insulation shall be with fiberglass felt and wrapped with water proofing jacket of the following thickness:

25 mm for pipes under 40 mm diameter
32 mm for pipes under 65 mm diameter
40 mm for pipes under 100 mm diameter
50 mm for pipes under 150 mm diameter

6117.13 COLD AND HOT-WATER PUMPS

Pumps shall conform to the following requirements unless other wise specified.

Floor mounted pumps shall be provided with at least 10 cm high concrete base with 12 mm reinforcing bars at 30 cm centers each way and dowel led into the concrete floor.

Piping shall be supported from the building structure so as- to . prevent any. strain-on the pump casing.

Pumps, unless otherwise specified, shall be of the centrifugal type with non-overloading characteristic and shall not overload the motor above its horsepower rating under any operating conditions- with ratings based on .continuous operation. Any motor horsepower[1] shown is estimated for minimum requirements and larger motors must be furnished if necessary to meet the non-overloading requirements.

The Contractor shall submit for approval complete descriptive information covering the pumps and motors which he proposes to furnish, pump efficiencies as well as construction will be taken into consideration when determining the acceptability of the pumps proposed.

Unless otherwise specified, pumps on hot water service shall be designed for a water temperature of 95 C. All pumps shall have cast iron casing, impeller and mechanical seal. All rotating parts shall be statically and dynamically balanced.

Flanged connections shall be provided on all pumps with a discharge connection larger than 50 mm. Smaller sizes may be screwed connections.

Pumps and motors of all pumps, other than close coupled type, shall be mounted on a continuous cast iron bed plate of the drip pan type with a tapping for drain pipe connection.

Pumps generally shall operate at not over 1750 R.P.M., but close coupled pumps operating at more than 20 m head may operate at higher speeds.

Pumps shall be designed for a working pressure of not less than 5 kg per sq.cm or 1-1/2 times the discharge pressure, whichever is greater.

Shafts for hot water pumps shall be stainless steel monel metal, or carbon steel with sleeves of bronze chrome iron, or nickel iron extending through the stuffing boxes.

Sewage pumps shall be of the submersible type of required capacity, suitable for raw sewage with sealed electric motor to be fixed in a pit provided under the civil works. The pit shall be provided with steel frame and cover. Each pump shall be provided with a gate and check valve on discharge side with a union. The pumps shall be provided with automatic control panel and level controls to operate the pumps according to water level in pit. Electric wiring between control panel and pumps is also included.

Pumps, shall be. suitable for operating on .22,0/380 V, 3-phase, 50 cyles supply, similar, to (LEE HOWL), (DAE) or similar as. approved. Two pumps shall be installed in one pit, one to be as standby." A set of spare parts such as bearings, ring, washers, shall be provided. All cost shall be included in the lump/sum.

Sump pumps shall be of the vertical shaft submersible or completely submersible drainage type to be installed in the pit, and of the capacity shown on the drawings. Price shall include a starter, float switch for operating the pump according to water level, and wiring between pump and starter. The pump shall be suitable for operating on 220 V, 50 cycles supply.

6117.14 ELECTRIC WATER HEATERS

Electric water heaters shall consist of galvanized storage tank insulated with a layer of fiberglass or similar approved insulating material and surrounded with an outer jacket of sheet steel white-enamelled. The heater shall be provided with a thermostat for temperature control, pressure relief valve, check valve on cold water supply line, vacuum relief valve, and all necessary fittings and safety devices. The heater may be floor' or wall mounted, as required in the drawings. Heating elements shall be suitable for operating on 220 V, 50 cycles per second A.C. supply.

6117.15 ELECTRIC WATER:COOLERS

Electric water coolers shall be of the automatic type with compressor and motor hermetically sealed, air cooled, with enamelled external jacket and chromium plated or polished stainless steel top of anti-splash design. Fittings shall be chromium plated including jet nozzle and glass filler operated by hand push and foot pedal. Capacity in litres per hour is based on a temperature difference of the water of not less than 15 degrees centigrade. Cooler shall be suitable for operating on 220 V, 50 cycles per second electricity supply.

6117.16 CHEMICAL FIRE EXTINGUISHERS

Fire extinguishers described in Clause 6116.3 shall be placed in a aluminium cabinet with glass panelled door having a chromium plated handle and wall mounted, or may be fixed on wall directly without cabinet, as required in the drawings, or directed by the Engineer's Representative. All costs for installation or mounting shall be included in the lump sum.

6117.17 WATER TREATMENT PLANT'

General:

The raw water brought by the water tanker to the ground level storage tank shall be oil-free, fresh surface water,, not polluted by any chemical poison or organic or chemical waste. Before being pumped into the elevated water tank, the drinking water shall be treated to comply with the "International Standards for Drinking Water" of the World Health Organization.

First, the raw water shall undergo pre-purification by means of coagulating chemicals (aluminum sulphate) in the settling tank (ground level storage tank). From the settling tank the prepurified water is passed through the filtration plant, where the impurities are filtered away and the water is bacteriologically cleaned by adding of chlorine. Due to the retention of impurities in the course of filtration, the plant will be in need of backwash after a certain filter resistance is reached.

The filtered and chlorine clean water is now pumped into a hydrophor (pressure vessel) and to the elevated tank. A sufficient pressure to the supply system has to be provided.

The plant shall work automatically, all necessary pumps control mechanism, piping and wiring shall be provided.

The settling tank (ground level storage tank)

In this basin the raw material will undergo a pre-purification. Raw water inflow shall be regulated via a float-controlled throttle flap. The pre-purified water shall be drawn off from a discharge gutter by means of a pump. Before entry into the settling basin, the water shall be chemically treated. The coagulating chemical is to be added by a feeder. A sludge removal equipment and a safety overflow shall be installed. To preclude any pollution due to wind-whirled particles, and any disadvantageous influence on the formation of floes due to wind-borne undulatory movement, the settling basin shall be covered.

The settling tank shall have a capacity of approx. 40 cu.m and shall be constructed of galvanized steel sheets. The use of water from the tank for irrigation purposes shall be possible.

All earthwork, concrete foundation and incidentals shall be included.

The painting of all visible parts shall be done to the satisfaction of the Engineer's Representative.

Filtration plant:

From the. settling tank the water shall be.pump-ed. to the filtration plant, by a suitable pump- The filtration plant shall be composed. of two steel filter vessels, a dosator for determinating chemicals (chlorine bleaching solution), and the hydrophor (control-pressure vessel). The filters and the hydrophor shal1'be corrosion proof and galvanized on all sides. ,A switching cupboard and all accessories and incidentals are included.

The filtration plant shall be operated by electricity and shall have a capacity of 8 cu.m/h.

Foundation and all incidentals as well as painting as required or ordered by the Engineer's Representative shall be included.

High level water tank:

The treated drinking water shall be pumped into the high level water tank which shall be provided and installed as shown in the drawings and described hereunder. The tank shall be made of pressed steel plates.4.5 mm thickness to be bolted together and sealed with jointing material for complete water tightness. A cover shall also, be provided made of steel sheets 3 mm thick and a manhole and a door. The pressed plates shall be 1.22 x 1.22 m in size. The tank shall be provided with a gangway around the tank, platform with railing, filling sockets, drain sockets, discharge tube, overflow, vents and water level indicator. Proper bracing inside tank and roof trusses shall be provided. The plates shall be with external flanges and the tank and cover completely galvanized.

The whole tank shall be placed over a structure of required height made of steel beams, angel iron and bracings designed to withstand the weight of the full tank plus and winds of 160 km/h, the construction shall also withstand the windload when the tank is empty. The foundation of the tank shall be of reinforced concrete designed to withstand the same loads and in strict accordance with the technical specifications for concrete works, using sulphate resisting cement. To obtain actual bearing capacity of the subsoil, the Contractor shall perform all necessary soil tests, the values to be used shall be approved by the Engineer's Representative.

All supply, delivery, overflow, and scour pipes to the base of tank are included. The supply pipe shall be fitted at top water level with a float control valve. The scour pipe shall be connected to the overflow pipe. Sluice valves with hand wheels shall be fitted to the supply, delivery, and scour pipes for the normal control.

The tank shall be complete with internal and external ladder from ground to- tank and should have at least one intermediate landing platform with railings.
The tank and all metal- structural work shall" be painted with at least two coats of approved paint as ordered by the Engineer's R-representative.

The tank shall be hydraulically tested for water tightness at the working head by the Contractor on completion of its erection.

The exact location of the tank shall be fixed by the Engineer's Representative at the site of works.

Working drawings:

The Contractor shall submit a complete proposal together with the manufacturer's requirements for the filtration plant and the design of the ground and elevated tank, including materials, specifications, statical calculations, detailed drawings and any incidentals to the Engineer's Representative for checking and approval.

Three sets of as built drawings, manuals and information for service and maintenance and the training of user staff shall be included.

All costs for supply and construction of the water treatment plant shall be included in the lump sum.

6118 HEATING, VENTILATION & AIR-CONDITIONING

6118.1 GENERAL REQUIREMENTS

The work shall include the provision of all required labour, materials, equipment and service necessary for the complete installation of the heating, ventilating and air conditioning works, in full conformity with the requirements of all authorities having, jurisdiction; all as indicated on drawings and/or herein specified, including in general the following: air conditioning systems, exhaust systems, automatic temperature control systems, and insulation.

6118.2 PAIN-TING-AND -NAMEPLATES

The Contractor shall deliver, paint to job in manufacturer's. original sealed' containers. Paint shall be best grade for purpose as made by manufacturer and' applied in accordance with his directions.

Paint all hangers and supports with three coats red lead of approved kind.

Name plates; stamped black with white enamelled lettering, applied as approved. Furnish nameplates under each gauge, meter, instrument, indicating pilot lamp, remote control switch, motor controller, and other equipment mounted on panels to indicate service.

6118.3 FOUNDATIONS

The Contractor shall furnish concrete foundations with approved vibration isolators for all rotating machinery and other equipment requiring foundations.

Submit to the Engineer's Representative for approval detail drawings for all foundations, and method of isolation.

Construct forms from the drawings thus submitted and approved. It is the duty of the Contractor to place any templates and anchor bolts, and to supervise the construction of these foundations.

6118.4 OPERATING TEST AND INSTRUCTION

The Contractor shall operate the entire system for 15 consecu- tive days upon completion and repeat in mid-summer, during which times there shall be no defects showing, necessitating interruption of service or repairs to any portion of the equipment. This period of operation will be considered a trial run test. During test, in the Contractor shall supply continuous services of a competent Operator who shall instruct the Employer's Representative in operating features of entire system, and supply all details, including instruction booklets and equipment cuts, so as to obtain maximum efficiency in system operation.

The Contractor shall be responsible for training a staff named by the Employer.

The Contractor shall provide three bound sets of complete operating instructions and parts lists for each piece of equipment, furnished in Arabic and English.

6118.5 VALVE TAGS AND- CHARTS

All numbers and letters on tags arid charts shall be both in Arabic and English.

Furnish on all controls, identifying numbered metal tags fastened to stem or handle by heavy brass hock or chain. Tags: Not less than 50 mm diameter, 1.6 mm (14 U.S.S.G.) aluminium with stamped numbers filled in with black paint.

Mount charts and lists of type, size and character as approved in glazed metal frames permanently in locations directed.

6118.6 ACCESS DOORS

Supply access doors of proper size for respective concealed i terns.

Supply doors flush type With 1.9 mm (14 U.S.S.G.) steel door and trim, 1.5 mm (16 U.S.S.G.) steel frame, metal wings for keying into construction, concealed hinges and screw driver operated stainless steel came lock, of approved type. Where space condition will not allow door to swing open, supply removable doors on lift-off hinges of approved type.

All access doors in hung ceilings shall be of all aluminium construction, and the sizes shall be of 300x300, mm to match with the accoustical tiles used in the hung ceiling.

6118.7 PERFORMANCE

Air conditioning system shall be capable of performing as follows:-

- Summer Operation:

  At all times when outside temperature does not exceed 46°C (115°F) of dry bulb and 24°C (75°F) wet bulb for buildings in middle of Iraq, and 42°C(107.6°F) of dry bulb and 29.4°C (85°F) wet bulb for buildings in southern Iraq, to automatically maintain throughout conditioned spares an average indoor temperature of 24°C(75 F) dry bulb and 50% ' relative humidity.

- Winter Operation:

To' automatica.lly maintain-,- when outside temperature is < . 39 F) dry bulb for buildings in-middle of Iraq and 8 C (46.4 F) *dry* bulb for buildings in southern Iraq, an average indoor temperature of 24 C(75 F) dry bulb and 30% relative humidity.

Automatic controls shall be such that variations from above conditions in any conditioned space will not exceed 1.5°C (2.7 F) or 5% relative humidity.

To operate without any drafts, noise or vibration of any kind, which is objectionable in the opinion of the Engineer's Representative.

6118.8 MODIFICATIONS & GUARANTEE

Sizes and capacities of all equipment and apparatus indicated are minimum .Drawings and Specifications stipulate minimum requirements of capacity, performance, design and quality of equipment and for ;floor space and headroom. Equipment, which deviate from drawings and Specifications, may be submitted for approval, provided such equipment conforms to minimum requirements specified or indicated; that it can be accommodated into floor space and headroom available and will be readily accessible for maintanctnce, repair and removal.

Should the Contractor propose to redway any ductwork or other-ioned wise modify conditioned air distribution system indicated, he shall submit for approval complete scale drawings of entire systems with necessary details, before starting erection.

The Contractor shall guarantee that all apparatus will develop capacities specified and that system will be all defects of materials and workmanship.

The Contractor shall be responsible for the performance of the workmanship, assembly and adjustment.

6118.9 TESTII

on drawings. ATI

After completion of the work, test and regulate all ventilating and air conditioning systems to conform to air volumes indicated Hests and adjustment of apparatus, dampers and

ducts for securing proper volumes and face distribution of air for each, grille, register and ceiling outlet, shall be made by the Contractor. Where required or directed by the .Engineer's Representative, fans shall be provided with larger or smaller pulleys at no additional cost, sized to drive-fans at the speeds necessary to give the indicated speeds necessary to give the and tests on heaters, packaged air cpnditioned units, and controls first operating season, and may shall be carried out during the coincide, if convenient,- with the training period to be provided by the Contractor's trained representatives. These tests shall be for a minimum of 15 days.

The following measurements shall be recorded and submitted in tabulated form to the Engineer's Representative:-

return and exhaust outlet.

- Air volumes at each supply,
- Total m^3/hr supplied by eaci supply fan
- Total m^3/hr exhausted by each exhaust fan.
- Total static pressure of each fan.
- Total m^3/hr of return air to each return fan.
- Motor speed, fan input amperes reading of each fan.
- Average velocity on intake side of each fan.
- Air tests shall be made by means of velometer or anemometer readings.
- Static pressure test shall be made by means' of Pitot Tube readings;
- Ampere readings shall be made by means of integrating watt or ampere meter.
- Air inlet and outlet temperature at all heat exchange equipment and where required.

Should the Contractor refuse or The neglect to make any tests necessary to satisfy the Representative that he has Engineer carried out the true meaning of the Specifications, intent and the Employer may make and charge the expense there such tests of to the Contractor.

The Contractor shall repeat all the tests specified in the presence of the Engineer's Representative for final check.

6118.10 DRAWINGS AND CATALOGUES

The Contract Drawings are in part diagrammatic and show the general arrangement and approximate location of equipment. The Contractor shall follow these drawings in laying out his work, and shall also consult the architectural and structural drawings, ' including the drawings of the various sub-contractors in order to verify all conditions and spaces affecting his installation. If any departures from the Contract Drawings are deemed necessary

by the Contractor, due to conflict with specified codes and the best, practices, of the trade,, then details of such departure's and: the reasons therefore shall be submitted as soon, as: possible to . the Engineer's-Representative for approval. No such departures shall be made without the prior written approval of the Engineer's Representative.

Maximum headroom and space conditions at all points shall be maintained, and where headroom or space conditions appear inadequate, the Engineer's Representative should be notified before proceeding with the installation. If directed by the Engineer's Representative, the Contractor shall, without extra charge, make reasonable modifications in the layout as needed, to prevent conflict; with work of the trades or for proper execution of the work.

the Contractor shall submit for approval detailed shop drawings ; . of all equipment and all materials required to complete the project, and no material or equipment may be delivered to the job site or installed until the Contractor has obtained the Engineer's Representative's written approval on the shop drawings and catalogues for the particular material or equipment.

All shop drawings shall be coordinated for space clearances be tween all trades by the Contractor before submission, and a note stating this fact shall be placed on each drawing.

he Contractor shall submit to the Engineer's Representative, for approval, within four months after the Contract is signed and r before five weeks at least, any installation the Contractor wants to start with, working drawings, patterns, models, samples required for the erection of the plants and equipment.

Copies of working drawings for which approval is required shall be submitted in four sets.

Working drawings shall be made according to the original drawings and submitted for approval before any installation.

No equipment shall be ordered and no work done before final approval of drawings. Any work done prior to approval of shop drawings shall be at the Contractor's risk, and if not approved, shall be removed and replaced as directed, including corrections to adjoining work disturbed, at no added expense to the Employer.

The product of any manufacturer used shall be; standard product, that is, it shall have been manufactured as listed catalogued item and have been installed and operating in a reasonable number of places. No product that has not been in use for at least three years will be considered a standard, product.

Where two or more units of the same class of equipment are required, these units shall be the product of ;a single manufacturer.

The equipment shall be installed in accordance with the recommendations of the manufacturer and to the satisfaction of the Engineer's Representative.

Final drawings shall be made according to the approved shop drawings on linen cloth. All lettering shall be stenciling. A sample of final drawings shall be made on linen cloth and submitted for approval to the Engineer's Representative before any^ final drawings are made.

Complete set of approved final drawings on linen cloth with four copies made from the approved final drawings shall be furnished to the Employer.

6118.11 EQUIPMENT APPROVAL

Where the Specifications list manufacturer's names and/or as approved, other manufacturers will be considered if their equipment:

- is identical' to all specification requirements
- has all features of the manufacturers equipment specified that are considered required by the Engineer's Representative.

If the Engineer's Representative rules that any particular manufacturer or product does not meet specification requirements, the Contractor shall furnish the equipment of one of the manufacturers specifically named.

Manufacturers specified by name are not relieved of the responsibility of meeting specification requirements. If this equipment cannot meet specification requirements,, this will be sufficient for rejection, if. so ruled by the. Engineer's Representative.

The Contractor may request the substitution for equipment or material, which, in his opinion, is equal to that specified. However, it shall not be his judgment as to what constitutes equality, the Engineer's Representative shall be the sole judge of the quality of the equipment or material offered for substitution.

Equipment shall be accepted only if the type has been in commercial- operation, for not less than three years. Operation of similar types that have technical differences will not be acceptable.

The Contractor shall submit in three sets three different. .manufacturer's-, engineering catalogues, with Pro-Formal invo-ices- for each equipment offered, and according to. specification showing complete details of the selected equipment, th.eir .performance and all technical information to. the Engineer's . "Representative for approval.

6118.12 WORKING DRAWINGS REQUIRED

The Contractor shall submit detailed construction drawings of bases and. foundations for all plants and equipment, all other builders .work associated with the works. Include details of vibration isolators, details of supports, hangers and fixings detail of built trenches for cables, details of manholes, details of openings in walls, roofs, ceilings, floors doors, etc., with details of frames, louvers and sleeves where applicable.

Access doors to the various plants and equipment and indicate the door dimensions on the working drawings.

General arrangement and layout drawings of all installations, - including mechanical and electrical items scale 1/50,

Working drawings of all ducting scale 1/50.

Electrical installation and wiring drawings of the mechanical equipment showing conduits, cables, etc., along with full details of each and every type of connections, including: final wiring diagrams of individual components and accessories, final schematic diagram including power and control wiring, type and size of conduits with number and size of wires in each, type and sizes of cables, details of protection and interlocks, description of sequence of operation, etc.

Detailed working drawings for every control system, include and indicate location of controls, panel terminal strips, colour code, input and output range and set point of each control device. Show all interconnecting wiring, include sequence of operation.

6118.13 FINAL DRAWINGS, OPERATION AND'MAINTENANCE INSTRUCTIONS

The Contractor shall prepare and supply the Engineer's Repre-sentative with four sets of all the working drawings as installed, and with schedules of all plant and equipment as specified before.

Prepare and supply the Engineer's Representative with four sets. of manufacturer's details drawings and catalogues of all air conditioning equipment, electrical diagrams, etc., suitably bound.-

Prepare complete operating and maintenance instruction, and part lists covering all items of plant and equipment, maintenance and operating instructions are to be the manufacturer's standard instructions amplified where necessary. When those instructions have been approved by the Engineer's Representative, the Contractor shall submit five copies suitably bound to the Employer through the Engineer's Representative.

Be responsible for any discrepancies, errors, or omissions in the drawings, equipment supplied and other particulars supplied by him whether such drawings, equipment and particulars have been approved by the Engineer's Representative or not.

6118.14 AIR COOLED PACKAGE COOLING UNIT

The" air cooled package cooling unit shall be factory built and shall be complete with one or multi compressors, air cooled condenser, evaporator, motor, fan, filters, controls, electric heater and all accessories.. The unit shall be of the packaged type and shall be completely assembled and tested at the factory.

The cabinet shall be of heavy gauge galvanized steel of single enclosed, weatherproof type. All interior and exterior surfaces shall be chemically cleaned before applying final coat of enamel. The cooling coil section shall be fully insulated to prevent sweating and to muffle sounds. The cab.inet shall be provided with draining base pan through a drain connection and an opening for power connections. Cabinet shall, have removable panels for complete accessibility to all internal parts for easy inspection and service.

The unit shall have one or multi compressor, motors of accessible hermetic or semi-hermetic type, having forced, feed lubrication utilizing a positive feed reversible oil pump. The compressor(s) shall be equipped with suction and discharge service valves. The compressor motor shall be designed for three phase 380 volts 50 HZ power.

The cooling coil shall be constructed of copper tubes and aluminum fins. The aluminum fins shall be mechanically bonded on the copper tubes. The cooling coil shall be designed for direct expansion operation for R-22 refrigerant and a maximum working pressure of 14 kg. per sq.cm (.100 ps'i).

The air cooled condenser coil shall be constructed of copper tubes and aluminum fins. The aluminum fins shall, be mechanically bonded on the copper tubes'.

The condenser fans shall be of the propeller type and shall be' directly driven or belt driven by a heavy duty motor(s) and shall have safety guard(.s) if not concealed by casing.

The evaporator blower fan wheels shall be of the double inlet forward-curved blade type, statically and dynamically balanced. Shaft shall be of larger diameter, heavy gauge steel. Bearings shall be of the self aligning boll type grease packed and sealed with grease seals mounted in rubber at cast iron bearing blocks.

The motor shall be designed for 380 volts, three phase, 50 HZ and 1450 R.P.M. The motor shall be equipped with adjustable pulley.

The filters shall be heavy gauge galvanized steel. Filters shall be of the permanent viscous washable type, 50 mm in thickness.

Electric heater shall be of the finned tubular heating element type, supported by a heavy gauge aluminized steel frame and shall be designed for three phase 380 volt, 50 HZ power.

The heater shall be constructed of individual elements, easy to replace and one in case of damage, the heater shall have two *or* three stage complete with two or three stage room thermostat.

The coil elements shall be constructed of the highest grade resistance wire centered in 13 mm diameter copper plated steel sheath. The coil from the sheath shall be insulated by Magnesium Oxide powder- The insulation shall be packed with special packing to ensure rapid heat dissipation.

The fins shall be constructed of 32 mm O.D. spiral wound, copper plated fin and shall have five passes per 25 mm around the outside of the tubular element.

The fins and element sheath shall be bounded by copper brazing at 1100 C, then sprayed with a high temperature aluminum paint and backed on at 260^{D}C.

The elements shall be firmly mounted in a sturdy metal frame, and shall have flanges for simple installation in their place. A removable terminal box cover shall be provided for access to the terminals with properly sized .knock outs for cable connections.

A built-in thermal cutout, which acts as a high limit safety device, shall be provided to automatically disconnect power to the heater in case of air failure.

The heater shall be furnished complete with-built-in magnetic contactors, factory wired to terminal strips for line and-control connections in the field. One contactor shall be furnished, for each stage. The holding coil shall be rated at 220 volts.

The heater shall be installed either in the unit or in a special enclosure supplied with the unit.

The controls of the packaged air cooled cooling unit shall be factory wired and shall include low voltage control circuit transformer, contactor, fan control and a compressor motor timer circuit. Compressor protection devices shall be of the automatic reset type. The evaporator fan shall be operated independently from cooling cycle for heating or ventilating only.

A cooling/heating thermostat or two thermostats, one for cooling and the other for heating shall be supplied to control the temperature of the building in summer and winter.

6118.15 ROOM AIR CONDITIONERS

Room air conditioners shall be of the package type unit for cooling and heating.

Cabinet shall be constructed of hot dipped galvanized steel, zinc coated and finished with stove enamel finish. The cabinet shall be lined with sound absorbing material to reduce operating noise to minimum.

The unit- shall have decorative front return air grille made of plastic or the return air shall return to the unit around sides and bottom of decorative front panel, made of plastic. The discharge grille shall have directional louvers to distribute the air inside the room.

The air filters shall be of the standard permanent washable type. Filters shall be easily removed without using tools for washing and cleaning and shall be located directly behind return air grille.

The unit shall be equipped with an exhaust vent for removing stale or smoke laden air.

The unit shall be equipped with completely sealed hermetic compressor quiet in operation. The compressor shall be equipped with in heret protected, permanent split capacitor motor. The compressor shall be mounted on vibration isolators. The condenser and evaporator coils shall be of the standard type. The unit shall be equipped with variable speed squirrel cage blowers.

The unit shall be designed for 220' volt single phase, 50 HZ current.

The unit shall be equipped, with all necessary operating and thermo-static controls to. give safe and automatic operation.

The unit shall be equipped with built-in electric element heater for winter heating with all necessary, switches and controls.

6118.16 ROOF FANS

Roof ventilators shall be of the centrifugal fan type of sizes and [capacities indicated on the drawings. The unit shall have a heavy-duty dynamically balanced fan of true, centrifugal wheel design with forward curved blades. Centrifugal wheel shall be constructed, of aluminum. The driving motor shall be mounted on vibration isolators to eliminate noise and vibration transmission to the building structure.

The base shall be designed to prevent recirculation and the out- I, let shall be a minimum of two times inlet opening.

. V-belt drive with adjustable drive sheaves and the belt shall be 'sized for minimum 150% of the HP.

The fan hood shall be constructed of aluminum hinged type to give
full access to motor and fan wheel.

Motors shall be rated for continuous duty and of weatherproof f n type. Motors shall be operated on single or three phase current L of 220 *or* 380 volts 50 HZ, as shown on drawings.
Ventilators shall be equipped with automatic louvers set in the

fan curb.

Ventilators shall be provided with bird screens.

Ventilators shall be of low sound level.

6118.17 SHEET METAL WORK

All sheet metal ductwork, and related items shall be in accordance with this "sheet metal work" section. The Contractor shall: make every duct bend with center Tine radius not less than' its width. I Make every change in size or shape of duct with taper not exceeding 1 in 5. Provide 'throats at all branches and- at all connections of branches of size that throat velocity is same as main duct velocity. Construct square throat elbows, indicated or required, with internal turning vane's in accordance,

with, details , indicated.

Joints in all ductwork shall, .form "smooth interior surface and be practically-airtight.

Support ductwork on iron hangers not less than 25x25x3 mm (l"xl"xl/8"), spaced not more than 2 meters on centers. Supports shall be painted with approved type paint.

Furnish dampers and turning devices indicated or required to balance distribution of air through various parts of duct systems 'to obtain air deliveries, indicated at all registers, inlets and outlets.

Ensure that rivets, screws and other accessories shall be made of the same materials as the ductwork, or zinc or cadmium-plated steel. Minimum screw size shall be No. 8 and minimum rivet diameter shall be 3 mm.

Ensure that sheet metal for casings and plenum chambers, including doors and other details, shall have a thickness of not less than 18 USSG unless otherwise indicated on drawings.

Ductwork shall mean all ducts, dampers, access doors, fire dampers, joints, stiffeners and hangers.

Unless otherwise specified or indicated, all ductwork material shall be as follows:-

All ductwork for the air conditioning systems, supply, return and exhaust systems shall be made of galvanized steel.

AM ductwork shall, except as specified, be of prime quality galvanized sheet steel.

- up to 750 mm (30 inches) wide	24 USSG
- 780 mm (31 inches) to 1500 mm (60 inches) wide	22 USSG
- 1530 mm (61 inches) to 2250 mm (90 inches) wide	20 USSG
- over 2280 mm (91 inches) wide	18 USSG

By "wide" is meant greatest dimension.

Transverse joint connections and ductwork stiffening shall, except as otherwise specified, be:-

- up to 600 mm (24") wide: "S" slip, drive slip, pocket slip or bar slip on 2350 mm (94") centers.

- 600 mm (24") to 750 mm (30") wide: "S" slip, drive slip, pocket slip or bar slip on 2350 mm (94") centers with 25 mm (1") angles on 1200 mm (48") centers.

- 780 mm. [31") to 1000'mm- (40") wide: Drive slip, 25-mm. (1") " ' pocket slip or 25 mm {1") 'bar slip .on 2350'mm (94") centers with'25 mm (1") angles on 1200 mm (48") centers-with 25 mm (1").'angles on 1200 mm (48") centers.

- 1025.mm (41") to iSOO.mm ("60") wide: 38 mm (1-1/2") angle connections, 38 mm (1-1/2") pocket slip *or* 38 mm'(1-1/2") reinforced bar slip on 1130 mm (45"'). centers, with 38'mm ..(1-1/2") angles on 1200 mm (48"). centers.

. - 1530 mm (61") to 2250 mm (90") wide: 38 mm (1-1/2") angle . connections, 38 mm (1-1/2") pocket slip or 38 mm (1-1/2") reinforced bar slip on 1130 mm (45") centers, with 38 mm (1-1/2") angle on 600 mm (24") centers.

Ductwork for distance of 6000 mm from fan inlet and outlet stiffened, as specified above, except angles spaced on centers not greater than 600 mm (24")

Stiffening Angles: Riveted to ductwork, may be of black structural steel. Girth angles on all four sides of ductwork, except where narrow sides of duct are 300 mm (12") wide or less, apply angle to wide sides of duct only. Angles may be omitted on ductwork up to 2250 mm (90") wide by using reinforced bar slip joints on duct sections not longer than 1130 mm (45").

Make longitudinal seams on all. ductwork with Pittsburgh double seams, locked and hammered type, with smooth interior duct surface.

In all ductwork systems, the Contractor shall furnish all dampers necessary for proper control and balancing of air distribution. The Contractor shall furnish dampers ,fn" all branches from trunk ducts, with operating levers readily accessible.

All dampers shall be of the same material as-ductwork rigid construction, free of all rattling and vibration with edges crimped or creased for stiffeners.

All dampers and splitter regulators shall be self-locking and shall be labelled "shut" and "open".

All dampers shall have through rods, not less than 9.4 mm (3/8") diameter fastened to blade with 2 or more yokes with set screws, with steel washer to each end of damper rod.

Damper blades, two gauge numbers heavier that ductwork, 18 gauge and lighter shall have, both edges double hemmed. Blades longer than 9G0 mm (36") shall have "V" crease in middle to receive damper rod.

Dampers less than 230 mm (9") wide (90) degrees to damper rod, shall have through damper rod with blend handle. Bearings at handle end", cast iron with set screws;-at opposite end, 14 gauge plate with close-fitting rod hole; bearings riveted to duct. Dampers wider than 230 mm (9"). shall have through damper rod with 14 gauge bearing

plate at one end; and quadrant and lever with lock screws at other end damper lever fastened to rod with set screws.

On insulated ductwork, mount quadrants on metal saddles finishing flush with insulation surface.

Dampers less than 430 mm (17") Wide, single leaf; 430 mm (17") and wider, multi-leaf.

Multi-leaf dampers shall comply with the requirements for single leaf dampers. All damper rods shall be linked together to operate as a unit.

Splitter dampers shall be used for air adjustment in throats at branches from trunk ducts. Rigid construction shall be securely held in adjusted position by heavy friction springs, with provision for operation by means of hook.

The Contractor shall, unless otherwise specified, make connections between ductwork and fans by means of approved neoprene impregnated fabric collars with cemented seams, fastened by means of bolted metal straps.

The Contractor shall make connections between ductwork crossing building expansion joints by means of approved neoprene impregnated fabric collars with cemented seams, fastened by means of bolted metal straps.

Flexible connection shall be approximately 150 mm long and shall be installed .with just sufficient slack to prevent transmission of vibration.

Collars shall not be painted.

6118.18 INSULATION

The Contractor shall furnish insulation for all equipment and ducts that transmit heat, permit heat less or gain, or form condensation.

No ducts or equipment shall be insulated until tested and approved for tightness. All ducts shall be dry before being covered.

All exposed duct covering shall be finished with Portland cement applied in two coats over chicken wire, and trowelled to a hard finish.

The supply and return ductwork shall be insulated with 25 mm thickness fiberglass insulation, with' a density, of 26 kg/cu.m.

All fiberglass insulation shall fit accurately and snugly and. be set up with joints tightly butted, secured by galvanized stapling. at 150 mm interval.

Fiberglass insulation shall have a vapour barrier cover consisting (. of Kraft paper with fiberglass reinforcement screen and aluminium foil of 25 microns thickness and all joints shall be sealed with adhesive tape of the same material.

The Contractor shall furnish and install in all supply and return ducts (after and before the fans of the air conditioning units) sound absorbers or sound linings of sufficient length to prevent r objectionable fan and apparatus noises from entering the duct systems and as shown on the drawings.

Other supply and return ducts shall also be provided with sound-absorbing duct linings, where required;, to prevent apparatus and L . fan or duct noises from entering the areas served.

The Contractor shall ensure that the.Free-cross-sectional area inside of lining be not less than duct sizes indicated on the drawings.

Sound linings shall be of 25 mm fiberglass duct liner made of long, fine, flame attenuated glass fibers, bonded with a thermo-setting resin. The duct liner shall have also an integral mat of tough, smooth, black fiberglass covering the surface facing the air stream. The sound lining shall have a performance to withstand an operating velocities up to 25.4 meters per second (5000 fpm) and temperatures up to 120 C (250°F).

6118.19 AIR DISTRIBUTION SYSTEMS

All registers grilles and diffusers shall be of types and sizes indicated or specified herein or on the drawings.

The Contractor shall provide each air inlet and air outlet with accessible control for accurate adjustment of air quantities.

All air. inlets and outlets shall be aluminium of approved design.

All supply outles shall have airtight felt, neoprene br plastic sealing strips, at all edges, designed to prevent leakage.

The diffusers shall be round, square or rectangular type, as indicated on the drawings or as directed.

The Contractor shall provide each diffuser.with air equalizing deflector and multiple blade type volume control adjustable from outside diffuser or approved type volume control.

Diffusers shall be aluminum, constructed to give one, two, three, or four-way blow, as indicated on the drawings, with each side delivering a quantity of air proportional to the area served.

Diffusers shall be similar to Tuttle and Bailey, Krueger or approved equal.

Return air linear diffusers: Diffusers shall be constructed of 4.8 mm x 19 mm grille bars on 12.7 mm centers, set at 0 deflection. Diffusers shall be equipped with self aligning devices, dampers, end caps and all necessary accessories and shall be capable of being installed without any visible means of fastening. Linear diffuser shall be Krueger Model 1500 and frame style 413.

Supply grilles and registers: Grilles and registers shall be double deflection type with multi-shutter, key operated damper behind each grille and register!

Return grilles and registers: Grilles and registers shall be multi-shutter, key operated damper behind each grille and register.

All grilles and registers shall be of aluminum constructed to give cu.m/h of air and throw as indicated on the drawings.

Grilles and registers shall be similar to Tuttle and Bailey, Krueger or approved equal.

6119 ELECTRICAL INSTALLATIONS

6119.1 GENERAL

The electrical installations shall be of the highest class. All materials and equipment supplied and work carried out are to be the best of their respective kind, and the Engineer's Representative reserves the right to order the removal and replacement, without extra cost, of any faulty and inferior material and work.

The electrical installation work must be coordinated with the building work-and the-work of other services. AIT the drawings and specifications relating to. these works shall be-carefully examined, and information! regarding building materials and. equipment supplied by others obtained from the respective source to determine the extent, type and location of all wiring required. All holes and openings in slabs and walls, which may be required for the passage of electrical cables and conduits and all hangers and supports which may have to be fixed to the structure, must be determined and information about them passed to the building contractor so that they may be provided for at time of pouring of concrete or construction of walls. Breaking of concrete, cutting and patching of the structure shall not be allowed unless absolutely necessary and after securing the consent of the Engineer's Representative.

Installation work shall be carried out under the direction and supervision of a qualified electrical engineer who has to be approved by. the Engineer's Representative.

A competent foreman electrician shall be available at site during all working hours.

The electrical installation shall be maintained by the Contractor for a period of one year from the date of handing over of the works, during which he shall replace at his own expense any faulty material and shall rectify any fault that may develop in the installation.

All the work of the electrical installations shall fully comply with the I.E.C. or VDE Regulations and with any local authority regulations which may be in force at the time.

All materials used in the electrical installation shall conform to the relevant VDE or I.E.C. Regulations.

Samples of wires, cables, conduits, boxes, switches, sockets, push buttons and other items shall be submitted for approval before their installation. Catalogues may be submitted in place of samples, and they should give complete description and specifications of the materials. Catalogues of major items such as switch boards, sub-distribution boards and lighting fittings shall also be submitted for approval before any of these items are ordered. The Engineer's Representative reserves the right to reject any material that he may consider inferior or unsuitable for any reason.

The Contractor shall submit, before starting work, complete and detailed working drawings in three copies prepared and signed by an approved electrical engineer. The drawings should show all cable and conduit runs, boxes, method of installation, number of wires in conduits, location and mounting details of all

equipment. The Contractor, shall not proceed with the installation work before the drawings are approved and returned to hi m. On completion of the works, the Contractor shall hand over to the Engineer's Representative- three complete sets of 'as built[1] drawings showing exact positions of all electrical equipment. Any variation from working drawings, which might become necessary during the progress of work, must be recorded by the Contractor at the time of their execution so that they may be incorporated in the 'as built drawings at the end of the work.

Manufacturer's catalogues, circuit diagrams and service manuals of all equipment used shall also be submitted in two copies at the end of the work.

Power source shall be from' diesel generator sets or from the public network providing 380/220 V, 50 Hz, 3-phase, 4-wire supply.

The work shall include the supply, delivery to site, installation, connection and testing of electrical equipment, including: main low tension switchboard, sub-distribution boards, main feeders, earthing system, lighting and power circuit wiring, air conditioning motor circuit wiring, lighting fittings, steel cable ducts for public and private telephone system.

After completion of installation work, the following electrical tests shall be carried out to ensure the correctness and safety of the installation: insulation resistance test between current-carrying conductors and between them and earth, earth resistance test, earth continuity test, polarity of single pole switches, tests to demonstrate the correct operation of overload and other tripping devices on circuit breakers, the results of the tests should comply with the values specified in I.E.C, or VDE regulations. The Contractor shall be responsible for providing all instruments required for the tests.

The electrical works shall be included in the lump sum for the rest area excluding works which are covered by prime cost items and road site lighting according to Section 62. The lighting pertinent to filling station is part of the lump sum.

6119.2 MAIN SWITCHBOARD

The switchboard shall be. of the cubicle type, metal enclosed, free-standing, floor-mounted on concrete base, dustproof, vermin proof, suitable for tropical climate, front-operated with safety interlocks, and of clean and modern appearance. It shall contain the circuit breakers/ switch-fuses-, starters, contactors, instruments, etc., as shown on the detailed drawings to be supplied. Plastic labels shall be.attached to the switchboards to indicate the load served by each part.

The Busbars shall be of hard drawn copper, air-insulated, of ample current-carrying capacity, rigidly supported by suitable insulators and neatly arranged for .4-wire, 3-phase system.

The Circuit Breakers shall be 500 V, 50 Hz, of ratings and' breaking capacities as indicated on drawings, manually operated easily isolated and withdrawn for maintenance; with mechanical interlocks to prevent withdrawing or inserting, when in the closed position, and mechanical "ON/QFF" indicators. They shall have magnetic tripping devices on each pole and current transformer-operated adjustable time over current protection, adjustable between 75 - 100 % of rated current,- adjustable instantaneous short circuit magnetic protection, and earth leakage protection.

The M.C.C.B.s shall be 500 V, 50 Hz of ratings and short circuit capacities as indicated on drawings. They shall have quick-made, quick-break, trip-free mechanism; silver contacts; are chutes with thermal overload and short-circuit magnetic protection. They shall conform to I.E.C. or VDE Regulations.

The Instruments shall be of the flush type and comprise a volt meter (0 - 500 V) with 6-position selector switch and three ammeters of suitable scale graduation.

The Switch-Fuses shall be of the quick make, quick-break, front- operated with interlocks and "ON/OFF" indicators. The fuses shall be of the H.R.C. type.
The Starters shall be of the magnetic type, suitable for panel mounting with start, stop and reset buttons readily accessible. L The starters shall be normally of the direction-line type equipped with thermal overload and low voltage protection, and provided with indicating lamps. They shall also contain the necessary auxiliary L contacts.

The Contactors shall be of the air break, solenoid operated type
with double break contacts and arc chambers suitable for panel mounting with minimum noise. The contacts shall be of silver, easily replicable. The coils shall be suitable for operation on 220 V.

6119.3 SUB-DISTRIBUTION BOARDS

The sub-distribution boards shall be heavy-duty, dustproof with sheet steel enlcosures and lockable hinged doors suitable for flush mounting in walls, the enclosures shall be painted with an anti-rust coat and two coats of enamel paint. The distribution

boards shall have copper busbars for the three phases and neutral, of ample current-carrying capacity with suitable terminals to accommodate thespecified cables. Each board shall have a number of miniature moulded case circuit breakers of trip-free release, with thermal and magnetic tripping and of number and rating as shown on the drawings. Multipole breakers shall be furnished with common bar trip handle. The distribution boards shall be provided with means of isolation from the supply in the form of on-load isolators. Each circuit shall be appropriately labelled.

6119.4 MOTORS

Motors for air conditioning equipment shall be supplied by an approved manufacturer. However, the supply of starters, and the connection of motors, starters, control boards and related equipment shall be carried out by a qualified electrician, who has to obtain from the air conditioning equipment supplier all necessary information regarding motors, controls and wiring connection of apparatus. The qualified electrician shall carefully examine the air conditioning plans and specifications, and shall obtain wiring diagrams necessary to install his part of the work. He shall receive all control equipment specified under the mechanical section and shall erect and connect all such equipment in their designated places. Mator sizes shown on drawings are of nominal sizes, some variation may occur in the final installation. The Contractor is required to obtain the final data from the supplier and to carry out his part of the work according to these data.

6119.5 STARTER UNITS

Where starter units are mounted separately for individual equipment, they shall be suitable for surface mounting on the walls and shall include starters combined with switches. The switches shall be interlocked so that .the starter units may not be opened unless the switches are in the OFF position. Starters shall have the same specifications as in 6119.2.

6119.6 ISOLATORS

Isolators shall be cast iron or sheet steel suitable for wall mounting. They shall be of the quick-make, .quick-break type, three phase or single phase and neutral and of ratings as indicated on drawings.

When located outdoors or on roofs, the isolators shall be of the waterproof type.

6119.7 CABLES

Cables shall be copper conductor, PVC insulated with heavy. duty PVC compound sheath, 1000 V, NYY or NYCWY type to VDE standards, and sizes as shown on drawings.. The cables shall be fixed on the walls and over false ceiling with suitable plastic saddles spaced not more than 400 mm for horizontal runs and 500 mm for vertical runs. The cables shall be neatly fixed in straight lines parallel to the lines of the building. Where a number of cables are run together, a clearance between adjacent cables, equivalent to the diameter of the largest cable shall be maintained. Where cables are bent, the minimum radius of bend shall be at least six times the diameter of the cables. When cables are passed through walls, beams or slabs, suitable galvanized steel sleeves shall be provided for their passage. Cables shall also be passed in galvanized steel conduits concealed in walls when brought down to sub-distribution boards.

Cables shall be connected to distribution boards and other equipment through proper cable glands.

6119.8 EARTHING

The following metallic parts shall be connected to earth: Conduits, and boxes, third pins of sockets, enclosure of switch-boards, distribution boards, isolators, starters, etc., motor frames and boiler shells, all other non-current-carrying metal parts.

Sockets, isolators motors and other equipment shall be connected to earth through PVC covered earth wires drawn in conduits. The earth bus in the main switch boards shall be connected by 70 sq.mm PVC - covered copper conductor inside galvanized pipe to the earth rods outside the building. The earth rods shall be of copper or copper-clad steel bars and the diameter shall not be less than 12.5 mm. The rods shall be of the extensible type and shall be installed to such a depth that the total earth resistance will comply with local regulations, but shall not be more than 10 Ohms. If necessary, more than three earth rods shall be installed to achieve the required values.

6119.9 LIGHTING AND POWER'CIRCUIT WIRING

Lighting and power circuit wiring shall be by means, of single core.PVC wires drawn inside heavy gauge galvanized conduits.

Conduits shall be heavy gauge, Type A conforming to DIN 49020 with screwed ends, concealed in walls, ceiling and floor or over false ceiling.

Conduits shall be continuous from outlet to outlet, from outlet to cabinets, junction or pull boxes, and secured to all boxes so that each system is electrically continuous from service to outlet.

Conduits shall be installed parallel to the lines of the building with minimum number of joints. They shall be rigidly secured to the walls with clamps. When embedded in concrete slab, the conduits shall be securely held in place during the pouring and construction operation. A template shall be provided to hold, groups of conduits terminating together or passing through floors.

Conduit ends shall be cut square and reamed to remove burrs and sharp edges. Exposed screw threads shall be coated with red lead and silver paint immediately after erection.

Bends in conduits shall be neatly made with a proper bending machine, the internal radius of bend being as large as possible, and in no case less than.2.- 1/2 times the outside diameter of the conduits.

Conduit terminals shall be connected to boxes by means of screwed couplers and male brass bushes unless terminated in threaded fittings. .

Conduits passing through walls that are not plastered have to be erected in position inside the walls at the time of laying of the' bricks or blocks.

When conduits have to be installed in the ground outside the building, they shall be painted with asphalt and allowed to dry thoroughly before being c6vered with earth.

Boxes shall be fixed independently to the building so as not to be supported by the conduits.

Empty conduits, when left for some time, shall be closed with metal plugs to prevent entry of foreign matter.

Outlet and junction boxes shall be malleable iron, galvanized or of plastic with, threaded, hubs suitable for the specified location, the. kind of-fitting to be used and "the number and arrangement of conduits connecting therewith. .. '

Outlet boxes for switches and sockets shall be of galvanized stamped steel *or* of plastic with knockouts installed true and square with the building finish.

Pull boxes shall be provided as required-for easy drawing, of wires with readily accessible steel covers flush with brass screws.

No wire is to be drawn inside conduits until completely installed and after plastering. The whole of the conduit system must be swabbed through to remove any dirt or loose matter before drawing of wires.

Proper draw in tape shall be used for pulling the wires.

No wires of different services shall be drawn in the same conduit *or* box.

The size of conduit shall be according to the number and size of wires to be drawn inside them as given in I.E.C. regulations, but no conduit smaller than PG 13.5 shall be used.

Wires shall be copper conductor P.V.C. insulated single core for drawing inside conduits. They shall be 600/1000 Volt grade. Conductors shall be continuous from outlet to outlet and no splice shall be made except within outlet and junction boxes. A separate neutral wire shall be provided for each circuit. Wires shall be left sufficiently long to permit making final connections. Wires shall be supplied to site in their original coils and shall not be in any way damaged. The colours of wires shall be different for each phase, the neutral and earth and as recommended in I.E.C. regulations.

Wires for lighting shall be 1.5 sq.mm
Wires for sockets shall be 2.5 sq.mm

Wires for power outlets shall be as indicated on drawings.

wires for telephones shall be 0-6 mm dia. 2-core or multi-pair cables, each pair twisted with overall P.V.C, sheath.

Sockets shall be of the three-pin, shuttered type 13 or 16 A with switches. The cover-plates shall be plastic of ivory colour securely fastened to the outlet boxes. Switches shall be connected to the phase wires and the third pins *to* the earth wire. Sockets shall be fixed flush in the walls, at a height of 300 mm above finished floor level. Each socket shall be provided with a matching plug.

Switches shall' be 250 Volt, 15-A. with silver contacts fixed. flush in the walls at a height of 1200' mm above finished floor level unless otherwise shown on drawings. The cover plate shall be plastic of ivory colour. Switches shall be firmly fastened to the boxes. If wires of different phases are brought in the same switch box, they shall be separeted by a barrier. Switches shall be connected to the phase wires and no neutral wire to be connected to a single pole switch.

6119.10 LIGHTING FITTINGS

The lighting fittings shall be of the best quality suitable for 220 V operation, at ambient temperature of 0 - 50 C. They shall be complete with housings, reflectors, ballasts capacitors, holders, lamps and enclosures as shown on drawings.

Flourescent tubes shall be bi-pin, high efficiency, switch-start type. The colour of the tubes shall be white, ballasts shall be polyester-filled, hermetically sealed with low noise level and interference suppression. The power factor shall not be less than 0.85. The housings and reflectors shall be of sheet steel of not less than 0.7 mm thickness, white stove enamelled throughout. All lighting fittings shall be connected with heat resisting wires. Lighting fittings shall be provided with suitable supports and hangers as may be required for each type of fitting and according to nature of coiling.

6119.11 PUBLIC TELEPHONE

For the installation of public telephones, on the drawings the necessary space is provided for. The installation will be executed by the official telephone services.

All cable ducts shall be provided according to the instructions of the Engineer's fepresentative.

6119.12 POWER STATION WITH THREE DIESEL GENERATOR SETS OF 150 kVA

The station comprises three diesel generating sets with their necessary auxiliary equipment, control panels and distribution boards for the power supply for the whole rest area.

All plant shall be'mounted in a pre-fabricated housing, provided with proper docking facilities to prevent non-authorized. people from entering.

General:

Reference is made to Clause 6209.1 with the following alteration: From the three diesel generator sets one has to be provided for spare; the remaining two diesel generator sets only should start running in accordance with energy requirements.

Engine:

Reference is made to Clause 6209.2, with the following alteration: A fuel storage tank shall be constructed with a capacity of 20,000 1. The fuel day tank shall have a content of approx. 400 1.

Generator:

Reference is ma de to Clause 6209.3, with the following alteration: The generator shall have a nominal capacity of 150 kVA.

Control Cubicle:

Reference is made to Clause 6209.4 with the following alteration: One generator set is running the whole time, the second generator set only should start running in accordance with energy requirements. In case of failure of the diesel generator set the standby set shall take over its duty automatically.

If two diesel generator sets are out of order the power, supply for the air-conditioning shall be automatically switched off.

Distribution Board:

As Clause 6209.5

The supply of the before mentioned power station is covered by a provisional sum .All other work for mounting and installation shall be included in the lump sum for the rest area.

6120 PURIFICATION PLANT

6120.1 GENERAL

The sewage water of the rest house and the service building shall be semi biologically purified in the purification plant shown in the drawings. The purified water shall be discharged in an open ditch to the next irrigation or drainage channel as directed by the Engineer's Representative. The same ditch shall be used for rainwater drainage of the paved areas.

The construction of the plant with all incidentals shall be included in the lump sum for the rest area.

6120.2 BRIEF DESCRIPTION

The purification plant shall be a three chamber under floor reinforced concrete structure with the dimensions shown on the drawings. For each chamber a manhole with a minimum diameter of 60 cm and step irons shall be provided to allow easy control and maintenance. The manhole covers shall be lockable and the weight of one part shall not exceed 65 kg. .

On the first chamber a ventilation pipe of 100 mm diameter and with a height of at least 50 cm above ground shall be installed, this pipe shall be of cast iron and shall have an adequate ventilation tap.

The height difference between inlet and outlet pipe shall be 10 cm.

If the water level in the purification plant does not permit a free flow to the discharge, a concrete pit has to be constructed behind the plant in which the clarified sewage water shall be elevated. Detailed description of installation of the sewage pump is given in Clause 6117.13.

To avoid disturbing of the biological purification caused by great quantities of oil and/or grease in the kitchen sewage water, a grease trap shall be constructed at the outlet of the kitchen sewage pipes. Detail's are shown on the drawings. The instructions of the Engineer's Representative shall be observed.

6120.3 CONSTRUCTION

All reinforced concrete parts shall be made of concrete Bn 250, with sulphate resisting cement. The concrete cover of all steel .reinforcement shall be 35 mm. Special attention shall be drawn ' to all applicable Clauses of. Part Five of these Specifications. All concrete surfaces which will be exposed to sewage water shall be protected with a double bituminous coat.

The structure shall be watertight.

The area of the purification plant shall be prepared according to the instructions of the Engineer's Representative, it shall be taken into account that for maintenance purposes heavy tankers must have the possibility of access.

6120.4 DRAWINGS

The Contractor shall perform all necessary stress calculations and detailed drawings which have to be approved by the Engineer's Representative.

6121 MEASUREMENT

The measurement of the resthouse buildings shall be a lump sum,
and shall include all plant, equipments materials and labour of
the. complete resthouse, including the service building, the purification plant, the water treatment plant, the filling stations, concrete hyperbolic paraboloid sheds, the ground and elevated water tank, all lines and installations and all incidentals of the various rest areas, as stated in the Bill of Quantities.

The earthwork fill shall be included in the quantities and measured together with the earthwork for the embankment according to Section 22.

Pavement outside of the buildings, i. e. roads, parking areas,
footways, shall be measured in accordance with Part 3. Road drainage for the areas outside of the buildings shall be measured in accordance with Section 44. The lighting for the various rest areas shall be measured in accordance with Section 62, but the lighting of the sheds for the filling station shall be included in the lump sum of the rest house, buildings. For the required water tanker, the power station, the mechanical and electrical work required for the filling stations, including fuel pumps, fuel tanks and all piping and electrical wiring and for the supply of movable furniture, provisional sums and/or prime cost items are included in the Bill of Quantities. All installations for the telephone system are included in Section 67.

6122 PAYMENT

Payment will be. made in accordance with the lump sum stated in the Bill of Quantities, and shall constitute full compensation

for furnishing all material, equipment and labour and for performing all operations necessary to complete the work. Provisions, delivery of material to the site, handling and storage and all incidentals shall be included in the lump sum. Special attention is drawn to Clauses 1103 and 1104 of the Specifications.

62 LIGHTING

6201 SCOPE

The work covered by this Section of the Specification consists in furnishing all plant, equipment, material and labour and in performing all operations in connection with' the construction of the power station distribution center, cables, ducts, lighting poles, generating plant and fittings complete, subject to the terms and conditions of the Contract, and in strict accordance with this Section of the Specifications, the applicable drawings and the direction of the Engineer's Representative.

6202 EXTENT OF CONTRACT

This work shall be subcontracted to a competent and specialized r-subcontractor stated in the tender and approved by the Engineer's Representative. The Contractor shall be responsible for the manufacturer's delivery to site and putting into satisfactory service the lighting installation for the rest areas and intersections, which shall consist of the generating plant, distribuTion center, low tension cable, lighting poles and all necessary lamps, junction boxes, switches, ducts, lighting fittings, etc., [f1] all as indicated on the drawings and to the satisfaction of the Engineer's Representative.

The system shall receive its supply from the generating plant at location, as shown on the drawing or as directed by the Engineer's Representative.

Each sub-station shall consist of two independent diesel generating sets with their necessary auxiliary equipment, and shall be mounted in a pre-fabricated housing or similar, as approved by / the Engineer's Representative.

6203 CLIMATIC AND OPERATING CONDITIONS

All components and material shall be suitable for the installation and operation in the climatic conditions prevailing in Iraq.

All electrical materials and components shall be suitable for an ambient temperature of 45 C with an occasional max. temperature of over 50 C in the shade, and shall be shielded properly when installed in the open air, to prevent damage by direct sunlight, and shall be designed to ensure satisfactory operation under working conditions.

6204 QUA1ITY OF MATERIAL. AND COMPONENTS.

All goods, material, plant and' equipment incorporated in the Contract shall be new and of the best quality of the respective kinds,, and shall comply with the applicable publication issued by the International Electro technical Committee and the relevant VDE Specification.

All plant and equipment shall be properly finished for the ambient conditions and circumstances of use and of approved manufacture. Corresponding parts shall be interchangeable whenever possible and suitable provision by means of eye-bolts or other means is to be made to facilitate handling of all items that are too heavy.

6205 PROGRAM AND WORKMANSHIP

As soon as practicable after the date of commencement of the Contract works, the Contractor shall submit to the Engineer's Representative for his approval a detailed program showing the planned time schedule of the supply of all equipment and materials, all work to be done and the completion, testing and handling of the project.

Furthermore;, the program shall show how the works for lighting will be coordinated with the work of the Contractor.

All workmanship must be the best of its kind and to the satisfaction of the Engineer's Representative. No labourer shall be' allowed to execute any type of work which is normally carried out by a skilled tradesman unless he is thoroughly experienced.

6206 DETAILED SPECIFICATION

The Contractor shall execute the lighting work in accordance to the Specifications supplemented by the manufacturer's detailed specifications and drawings as necessary, which shall be submitted with the tender and which, after approval and/or amendment, shall become part of the Contract.

The names of proposed manufacturers and places of manufacture, testing and inspections before despatch of the various portions of the lighting works shall be set out in an appropriate schedule.

6207 INSPECTION AND TESTING.

The whole of the plant and equipment shall be subject to inspection and testing during manufacture and testing after completion at no cost to the Employer.

All tests shall be carried out in accordance with the relevant IEC or VDE Standards.

The Contractor shall carry out the tests scheduled in this Specification and such additional tests (in the manufacturer's works *or* elsewhere) as, in the opinion of the Engineer's Representative, are necessary to determine that the equipment complies with the requirements of this Specification (including any manufacturer's specification incorporated therein with the Engineer's approval) whether under test or ordinary site working conditions.

6207.1 CABLES

Insulation, pressure and conductivity tests shall be carried out on all cables.

6207.2 TESTS DURING ERECTION

The whole of the installation equipment shall be subject to such tests as may be required by the Engineer's Representative during erection. These tests shall include the accurate setting and alignment of the various parts.

6207.3 TESTS ON COMPLETION

Tests on completion shall be carried out on site in the presence of the Engineer's Representative. All equipment and parts shall pass such tests on site as required by the Engineer's Representative to prove compliance with the Contract irrespective of any tests which may have already been carried out at the manufacturer's works. In particular all electrical tests of made at the manufacturer's works shall be repeated at voltages accordance with the relevant IEC or VDE Standards.

Each complete system shall be tested as a whole under operating conditions to ensure that each component functions correctly in conjunction with the rest of the system.

The Contractor shall include in. his price the complete testing of the electrical functioning of the installations as well as tests previously' specified.

6208 INTERFERENCE SUPPRESSION

All electrical apparatus must be adequately suppressed in order to reduce interference with radio and radar equipment to a minimum. The equipment shall be in accordance with recommendations of the British Standard Code of Practice (General Aspects of Radio Interference Suppression) C.P. 1006: 1955, where applicable.

6209 POWER STATION WITH TWO DIESEL GENERATOR SETS OF 75 kVA

On the location approximately shown on the drawings self-contained power generating stations shall be supplied and installed.

One station comprises two independent diesel generating sets with their necessary auxiliary equipment, control panels and distribution boards for the street lighting circuits.

All plant shall be mounted in a pre-fabricated housing, provided with proper locking facilities to prevent non-authorized people from entering.

For the supply of the power stations provisional sums are stated in the Bill of Quantities. The installation with all necessary additional work and the switch board shall be included in the lump sums for lighting.

6209.1 GENERAL

The housing of the power station shall consist of a rigid base made from steel sections, of adequate size and a structure made from angle irons and sheet, steel. AH steel components used shall be hot dip galvanized in accordance with ISO-publications Nos. 1459, 1460 and 1461. The roof of the housing shall be constructed with heat insulating materials so that the heat transmission coefficient is max. 1.5 W/sq.m C.

Two lighting points with a switch at the entrance door shall be provided for maintenance or inspection during the night. One switched emergency lighting point, consisting of a 12 W fluorescent lamp and fed from the 24'V dc. starting battery shall- be provided for repair works in- case of a breakdown of the power supply.

The housing shall be placed on a concrete slab to be provided by the Contractor. This slab shall have an adequate steel reinforcement. Only where underground cables enter the housing the concrete slab shall be constructed in such a way that the cables can enter vertically on the inner side of the wall where the distribution board is mounted,

Each diesel generator set shall be mounted on a common base plate made of steel, rigidly ribbed and electrically welded. The engine and generator shall be rigidly connected and their shafts shall be flexibly coupled. The mounting on the base plate shall be by means of rubber anti-vibration blocks.

One generator set will be running during the night, the other is spare and must be connected in an automatic standby positions taking over the duty of the other set in case of a breakdown.

The power station shall be designed and constructed to operate in a maximum ambient temperature of 45 C with an occasional max. temperature of over 50 C in the shade with 90 % relative humidity, and a minimum temperature of minus 5 C.

The equipment shall be capable of operating continously and without adverse effects of overheating under all specified conditions and shall provide a supply having variations not greater than 2 % in voltage and 2.5 % in frequency.

The nominal output of the power station shall be guaranteed for installation at zero up to 800 m above sea level with relative humidity of 90 % at zero up to 10 m and 25 % of 10 m up to 800 m above sea level.

6209.2 ENGINE

The diesel engine shall be of compact design, with cylinders in line, totally enclosed pump circulated water or air-cooled, force lubricated, operating on a four stroke compression ignition
cycle.

The performance of the engine shall be such that a continous output of the power specified for the alternator is provided at a rotational speed of 1,500 r/min. The engine shall be rated for continuous operation in accordance with DIN 6270 at ambient conditions as described in Clause 6209.1..

The engine shall be able to supply instantaneously its maximum

output at an ambient temperature of minus 5 C.

The engine shall have an overload, capacity of 10 % for one hour within any six hours. The engine shall be capable of running, at full load for at least 800 hours without maintenance adjustments, 2,000 hours without cylinder head revisions and 6,000 hours without a major overhaul.

Forced air intake by means of a blower driven by the exhaust gas will not be permitted.

A gear type or other form of integral engine driven pump shall be used for circulating the lubricating oil in the engine system. The pump shall commence pumping as soon as. the crankshaft turns and it shall be readily accessible for maintenance.

A full flow lubrication oil filter shall be provided suitable for 800 hours operation without cleaning or replacements.

The sump.shall have enough lubricating oil capacity to permit the engine being run at continuous full load for 800 hours without replenishment being necessary. A dip-stick shall be provided in a position of convenient access showing "full" and "low" marks and a breather shall be fitted and arranged to discharge sump pressure into the engine air inlet duct.

A lubricating oil cooler shall be provided on the engine, served by the cooling system. The oil shall be pump circulated through the cooler by the main circulating pump.

Instruments shall be installed on the engine instrument panel for indication of the lubricating oil pressure and the temperature in the sump.

A pressure switch shall be provided, which closes an electrical contact when the lubricating oil pressure falls to a predetermined amount. The arrangement of this pressure switch is such that it does not operate during the oil pressure build up during the starting sequence.

A hand operated drain pump shall be provided for emptying the sump in case of changing the lubricating oil.

If the engine is water cooled it must be performed on a closed circuit by means of an air blast radiator with an engine driven fan. The cooling system shall have a thermostat operated bypass to accelerate warming up. Provision shall be. made for draining the engine and auxiliaries completely of water. An engine driven cooling water circulating pump shall be provided and shall be of a type which does not require separate lubrication or attention to. the shaft or gland.

The cooling, water shall contain an approved additive to prevent freezing up to a minimum temperature of minus 5.C, .

A temperature operated switch shall be provided in the cooling system, which operates when the temperature rises above a predetermined valuer An instrument shall be installed on the engine instrument panel indicating the temperature.

The necessary air for cooling shall enter the power station throughone set of electrically operated louvers, i.e. the louvers shall be closed when the engines are shut down. This air inlet shall have sufficient capacity to handle the air quantities at full load in accordance with manufacturer's instructions, and bird screen shall be provided to prevent animals and other foreign objects from entering the station.

The air blow through the radiator shall leave the power station directly through louvers, which are opened by the pressure of the air flow and close automatically when the engine is shut down. Flexible air ducting shall be provided between radiator and louvered air outlet.

Inside the base structure of the housing of the power station, a fuel storage shall be constructed with a content of approximately 10,000 1. The filling pipe shall have a connector for accepting pressure delivery from a tanker. The pipe shall be covered with a screwed cap with locking, provisions.. The tank shall be provided with a galvanized steel breather pipe with a drip-proof cap to a height of at least roof level of the housing.

A fuel day tank of approximately 200 1 shall be provided to each engine. This tank shall be filled by a float switch operated, electrically driven pump. A low level float switch shall be provided causing the engine to stop when the fuel level in the daytank drops below the minimum level.

Full-way filters shall be fitted immediately before each engine fuel pump suitable to operate during at least 800 hours.

The engine governor shall be mechanical servo-type suitable for starting, stopping, speed adjustment and load regulation. The governor shall be capable of maintaining automatically the engine speed within plus and minus 2.5 % of the adjusted speed between no load and full load.

An overspeed device shall be provided and set to operate when the engine speed exceeds, the normal- speed by more,than 20 % and cut off the fuel, supply instantly.

The- engine air intake shall be fitted with a heavy-duty cyclonic air filter with precleaner and indication.

A complete, exhaust system shall be provided, with an industrial type silencer. The exhaust pipes shall be insulated with calcium silicate shells, covered overall with aluminium sheet.

Each engine shall be fitted with an electric starting system with storage battery and charging equipment. The starting battery shall be of sufficient capacity to allow 3 cold starts in one hour without recharging. An engine driven dynamo shall recharge the battery after having started the engine, while the battery of the standby diesel generator set is maintained in condition by a tricle charger set in the alternator control panel.

All electrical wiring on the engine for alarms and control, which are to be connected with the control cubicle, shall be terminated in one terminal box.

6209.3 GENERATOR

The generators shall have a nominal capacity of 75 kVA at 220/380 V, 50 Hz, 0.8 power factor and 45°C ambient temperature, with an occasional max. temperature of over 50 C in the shade. They shall be of the self-regulating brushless revolving field type.

They shall be totally enclosed, constructed in IP 55 in accordance with I.E.G.-Publication No. 34 and 35. The insulation of the widenings shall be class F.

From no-load to 110 % at any power factor from unity to 0.8 lagging, hot or cold, the steady state voltage shall be maintained within plus and minus 2 % of the rated voltage.

The generator wave form shall be smooth, and the values of the harmonic content shall not exceed the permissable values in accordance with the VDE-Specification 0530.

6209.4 CONTROL CUBICLE

The control equipment for both diesel generator sets shall be mounted in an industrial type totally enclosed dust-proof sheet steel cubicle.

The front panelshaTV be hinged, Cable entries shall be ar;-ranged by detachable gland plates.

The wiring shall be carefully arranged and supported and fully identified by colour and numbered ferrules. Separate terminals of the correct rating shall be provided for each outgoing cable connection.

The generator neutral shall be earthed inside the control cubicle. The main contactor shall be equipped with an adequate overload and short circuit protection. Electrical interlock facilities shall be provided for the two main contactors to prevent closed position of both contactors simultaneously.

The control gear for starting and stopping the engine shall be of electronic type. The starting and stopping sequence of the Diesel engine shall be initiated by a photoelectric cell mounted in the nearest lighting pole, the lighting level producing the start and stop signals shall be adjustable.

In case of failure of the running diesel generator set, the standby set will take over its duty automatically and control will then proceed with the same photoelectric cell combination.

A clock-operated duty selector shall be provided to select the running and standby diesel generator set. Duty selection will change automatically every 24 hours.

As soon as the generator produces the correct voltage the corresponding main contactor shall be closed automatically. The contactor shall open immediately when the stop engine sequence is initiated.

The control cubicle shall comprise the following operation and indication components for each diesel generator set:

- Voltmeters for the generator voltage, each with a selector switch
- battery voltmeters
- sets of 3 ammeters for the generator current
- battery charging ammeters
- battery charger on/off control switches
- auto-hand-off control switches for engine control

- sets of start-stop and test buttons or equivalent manual controls

- sets of fault lamps.

- fault reset buttons

- duty selector switch as manual override of the clock-operated selector

- hour meters indicating the running period of the engines

- potential-free contacts connected to a terminal block for the following functions:

  - Diesel generator set No. 1 running!
  - Diesel generator set No. 2 running!
  - Diesel generator set No. 1 fault!
  - Diesel generator set No. 2 fault!
  - Minimum fuel level!
  - Low generator voltage

The following faults shall cause the engine to stop:

- low lubricating oil pressure
- high lubricating oil temperature
- high cooling water temperature
- low fuel level in daytank
- overload tripping of the main contactor.

These faults shall be monitored on the control panel and shall need a manual resetting to proceed operation.

6209.5 DISTRIBUTION BOARD

The distribution board shall be suitable for operation on a 3-phase, 4-wire, 380 V, 50 Hz system and the construction shall be fully dust-proof.

The board shall be mounted outside the power station on an own foundation against the outer wall and proper cable entry facilities shall be provided.

The interior shall comprise a mounting panel with all equipment and wiring exactly in accordance with the single line diagram shown on the drawing.

The housing of reinforced polyester or enameled hot galvanized sheet steel must be dust- and splashproof in accordance with IP 54 of the I.E.C. 144 requirements,

All electrical components shall 'be suitable to operate under local-, elimate conditions.

A common multiway earth bar shall be fitted' to which the armouring of the cables shall be. connected.

The inside of the access door shall be provided with a clear schedule showing the designation of all circuit ways in use.

The distribution board shall be included in the lump sum for the road lighting projects,

6210 INSTALLATION OF CABLES

The distribution cables shall be run in the longest possible lengths without joints, Where more than one cable is to be laid
in a trench, they are to be placed 5 cm apart from each other.

Sharp bends shall be avoided and at least 0,25 m clearance shall < be given from any gas and water mains. All cables shall be laid continuously, i.e. each fresh length of cable shall be rolled [1] off its drum away from and not towards the "A" end of the previously laid cable length.

Where rollers are used, they shall be spaced sufficiently close together to prevent abrasion of the cables. Cable grips shall f be undamaged and of the size appropriate to the cable being [Li] laid. Cables shall be snaked at all joints and junction boxes.
Where cables are laid in the ground, the trenches shall be of such depth that the top of the cables are not less than 0.8 m from the finished surface for L.T. cables; The bottom of the trenches shall be free of large stones or other material liable to damage the cables.

Cables crossing over each other shall have a minimum of 5 cm .vertical displacement with the highest cable kept at or below the minimum required depth.

In straight cable runs "in one trench cable crossings are not permitted except where cables branch from the main run to a 1igh ting pole.

The bending radius of any cable shall be not less than 15 times the outside cable diameter.

When straightening out the cables, excessive tension and kinks shall be avoided, and the Engineer's Representative may reject a cable when in his opinion the cable has not been treated properly as regards these aspects.

A cable slack of one meter shall be left in each cable connected to the distribution boards and in each cable entering a lighting pole. The slack shall be placed in the trench in a series of S-curves.

If possible, the cables will be laid in one length and through joints will not be permitted without the approval of the Engineer's Representative.

Joints shall be made by experienced personnel regularly engaged in this type of work. They shall be made with the greatest care and exactly in accordance with the instructions of the manufacturer of the jointing materials. The electrical continuity of the armoring in a joint shall be secured properly.

6210.1 EXCAVATION AND BACKFILL

The excavation shall not be wider than necessary for the proper installation of the electrical cables and foundations. Excavation shall not be carried out until immediately before the installation of cables and lighting poles; backfilling shall be done immediately after the cables have been laid in the trench.

Backfilling shall be done with materials approved by the Engineer's Representative. Unless otherwise permitted by the Engineer's Representative, all surplus excavated material shall be removed and disposed of as directed by the Engineer's Representative.

6210.2 CABLE TRENCHES

The depth of the excavation for cable trenches shall be minimum 90 cm and shall be at least 40 cm wide in locations where cable joints have to be made.

Before laying the cables, the trenches shall be filled with a layer of earth, free from stones, or clean sand, having a thickness of 10 cm. The cables shall be covered by another layer of the same material and thickness.

Over this second layer, a polyethylene sheet shall be laid to protect the cable against damaging. The sheet shall have a minimum thickness of 3 mm and shall be at least 30 cm wide. The sheet shall be marked' continuously over the entire length with the word "DANGER", alternately in the Arabic and the English language, printed in clear moisture- and rub-proof letters.

The trenches shall be backfilled in tamped layers of approved material with a thickness of 15 cm, free from stones and other hard materials, and the moisture content shall be adjusted to reach a satisfactory compaction.

6210.3 TYPE OF CABLES

The multicore underground cables shall be of the 600/1,000 V type, and shall comply with the relevant I.E.C. or VDE regulations. The cables shall have PVC-insulated copper conductors, armoured and PVC-sheathed overall.

The armouring of the underground cables shall contain or represent an earth conductor with a nominal equivalent cross-sectional area of at least the same size as the cable conductors up to and including 25 sq.mm. For cables with cores larger than 25 sq.mm, the equivalent cross-sectional area shall be at least half the size of the cable conductors with a minimum of 25 sq.mm.

The multicore cables installed in the masts between the fuse and the lantern, shall be of the same type as the underground cables but thearmouring may be omitted.,

The cables shall be delivered to site in the same coils as despatched from the manufacturer and the labels showing size, type and length shall be removed only in the presence of the Engineer's Representative, and handed over to him.

6210.4 TESTING OF CABLES

The Contractor shall furnish all necessary equipment and appliances for testing the underground cable- circuits after installation.

The Contractor shall test to his own satisfaction and then request the presence of the Engineer's Representative to witness and demonstrate to his satisfaction the following:

a) That all cables for lighting and control circuits are continuous and free from short circuits,

b) that the insulation resistance between phases and earth is not less than 100 megohms, measured with a 1,000 Volt Megger,

c) that all cables are connected in accordance with applicable wiring diagrams, and that these connections are corrosion free and mechanically sound.

6210.5 CABLE JOINTING

For jointing, screwed connectors of an approved type shall be used. The jointed conductors shall be isolated by a thermosetting resin; produced from two components packed by the manufacturer in .properly graduated quantities in relation to each other.

The casting mould shall be made of hard PVC and shall have a dimension suitable, for the splice.

6211 DUCTS

6211.1 GENERAL

Where cables cross under paved areas they shall be installed in PVC ducts. The inner diameter of the ducts shall be 90 mm, but it will be the option of the Contractor at his expense, to use ducts of larger size if desired and, where used, it shall be for the entire length of the crossing. Reducing couplings will not be permitted. In each duct only one: cable shall be installed. Moreover, in every location, where one or more ducts are installed, one extra duct shall be provided for spare purposes.

6211.2 MATERIAL

.The ducts shall be of a rigid type, made from high impact PVC or similar and approved by the Engineer's Representative. The inner diameter shall be 90 mm and the wall thickness shall be at least 2.2 mm.

PVC couplings shall be solvent welded to the duets, using manufacturer's recommended solvents and methods.

6211.3 INSTALLATION

The ends of all ducts shall be reamed to remove burrs and rough edges. Cuts, shall be made square and true. Slip joints will not be permitted for coupling ducts.

Before installation under existing pavement, a hole with diameter larger than the duct has to be pre-drilled as directed by the Engineer's Representative. Then the duct will be installed by hand.

The ends of the ducts shall extend 50 cm beyond the edge of pave- r merit and this point shall be marked with a special tile, which shall be chained to the end of the spare duct. L

Ducts shall be laid to a:,depth of not less than 70 cm below the kerb grade in the sidewalk areas and median areas and 100 cm below'roadway pavement grade under road areas.

All ducts shall be capped until the cable will be installed. [Ducts for future use shall remain capped. A pull wire shall be installed in all ducts; at least 50 cm of pull wire shall be doubled back into the duct at each termination.

Road crossings shown on the plans may be changed with the approval of the Engineer's Representative to avoid underground obstructions.

6212 EARTHING

All metal components of the installation such as "lanterns, lighting poles, anchor bolts, generators, exposed metal parts of distribution, and control equipment and cable armouring, shall be made mechanically and electrically secure to form a continuous system which shall be effectively earthed. The earthing shall be effected by means of earth rods which shall be furnished and installed:

a) At each, electrical distribution board.

b) At the lighting pole of every row of poles farthest away from the corresponding distribution board.

The earth rods shall be of copper or copper-clad steel bars and the diameter shall not be less than 12.5 mm. The rods shall be of the extensible type and shall be installed to such a depth that the total earth resistance will comply with local regulations, but shall not be more than 10 Ohms. If necessary, more than one earth rod shall be installed to achieve the required values.

In the lighting poles, the cable armouring shall be secured to the earth terminal and from there the lanterns shall be earthed via one of the conductors of the multicore rising cable.

6213 LIGHTING POLES

Lighting fittings mounted at a height not exceeding 20 m above ground level shall be/installed on lighting poles as described hereafter.

The poles shall consist of a steel column, with or without a single or double bracket with mounting height and outreach as indicated on the drawings.

The poles shall have a harmonious silhouette,and the Contractor shall submit in his tender full information on the shape and detailed dimensions of the proposed poles. The columns shall either be made of one piece of steel sheet folded in a conical section and automatically welded in one longitudinal seam, or else they shall consist of stepped tubular sections.

Columns with a mounting height exceeding 12 m may consist of two telescopic jointed conical lengths which are to be assembled without welding or bolting.

All steel parts of the lighting poles shall be hot dip galvanized in accordance with ISO publications Nos. 1459, 1460 and 1461.

At the bottom the poles shall be provided with a flange which is to be bolted to a reinforced concrete foundation. This foundation shall be made of concrete Bn 250 and rolled steel bars, and shall have the following approximate dimensions:

for. 8 "m" pole-	60 cm square, 126. cm'deep-
for 12 m pole	70 cm square, 150. cm deep
for 16 m pole	80 cm square, 175 cm deep
for 20 m pole	100 cm square, 200 cm deep

Anchor bolts shall be placed and adjusted by means of a suitable jig before pouring the concrete. Two, if necessary three pieces of conduit shall be provided in the concrete to provide a suitable cable entry. These conduits shall enter the foundation at approx. 50 cm below ground level and discharge at the top near the vertical center line of the lighting pole. The inside diameter of the conduits shall be at least 34 mm and the bending radius shall be suitable to ensure a smooth entry of the underground cables.

The poles shall have a base compartment with an access door of sufficient dimension to facilitate easy connections of the cables and access to the electrical gear. A corrosion proof mounting plate shall be installed in the base compartment comprising:

suitable clamps or glands to secure the incoming cables,

a terminal block capable of receiving the incoming cables and the rising cables to the lanterns,

one fuseholder with fuse for each lantern mounted on the lighting pole,

one earth terminal, electrically connected with the column, to receive the armouring of the underground cable.

The Contractor shall submit to the Engineer's Representative's satisfaction and approval calculations showing that the lighting poles will be capable of withstanding a windspeed of 160 km/hr. at a height of 10 m. The calculations shall show for the complete structure, including brackets and lanterns,

a) that all parts of the assembly are not submitted to stresses of an acceptable defined limit,

b) .that the deflection caused by dynamic forces is not exceeding an acceptable limit,

c) Calculation in accordance with DIN 4131, 49778, 49779, 2448, 2458, and VDE 0210/5.

6214 HIGH MASTS

Lighting fittings mounted at a height exceeding 20 m above ground level shall be installed on high masts as described hereafter.

The masts shall be made of steel folded in conical sections, automatically welded inone longitudinal seam. The sections shall .be telescopic jointed or by means of bolts. If bolted joints are used, flanges shall not disturb the aesthetics of the silhouette of the mast and should preferably be positioned inside the mast.

The steel parts of the mast shall be hot dip galvanized in accordance with ISO publications Nos. 1459, 146Q and 1461, or else they shall be finished in accordance with the following process.

After installation of the mast, all exposed anchor bolts and securing nuts on the foundation shall be given one coat of an approved bituminous paint.

All scratches and other damage of the finish occurred during transport or installation works shall be thoroughly cleaned and touched up.

The masts shall be bolted on a reinforced concrete foundation by means of steel bolts and nuts of adequate diameter and quantity. The foundation shall be made of concrete B'ri 250 and rolled steel bars in accordance with international recognized standards.

The Contractor shall submit to the Engineer's Representative's satisfaction and approval construction drawings of the foundations and calculations showing that the foundation and the anchor bolts will not move and will be capable of withstanding a windspeed of 160 km/hr.

The masts shall have a lockable access door at ground level. The diameter of the mast shall be sufficient to provide internal climbing facilities for servicing the lighting' fittings on the top.

The lamp accessories such as fuses, ballasts, ignitors and capacitors shall be mounted on suitable frame and installed inside the mast on ground level. Provisions shall be made that no moisture, either from condensation or from entering rain water, will drip on the lamp accessories. Rising cables from the accessories to the lamps shall be properly terminated on terminal blocks and shall be bunched and fixed in the mast. Near the accessory frame inside the mast an earth terminal of at least M10 diameter shall be provided,, directly welded to- the mast,

At the top. of the mast, a head, frame shall be provided, suitable to. receive the-lighting-fittings in quantities and directions as shown on the drawings.'

The masts shall have a harmonious silhouette and the Contractor shall submit in his tender full information on the shape and detailed dimensions of the proposed masts.

Before manufacturing the masts, the Contractor shall provide and obtain the Engineer's Representative's approval for detailed construction drawings of the mast together with calculation showing that the masts will be capable of withstanding a windspeed of 160 km/hr. at a height of 10 m. The calculations shall show for the complete structures including headframe and lanterns,

a) that all parts of the assembly are not submitted to stresses of an acceptable defined limit,

b) that the deflection caused by dynamic forces is not exceeding an acceptable limit,

c) calculation in accordance with DIN 4131.

6215 ROADWAY LUMINARIES

6215.1 LIGHT: SOURCES

The high pressure mercury fluorescent lamps shall be suitable for an E27 screwed landholder. The burning position shall be universal and the lighting output after 100 burning hours shall be at least 3,-800 lumen for the 80 W lamps and 6,300 lumen for the 125 W lamps.

The high pressure sodium lamps used on the lighting poles up to 20 m height shall be suitable for an E40 screwed lampholder. The burning position shall be universal and the lighting output after 100 burning hours shall be at least 14,000 lumen for the 150 W lamps, 23,000 lumen for the 250 W lamps and 43,000 lumen for the 400 W lamps.

6215.2 LAMP CONTROL GEAR

All ballasts shall be drip-proof, canned, polyester-filled and shall be equipped with terminal blocks for the electrical, connections.

Instructions for making the electrical connections shall, be printed clearly on the can of the ballast..

The power losses in the ballasts shall not exceed the following values:

H.P. mercury	80 W:	10 W
H.P. mercury	125 W:	14 W
H.P. sodium	150 W:	20 W
H.P. sodium	250 W:	30 W
H.P. sodium	400 W:	36 W

Ignition devices shall be drip-proof, canned^ and shall be suitable to operate with a can temperature of at least 75°C,

The power factor of a lamp combination shall have a higher value than 0.85 and shall be achieved by connecting parallel capacitors with sufficient capacitance across the mains. The capacitors used for this purpose shall be suitable to operate at a nominal voltage of at least 250 V.

6216 LANTERNS

The pole mounted lanterns for high pressure sodium lamps shall comprise three main parts, viz.:

a glass-fiber reinforced non-corrosive polyester housing containing an optical system for[1] cut-off light distribution according to C-.I.E. recommendations,

a high pressure die-cast aluminium mast-entry piece containing all the necessary electrical gear and facilities for easy mounting on mast-arms or on top of masts,

a highly translucent acrylic bowl for maximum lantern efficiency.

The lantern shall be provided with an adjustable lamp holder for toe-in-angles of 5 - 10 - 15 - 20 and for adjustment of light distribution.

The lantern shall be rain- and dust-proof.

The sealing between the housing and the acrylic bowl shall be of weather-resistant felt, enabling the lantern to breathe through the felt, yet at the same time preventing the penetration of dust into the housing.

The lantern shall be provided with a mast mounting bracket, enabling side entry mounting on 60mm: mast arms and post-. top mounting on 76 mm masts.

The lantern shall be designed for easy maintenance with removable optical and electrical units.

The acrylic bowl shall hinge from the housing to facilitate re-lamping or maintenance,

All exposed parts shall be of non-corrosive stainless steel material.

The pole mounted lanterns for high pressure mercury vapour lamps shall comprise two main parts, viz.:

a glass-fiber reinforced non-corrosive polyester canopy, coloured natural grey, containing the optical system for one mercury, vapor lamp, providing a cut-off light distribution in accordance with C.I.E. recommendations and a ballast compartment in which all the electrical components are built,

a highly translucent acrylic bowl ensuring maximum lantern efficiency.

The lantern shall be rain- and dust-proof.

The sealing between the housing and the acrylic bowl shall be of weather-resistant felt, enabling the lantern to breathe through the felt, yet at the same time preventing the penetration of dust into the lantern.

All exposed metal parts shall be made of non-corrosive stainless steel.

The acrylic bowl shall hinge from the housing to facilitate re-lamping or maintenance.

The lantern shall be provided with a mast mounting bracket, enabling side entry mounting on 42 - 48 mm mast arms and post-top mounting on 60 mm masts.

The floodlight lanterns mounted in the high masts *for* two high pressure sodium lamps shall comprise three main parts, viz.:

a low-pressure die-cast aluminium housing,

a toughened front glass, attached to the housing by two hinges and four clips of stainless steel,

a hot dip galvanized mounting bracket.

The floodlight lantern shall be fitted with an asymmetrical. optical system of special design, made of high- purity aluminum which has been chemically polished and anodized..

In its basic mounting position with the glass front cover in an absolute horizontal position the floodlight shall keep all distributed light below the horizontal plane, providing a cut>off light distribution with perfect glare limitation in accordance with the C.I.E. recommendations.

The neoprene rubber seal between the housing and the glass front cover ensures that the floodlight is splash- and dustproof in accordance with IP 54 of the IEC 144 requirements.

All exposed metal parts shall be made of non-corrosive materials.

The design of the floodlight lantern shall be such that the shape factor is as small as possible.

6217 CALCULATIONS

The Contractor shall submit with his tender, detailed light distribution diagrams for each type of lantern offered in his tender.

Furthermore, computer calculations shall be submitted showing the horizontal illuminance in lux on roadway level and the luminance distribution in candela per sq.m for every 2 m in roadway direction and every 1.2 m across the roadway.

These calculations shall also show the average horizontal illuminance on roadway level and the average level and uniformity of the luminance distribution. The calculations are to be based on an average luminance coefficient of the roadway qo 0.1 and a specular factor xp 0.38.

The minimum average maintained value of the luminance on the motorway surface shall be:

1.5 cd sq.m for standard interchanges

Uniformity: $g_1 = L_{min}$ $L_{m,ax} =' 0.77$

$g_2 = L_{min}$ $L_{max} = 0.25$

2.0 cd sq.m for interchanges Baghdad-West
Baghdad-South
Basra junction
Falluja
Jordan junction

Uniformity: $g_1 = L_{min}$ L_{max} 0.77

$g_2 = L_{min}$ L_{max} 0.25

2.0 cd sq.m for roundabouts Safwan + Basra

Uniformity $g_1 = L_{min}$ L_{max} 0.77

$g_1 = L_{min}$ L_{max} 0.25

The minimum average maintained value of the luminance of the resthouse areas shall be 12 lux,

Emin : Emax ≥ 1:6 and

Emin : Em ≥ 1:3

with exception of the outer zones of the parking places.

The expressway at all interchanges, except for the roundabouts, shall have an adaption of approx. 400 m.

Restriction of glare for all fitting and floodlighting fittings cut off.

6218 RECORD DRAWINGS

Upon completion of the contract works the Contractor shall submit "as-built" or corrected drawings and any other data showing in detail the exact location of cables, lighting poles, underground ducts, etc.

All drawings and any other data shall be submitted in the English language.

6219 CONTRACTOR'S DRAWINGS

Within 30 days following the notice from the Engineer's Representative to proceed, the Contractor shall submit for the Engineer's Representative's approval, drawings showing the general arrangement and detailed wiring diagrams of all switch- and fuse-board, together with detailed information on the components used, such as switches, circuit-breakers, fuses, busbars, etc.

6220 REMOVING AND REPLACING IMPROVEMENTS

Improvements such as kerbs, gutters, concrete and bituminous concrete courses and any other improvements removed, broken or damaged by the Contracotr's operations, shall be replaced or reconstructed with the same kind of material as found on the work or with materials of equal quality at the Contractor's expense. The new work shall be left in a condition satisfactory to the Engineer's Representative.

6221 LIGHTING IN UNDERPASSE

Where lighting in underpasses is required, lighting fittings with fluorescent lamps shall be installed as described hereafter.

The lighting fittings shall consist of aluminium extrusion or aluminium sheet housing, fitted with a plug-in optical/electrical gear tray, and shall be closed water-tight with a suitable front-glass assembly. The corrosion-resistant finish shall be white on the inside, and grey outside. On the optical/electrical gear tray ,all optical and electrical gear shall be mounted, being reflector, >;lamp holders, ballasts, ignitors, fuse and fuse holder, plug and socket arrangement, earth connection and inner circuitry wiring.

The front glass assembly shall consist of a toughened glass plate and shall be pressed on any in-laying gasket at the front side of the housing by six screw-head type closing devices, which require 90 turning for opening *or* closing the fitting. The front glass shall be fastened to the housing by two hinges of a special design, which on their turn can be opened without the use of tools, thus permitting quick replacement.

The fittings shall be fixed to the concrete by means of at least 4 raw! bolts or self-drilling anchors of approved type, which shall not enter the concrete more than 4 cm.

Cables for these fittings shall be laid in small PVC-trunking with cover.

6222 SPARE PARTS

The Tenderer has to deliver with his bid a priced list of recommended spare parts required for a two-year period of operation of the lighting equipment,' to be delivered to a place stated by the Engineer's Representative. A prime cost item for this purpose is included in the Bill of Quantities.

6223 MEASUREMENT AND PAYMENT

The payment for lighting installation shall be made by lump sums and shall include all material., labour and testing of the completed installation of the various interchanges and rest-camps as stated in the Bill of Quantities.

Generators shall be paid for as prime cost items including allowances for Contractor's profits and attendance as stated in the Bill of Quantities.

Payment will be made in accordance with the prices stated in the Bill of Quantities for the various items in accordance with the Specification, and shall constitute full compensation for furnishing all material, equipment and labour and for performing all operations necessary to complete the work. Provision, delivery of material to the site, handling, storage and maintenance and all incidentals shall be included in the lump sums for the various lighting projects.

Special attention is drawn to Clauses 1103 and 1104 of the Specification.

63 FENCING

6301 SCOPE

The work covered by this Section of the Specifications consists in furnishing of all equipment, material and labour, and in performing all operations in connection with the construction of chain link fencing and gates, subject to the terms and conditions of the Contract and in strict accordance with this Section of the Specifications, the applicable drawings and the direction of the Engineer's Representative.

630.2 DESIGN AND TYPE

The fence shall be a chain link type with gates galvanized or plastic coated, and shall be constructed in accordance with the, design shown on the drawings.

6303 MATERIAL

6303.1 POST AND STRUTS

Steel fence posts and struts of the diameter and length, as indicated on the drawings, shall be of the steel quality "St42" DIN 17100 or similar quality.

6303.2 CHAIN LINK MESH

Chain link mesh shall comply with DIN 1199 or AASHTO M 181. The width of .the mesh shall be 1.50 m and the openings in the mesh 6.0 cm and 3.4 mm wire diameter.

6303.3 FENCING WIRE

Line wire shall consist of solid mild steel wire, and stirrup wire and tying wire, of annealed mild steel wire, all complying with B.S. 1052, or similar as approved by the Engineer's Representative. The following sizes of wire shall be used:

Line wire used with chain, link fencing -
B.S.W.G, No. 9

Stirrup wire for securing line wires to

intermediate posts - B.S.W.G. No. 12-1/2

Tying wire for securing chain link mesh to line wires - B.S.W.G. No. 14-1/2. *

6303.4 FITTINGS

The fittings for the fences shall comply with the following requirements:

Winding brackets shall be of suitable design, manufactured from mild steel flat not less than 33 mm x 5 mm and shall be fitted with a winding bolt of .16 mm minimum diameter and a ferrule, or ratchet winder.

Clamp Bars shall consist of mild steel flat 22 mm x 5 mm. They shall be secured to the straining posts by 8 mm diameter steel bolts.

6303.5 CONCRETE FOOTINGS .

The concrete to be used for the footings shall be Bn 150 in accordance with Section 54.

6304 PROTECTION

6304.1 GALVANIZED

Steel posts, struts, line wire, wire mesh and all fittings shall be galvanized in accordance with DIN 50975 or AASHTO M 111.

6304.2 PLASTIC COATED

Where directed by the Engineer's Representative, fencfe posts, struts,, line wire and wire mesh shall be plastic coated in a grey colour in accordance with DIN 50011 and DIN 50018.

6305 GATES

Single and double leaf hand operated gates shall be-manufactured and erected where directed by the Engineer's Representative,, and according to the drawings. The.opening direction is inwards.

The gates.shall be covered on one side with chain link mesh, as specified in Clause 6303.2,and fixed to the frame. This mesh shall be extended past the bottom of the frame to within not more than 5 cm of the ground.

Each gate shall have a locking dropholt complete with padlock and two keys, a center stop, counter-balanced holding back catch, and three journal type hinges on each side with bolts for fixing to the straining posts. All parts of fittings in the ground shall be set in concrete. Each pair of double gates shall have a slip bolt. All the fittings shall be of mild steel.

All welds in the frame, between the chain link mesh and the frame and between the fittings and the frame, any areas where the galvanizing has become' damaged, and any ungalvanized mild steel fittings, shall be primed with red lead oil priming paint in accordance with B.S. 2521/4. The completed gates shall then be painted with two coats of approved aluminium paint.

Alternatively gates may be in accordance with a design and specification submitted by the Contractor and approved by the Engineer's Representative. Such a design shall be at least equal to the design indicated on the drawings and specified above.

All gates are to be operated with the same key.

6306 ERECTION OF CHAIN LINK FENCING

Chain link fencing with the gates shall be erected to the lines and in the positions shown on the drawings, or where directed by the Engineer's Representative.

Straining posts shall be provided at all ends and corners of fences, at changes of direction or acute variations in level, at gate openings, and at intervals not exceeding 40 min straight lengths of fence.

Struts shall be fitted to all straining posts in the direction of each line of fencing-secured to them.

Intermediate posts shall be equally spaced between straining . posts at intervals not exceeding 4m.

Each straining post, strut and intermediate post shall be set in the ground and surrounded with concrete, as shown on the drawings. The hole shall be excavated with vertical sides and the concrete surrounding shall completely fill the hole to the depth shown. After the concrete has set, the remainder of the hole shall be backfilled with soil which shall be well rammed and compacted as-filling proceeds.

Three (3) lines of wire shall be strained tight by means of winding brackets secured to the straining posts, and fixed to each intermediate post by means of a wire stirrup passed through a hole in the post and secured with three complete turns on each side of the post.

The chain link mesh shall be strained between each pair of straining posts and secured to them by means of tying wire. The mesh shall then be attached to the line wires by wire ties spaced 15 cm apart on the top line wire, and 45 cm apart on the middle and bottom line wires.

6307 MEASUREMENT AND PAYMENT

Chain link fencing shall be measured in linear meters in place and accepted by the Engineer's Representative, including fence posts, struts, line wire and all fittings and concrete foundation. The length paid for shall be the overall length, parallel to the ground surface, from center to center of end posts, including the length occupied by gates. The different types of gates shall be measured per number.

Payment per chain link fencing shall be made at the unit price per linear meter of the items stated in the Bill of Quantities.

Payment for the gates will be made per number at the unit prices of the various items in the Bill of Quantities.

The payment shall constitute full compensation for furnishing of all equipment and labour and for performing all operation necessary to complete the work in accordance with this Section of the Specification.

The Contractor may propose alternative solutions for fencing, which must be accompanied by detailed specifications, drawings and financial terms, subject to approval of the Engineer's Representative.

64 GUARD RAILS

6401 SCOPE

The work covered by this Section of the Specifications consists in furnishing all plant, equipment, material and labour and in performing all operations in connection with guard rails, complete, subject to the terms and conditions of the Contract and in strict accordance with this Section of the Specification, the applicable drawings and the directions of the Engineer's Representative.

6402 GENERAL

The term "Guard Rails" refers to the complete structure composed of various posts, rail members, and pieces, brackets, fittings, fastenings., etc., as shown on the drawings. The type of guard rail to be used at any given location shall be as indicated on the drawings or directed by the Engineer's Representative.

The type of guard rail shall be the same for all sections of Expressway No. 1

6403 MATERIAL

All flange steel posts and bearing plates shall, be in accordance with UST 37 - 1 DIN 17100 and all steel rail types, metal rail members and fittings, etc. in accordance with UST 37-2 DIN 17100/DIN 1016 and DIN 267.

6404 PROTECTION

All steel posts, steel rails, plates, fastenings, fittings, etc. shall be hot dip galvanized in accordance with DIN 50975.

The thickness of galvanizing shall be for posts more than 80wm
for all other parts more than 60 //m.

6405 SAMPLING AND TESTING

AIT sampling and testing, shall be done in accordance with DIN 50049.

6406 CONSTRUCTION REQUIREMENTS

Guard rail of the kind and type shown on the drawings shall be constructed at the location shown thereon or as directed by the Engineer's Representative.

6406.1 GUARD RAILS ON EMBANKMENT

Single and single spaced guard rails on shoulders and/or central reserve shall be driven into the ground to the levels and dimensions as shown on the drawings.

6406.2 GUARD RAIL OVER CULVERTS

The flange steel posts over culverts are to be cut to the required lengths and encased in concrete as shown on the drawings or as directed by the Engineer's Representative.

6406.3 GUARD RAIL OVER BRIDGE DECK

Guard rail posts of the profile mentioned above over bridge decks shall be fitted with a bearing plate and nuts to the prepared and encased bolts in the deck slab of the various types as shown on the drawings.

6406.4 ENDS AND REMOVABLE GUARD RAILS

Double removable guard rails shall be erected in holes to the directions of the Engineer's Representative and at locations and in accordance with the drawings. The end section of single . or double guard rails shall be sloped to the ground according to the drawings and/or the directions of the Engineer's Representative.

6407 WORKMANSHIP

All posts shall beset vertically. Only high-grade workmanship. will be accepted. All joints shall be accurately fitted, and the complete guard rail shall be true to the lines and grades to which it was ordered by the Engineer's Representative to be constructed.

6408 MEASUREMENT

The unit of measurement for the various types of guard rails shall be the linear meter complete, including earthwork and incidentals. For different space of posts and for the special construction in accordance with Clauses 6406.2, 6406.3 and 6406.4 no separate measurement will be made.

6409 PAYMENT

The linear meters of the completed and accepted guard rail will be paid and measured as defined in Clause 6408.

Payment will be made in accordance with the unit prices in the Bill of Quantities for the various items in accordance with the Specification, and shall, constitute full compensation for furnishing all material, equipment and labour and for performing all operations necessary to complete the work. Provision, delivery of material to the site, handling and storage, all cutting and - waste, and all incidentals shall be included in the unit prices for the various items.

65 ROAD-MARKINGS

6501 SCOPE

The work covered by this Section of the Specification consists in furnishing all plant, labour, equipment and materials and in performing all operations in connection with the construction of Road Markings complete, subject to the terms and conditions of the Contract and in strict accordance with this Section of the Specification, applicable drawings and the directions of the Engineer's Representative.

6502 MATERIAL

Hot applied thermoplastic material shall be used for road markings. The thermoplastic material shall be factory mixed, from an approved manufacturer, of a white reflecting paint, well visible by day and night, durable and not being dangerous for skidding. It shall be suitable for the type and location of application. The material shall posses adequate thermoplastic properties over the range of climatic conditions of the location viz. resistance to spreading under traffic at the highest road temperatures and retention of plasticity at the lowest road temperatures. The marking should be effective and durable for at least twentyfour (24) months under heavy traffic conditions. The composition of the material with minimum and maximum proportions and grading of the constituents, the acid value of the binder, the temperature range of mixing and application, the settling time, the softening point (C) and the open flash point (C) shall be stated to the satisfaction of the Engineer's Representative.

The material shall be supplied in containers, which do not contaminate the contents and which protect the contents from contamination, and shall be stored in accordance with the manufacturer's instructions.

The date of manufacture shall be marked on each container.

6503 CONSTRUCTION METHODS

6503.1 APPLICATION

Immediately before the application of the road markings, the surface to receive it shall be brushed, chipped if necessary and airblasted clean and free from oil, surplus, bitumen, mud, dust and other loose or adhered material. The surface shall be dry at the time of application. The lines shall be laid or painted by suitable and approved equipment to the dimensions shown on the drawings.

The pavement has to be cut to a depth as detailed in the Bill of Quantity by a milling machine to receive the thermoplastic material or be placed on top of the pavement.

6503.2 PREPARATION OF THERMOPLASTIC MATERIAL

The material shall be melted in accordance with the manufacturer's instructions in a heater fitted with a mechanical stirrer to give a smooth consistency to the thermoplastic and such that local overheating shall be avoided. The temperature of the mass shall be within the range specified by the manufacturer, and shall on no account be allowed to exceed the maximum temperature stated by the manufacturer. The molted material shall be used as ex-peditiously as possible, and for thermoplastics, which have natural resin binders or are otherwise sensitive to prolonged heating, the material shall not be maintained in a molten condition for more than 4 hours.

The colour shall be white; the thermoplastic material shall be of a kind approved by the Engineer's Representative and shall contain glass pearls for reflection purpose.

6503.3 LAYING

Center lines, lane lines and edge lines shall be applied by approved mechanical means and shall be laid to a regular alignment. Other markings may be applied by hand-screed, hand-propelled machine *or* by self-propelled machine as approved or directed by the Engineer's Representative. After transfer to the laying apparatus, the material shall be maintained within the temperature range specified by the manufacturer and stirred to maintain the right consistency for laying,

The thickness shall be as shown in the Bill of Quantities,

6504 MEASUREMENT

The unit of measurement for traffic lines shall be the linear meter of the completed and accepted various lines. In case of interrupted Tines, only the painted length shall be measured.

The unit of measurement for restricted areas shall be the square meter completed and accepted to the dimensions as shown on the drawings excluding longitudinal borderlines. The pay area includes in this case painted and unpainted areas within the borderlines.

The unit of measurement for various traffic arrows shall be the number.

6505 PAYMENT

Payment will be made in accordance with the unit prices in the Bill of Quantities for the various items in accordance with the Specification, and shall constitute full compensation for furnishing all material, equipment;, and labour and for performing all operations necessary to complete the work. Provision, delivery of material to the Site, handling and storage and all incidentals shall be included in the unit prices for the various items, and including the cutting by a milling machine.

66 TRAFFIC SIGNS

6601 SCOPE

The work covered by this Section of the Specification consists in the furnishing of all labour, equipment, supplies and materials and in performing all operations in connection with traffic signs, subject to the terms and conditions of the Contract and in strict accordance with this Section of the Specification, the applicable drawings and the directions of the Engineer's Representative.

6602 GENERAL

The term "Traffic Signs" refers to the complete structure of all kinds of traffic signs composed of foundation, post structures, metal sign boards and all fittings. The type of traffic sign to be used at any given location shall be as indicated on the drawings and/or as directed by the Engineer's Representative.

The sign boards shall be lettered with Arabic and English type letters in accordance with the drawings,

6603 FOUNDATION

Reinforced concrete foundation shall be constructed in concrete, class Bn 250, and shall conform to Section 54 of the Specifications. Where unreinforced concrete foundations are applied concrete Bn 150 shall be used.

6604 SIGN STRUCTURES

All sign board structures, masts, posts and all fittings shall i be of the steel quality St37 according to DIN 17100 or ASTM A 53.

All supports and foundations must be based on stress calculations in accordance with the relevant sections of Part Five of the Specifications, a wind speed of 160 km/h and on permissible soil pressures to be determined by appropriate tests, subject to the approval of the Engineer's Representative.

Detailed drawings shall be submitted to the Engineer's. Representative for approval prior to the execution of the works.

6605 GALVANIZING

All sign board structures, tubes, steel posts and fittings shall be galvanized in accordance with AASHTO M 111 or DIN 50915 and DIN 50916 and all bolts, nuts, washers, etc., in accordance with ASTM A.153.

6606 SIGN BOARD MATERIAL

The material for sign boards shall be subject to the approval of the Engineer's Representative and shall meet the following requirements.

a) Aluminium alloy sheets shall conform to ASTM B 209, 6061-T 6 aluminium or similar, degreased and alodine-treated, 3 mm thick, unless otherwise indicated on the drawing.

b) Steel sheets shall conform to the requirements of the Specification for cold-rotted carbon sheets ASTM A 366 or similar as approved by the. Engineer's Representative.

c) Stainless steel bolts, washers, nuts, etc. shall conform to ASTM A 276 or similar, as. approved by the Engineer's Representative.

d) Reflective sheeting shall be as shown on the drawings or as otherwise approved by the Engineer's Representative.

Reflective sheeting shall consist of synthetic sheet resin or other approved noncellulostic materials, transparent plastic of each of the colours specified, and glass spheres. The glass spheres shall adhere to the synthetic sheet resin, and be embedded beneath a flexible transparent plastic film forming a smooth flat surface. The reflective sheeting shall have a precoated pressure sensitive adhesive backing or a precoated tack-free solvent or heat activated adhesive backing. The sheeting shall adhere tightly to the prescribed surfaces when applied in accordance with the manufacturer's recommendations. The precoated adhesive shall not require additional adhesive coats on the reflective sheeting or application surface. The precoated adhesive shall form a durable bond to clean corrosion-proof metals and shall adhere securely under normal service. After forty-eight (48) hours of aging at twenty-four (24) degrees C from time of application, the precoated adhesive shall be capable of withstanding eight (8) hours of soaking in water at twenty-four (24) degrees C without appreciable decrease in adhesion. The precoated adhesive shall have no staining effect on the reflective sheeting and shall be mildew resistant. Protective liner for preventing

contamination .or-premature adhesion shall be removable by peeling without the necessity of soaking in water or other solvents. The Contractor shall submit samples of each colour of the reflective sheeting to the Engineer's Representative - for approval, prior to ordering materials.

e) All sign faces shall be of the type, colour, design and size as shown on the drawings. Direction signs in connection with the Expressway shall be blue and white; for other roads black and yellow in accordance with DIN 6171 or similar.

All signs, except as otherwise shown on the drawings or directed by the Engineer's Representative, shall meet the International Road Traffic Sign Standards (European Agreement, Geneva 1971/73).

The Contractor shall submit to the Engineer's Representative for approval copies of drawings for all special sign faces and all sign faces bearing messages, showing the design and/ or arrangement and spacing of both the Arabic and English sign messages.

6607 STORAGE OF SIGNS

Signs delivered for use on a project shall be stored off ground and under cover in a manner approved by the Engineer's Representative. Any sign damaged, discoloured or defaced during transportation, storage *or* erection shall be rejected.

6608 CONSTRUCTION REQUIREMENTS

a) Placement:

The sign shall be laterally positioned from the shoulder edge or kerb as shown on the drawings or as directed by the Engineer's Representative.

The Contractor shall stake the location of the sign supports.
The Contractor shall be responsible for the proper elevation, off-set, level and orientation of all sighs he erects. He shall exercise due care in the preservation of stakes for his and the Engineer's Representative's use. If any stakes are lost, damaged, displaced or removed, the Contractor shall have them reset at his expense.

b) Footings for Posts:

Footings shall be excavated to the dimensions shown on the drawings to be prepared by the Contractor. Forming of the entire footing will not be permitted unless approved by the Engineer's Representative. Concrete shall be thoroughly rodded and spaded so as to eliminate all voids. Tops of footings shall be finished with a wood float and all exposed edges shall be rounded with an edger. Backfill shall be thoroughly compacted by mechanical tampers, and care taken to prevent damage to the finished concrete. Backfill shall be brought up level with the finished ground line. Pipe post bases and/or posts set in concrete shall be firmly supported plumb and vertical and at the proper elevation.

Surplus material shall be disposed of by the Contractor and the surrounding earth shall be leveled.

c) Sign Posts:

Post lengths shown in the drawings for signs are for bidding purposes only. The Contractor shall be responsible for determination of post lengths to provide the vertical clearance shown on the drawings. Field cutting of posts shall be performed by sawing.

d) Fastening Signs to Sign Posts:

Signs shall be fastened to sign supports in accordance with the recommendations of the sign manufacturer and to the satisfaction of the Engineer's Representative.

e) Where necessary, the Engineer's-Representative will establish or approve the position of the traffic sign.

6609 DELINEATORS

Delineators shall be made of galvanized steel, aluminium or hard plastic material which is subject to the approval of the Engineer's Representative. Shape and dimensions shall comply with the drawings. Supports, painting and reflectors shall be of approved manufacture.

Delineators along the Expressway shall be equipped with black arrows pointing to the next telephone pillar,

The erection of the delineators shall be done at the positions and intervals as shown on the drawings and/or as directed by the Engineer's Representative.

6610. LIGHTING OF-OVERHEAD TRAFFIC SIGNS

Overhead traffic signs shall be equipped with, illumination devices. This shall be made of a-continuous row of fluorescent lamp fittings with two lamps, mirrors and bowls.

The fittings shall be mounted in accordance with the drawings, A uniform light distribution is required.

The following values o luminance have obtained.

Colour	Value of luminance (cd/sq.m)
white	225 + 50
blue	6 + 2
yellow	180 + 40

The connection to the power cables of the illumination system is to be included.

6611 MEASUREMENT

Traffic signs shall be measured by the unit for each type as installed and accepted by the Engineer's Representative, and shall include all excavations and backfilling, concrete, reinforcement, anchor bolts and plates, sign posts, sheets and all fittings according to the drawings.

6612 PAYMENT

Payment of traffic sign will be made per number in accordance with the unit prices of the various items stated in the Bill of Quantities, and shall constitute full compensation for furnishing of all equipment and labour and,for performing all operations necessary to complete the work in accordance with this Section of the Specifications.

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