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ARCHITECTURAL-AND-CIVIL-ENGINEERING-DESIGN-SERVICES-IN-FOUR-LOTS

LOT 01 : 3/3 AL GARMAH RIVER BRIDGE REHABILITATION

FINAL DESIGN REV 0

TECHNICAL SPECIFICATIONS

JULY,2017

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## PART THREE : 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, shall 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, 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 occurring 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 prepared 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, recompact 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 <i>every</i> 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 für bodenphysikalische Prüfverfahren im Straßenbau, edited 1963 by Forschungsgesellschaft für das Straßenwesen 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  $E_2$  shall be calculated as follows:

$$E_2 = \frac{1.5 \times r \times \Delta p}{\Delta s}$$

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

$r$  = Radius of the bearing plate (cm)

$\Delta p$  = Difference of the pressure appearing at the beginning and end of that part of the pressure - settlement curve which is nearly a straight line.

$\Delta s$  = 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, will 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 compacted, 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 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. 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<sup>TM</sup> 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 centerline 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 GOR "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 GOR 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 frequently as deemed necessary by the Engineer's Representative for conformance 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 Representative 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 equipped as to distribute the bituminous material uniformly on variable widths of surface at readily determined 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 00Q 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 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.

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#### 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.

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 Specification, 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 with a relation of more than 3 to 1 between length and thickness. The 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 SO<sub>2</sub> 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 shall not exceed 1.0 % 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	T 90)	30 - 100
	0.005 mm		min. 100
Plasticity	(No. 200)		max. 5
			2
Index (AASHTO)			

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 <sub>m</sub> <i>sin</i> 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 Or- ganic 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 aggregate (considered as 100 % by weight) shall be added bitumen with-

in the percentage limits set in the specifications for the specific 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	15 - 30	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 percentage of bitumen to be used in the mixtures and the mix temperature. The Contractor will be allowed the following tolerances from the approved job mix formula:

Aggregate passing sieve 5 mm (No. 4) or larger	+6 %
Aggregate passing sieve 2 mm and smaller (No. 10 and 40)	+4 %
Filler (No. 200)	+2.0%
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	min. 700 kp	1,000 kp
Flow Marshall	mm 2-5	2 - 5
Percent voids in mix %	3 - 7	2 - 5
Swelling after 28 days % volume	max. 1.0	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 grad-line 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 the weather is not rainy.

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, 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 suspension 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 joint 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 occurring 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 not 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<sub>1</sub> = volume of specimen before soaking

V<sub>2</sub> = 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  $\pm 1$  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 centerline and upon the surface of the road, 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 various 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.

Such 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, 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.

## 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 cured 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	Grading A	Grading B
MC 800 (kp/sq.m)	1.50 - 1.80	0.90 - 1.10
RC 800 (kp/sq.m)	1.50 - 1.80	0.90 - 1.10
Aggregate (liter/sq.m)	11 to 15	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 retarded 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 barricade 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 conditions 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, dense 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  $\pm 6$  mm, width  $\pm 3$  mm, height  $\pm 3$  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 larger 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, straight kerbs of a length of 50 cm shall be used. In case of curves smaller than 5 m, 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. Underlying 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<sub>5</sub> as specified in Clause 3902<sub>s</sub> 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 value 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** 40,000 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 CULVERTS AND DRAINAGE**

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 connection 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: The Contractor shall install over a culvert shall be at the Contractor's risk. Any pipe damaged thereby shall be repaired in 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, 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: In addition to what is specified in Section 22 of this Specification or as shown on the drawings, backfilling of pipes shall be carried out with approved material and compacted in layers not exceeding 15 cm in thickness.

Backfilling under present and future road surfaces shall be compacted to 95% of modified AASHTO density. Road compaction equipment shall 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 from  $S = 1.5$  to  $S = 1.75$ . The reinforced concrete pipes shall be laid on a foundation bed in concrete including haunching in Bn 100, 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 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 MEASUREMENT.

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.<sup>3</sup> 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 head-wall 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 construction 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, 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 Representative.

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.



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, 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, 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 measurement 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 consist 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 bituminous mixture to permit a good bond and eliminate the danger of washing out. On the lower end a footing block, class Bn 150, shall 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. All 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, 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 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.

Special attention is called to Clauses 1103 and 1104.



## PART FIVE: S T R U C T U R A L   W O R K

### 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 GmbH  
Burgenstraße 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 lines.

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 Engineer'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 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 Engineer'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 clearances frames shall be erected over the road at a suitable distance from the falsework on both sides. The frames shall be constructed with 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 <sub>w</sub> . "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 <i>f and</i>		5	10
450 L	2		
4 450 F and		3	6
550	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, equipment and all items including 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, 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<br>Bemessung und Ausführung (Jan. 1972)<br><br>Concrete and reinforced concrete<br>Structures<br>design and construction (Jan. 1972) |
| DIN 1048 | Blatt 1 und Blatt 2 .<br>Prüfverfahren für Beton (Jan. 1972)<br><br>Sheet 1 and sheet 2<br>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	Porll 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 ultrafine 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 ultrafine material is especially important in concrete which has to be conveyed long distances or through pipelines, in concrete for thinwalled densely reinforced components, and in waterproof concrete.

In general an ultrafine 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 ultrafine 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 grading 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 size 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's Representative.

When 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 content, 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, salt, 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, 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<sub>4</sub> per liter for prestressed concrete, 1300 mg SO<sub>4</sub> per liter for reinforced concrete, and 1500 mg SO<sub>4</sub> 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, 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 C<sub>J</sub>V of not more than 3 percent in weight and with a content of aluminium oxide A<sub>UCL</sub> 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,

Admixtures 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.

Admixtures 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 B<sub>50</sub> to B<sub>550</sub> (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,

unless 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  Bn 100		50 (710)	80 (1130)	Clause 5404.2	For plain concrete only
2			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 Bn 450 Bn 550		350 (4880) '	400 (5690)	Clause 5404.3	
6			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 concrete:

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 preliminary 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 1 x )	K 2	K 3
1	Bn 50 m)	favorable- (3)	140	160	-
2		serviceable (4)	160	180	-
3	Bn 100 κ)	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, 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, 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 exceed 0.65 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 Engineering Representative.

### 5404.4 CONCRETE WITH SPECIAL PROPERTIES

#### General Requirements:

Prerequisite conditions for producing 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<sup>-</sup> per liter, or by soils containing more than 3000 mg of SO<sub>4</sub> 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 action, 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 or, 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 <sub>4</sub> in		Type of Cement to be used, Ratios of Mix <sub>s</sub> 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 shall 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 <b>or</b> tamping
3	K 3 Soft concrete	liquid	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 shall 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 automatically 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, 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 sufficient 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, or when Rapid-Hardening Portland Cement is used., this limit shall be reduced to 15 minutes, 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 obtained.



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 conveying 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 RETEMPERING

The concrete shall be mixed only in such quantities as are 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 be 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 separation of the ingredients. After this operation, the entire equipment 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 Engineer'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 members 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 more than 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 the 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 Engineer'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 to 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, COLUMNS 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, 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, 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, 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 Representative 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, 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  $-3^{\circ}\text{C}$ , the temperature of the concrete on placing should be at least  $+10^{\circ}\text{C}$ . 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 ( $350^{\circ}\text{F}$ ,  $450^{\circ}\text{L}$ ,  $450^{\circ}\text{F}$ ), has not fallen below  $+10^{\circ}\text{C}$  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, 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  $20^{\circ}\text{C}$ , but not more than  $70^{\circ}\text{C}$ , 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 the 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  $35^{\circ}\text{C}$ , special precautions shall be observed during concreting and curing.

Concreting, when the shade temperature is above  $40^{\circ}\text{C}$ , shall preferably be 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 number of 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 a 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.

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, 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, 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, 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, and shall consist of mesh or round bars, spaced not less than 5 cm *no* i . t l 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 GENERAL REQUIREMENTS

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 •for the execution of all sampling and testing. All materials 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 addition 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 5404.3).
- c) Concrete with special properties always (see Clause 5404.4)

The 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

Preliminary 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  $f_{cm}$  of three cubes made of the concrete mix, to be adopted for the actual job, shall exceed the values  $f_{ctd}$  in the table, column 4 (see Clause 5404.1) by a certain margin:

For concrete of strength class Bn 50 the margin is <sup>at</sup> least 30 kg/sq.cm, for concrete of strength classes TjrTTcK) to Bn 250 (inclusive) it is at least 50 kg/s<sup>^</sup>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 done 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, except 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 control (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  $f_{cu}$  can, if the specimens are stored under similar conditions, be derived from the cylinder strength  $f_{cd}$  as follows:

$$f_{cu} = 1.25 f_{cd} \quad \text{for strength classes Bn 150 and lower, with } f_{cd} \leq 15 \text{ N/mm}^2$$

$$f_{cu} = 1.18 f_{cd} \quad \text{for strength classes Bn 250 and higher.}$$

If cubes or cylinders of some other size are used, the compressive strength ratio with respect to the 20 cm cube shall be verified separately 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  $f_{cu,28}$  is to be estimated from the 7-day cube strength  $f_{cu,7}$  in preliminary tests and quality-control tests, this may in 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 $f_{cu,28}$ / $f_{cu,7}$
1	250	1.4
2	350 L	1.3
3	350 F and 450 L	1.2
4	450 F and 550	1.1

#### 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 specimens, 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 specimens 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 pneumatically 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^ cement, 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 piling, which he proposes to use, 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 work, 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 stated by 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 of such enlargements shall be the sole responsibility of the Contractor,

#### 5504 EQUIPMENT

The equipment, which the Contractor 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 for 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, 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 over 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, 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.

After the excavation has been brought down to the proper elevation, all disturbed soil and loose materials shall be pumped out in such a manner that, after clean-out operation, the bottom of the borehole remains horizontal. Water shall be pumped continuously into the 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 made for a period of at least five minutes, then pumping shall be resumed and shall continue until the Water being pumped out is clean.

The cleaning of the bottom of the boreholes is subject to checking and approval by the Engineer'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, 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 responsibilities.

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 l in m for Co-efficient 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	15	11
1.5	18	13
1-,8	-21	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 content 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"<sup>11</sup>, 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 than 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 is at least 40 cm above cut-off elevation,

When concreting of a pile is completed with the surface of the concrete more than 1.0 m below ground elevation, a sand layer not less than 50 cm thick shall be deposited on top of the concrete before removing the pile casing.

When applicable, 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 missing additional piles shall be placed at the expense of the Contractor 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 execution of 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 than as compared to the drawings. The inclination of the pile shall 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 level 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 by 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 and 56 of the Specification.

The equipment to carry out Standard Penetration Tests, 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, 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, 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 50/55 {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, 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 the forms shall be precast concrete blocks or 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 blocks shall 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 wooden blocks will not be permitted. Reinforcement in any member shall be placed, inspected and approved 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 be 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, 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, no allowance will be made for the additional steel required.

For the purpose of computing weights of reinforcing steel the following 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.cm
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.

## 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, .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, 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 the 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.

That 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 the force to the concrete and minimum strength of the latter necessary for prestressing in systems where the 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 SPECIFICATIONS

Prestressing steel and prestressed concrete members shall be in accordance with the German "Richtlinien für Bemessung und Ausführung von Spannbetonbauteilen (Juni 1973) unter Berücksich-

tigung von DIN 1045 (Januar 1972) als vorläufiger Ersatz des Normblattes DIN 4227 (Oktober 1953)".

Code of 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      Straßen- und Brücken Lastannahmen  
(November 1967).

Road and foot bridges design loads.

DIN 1075      Richtlinien für die Bemessung und Ausführung  
massiver Brücken: (August 1973).

Concrete bridges, design and construction.

Richtlinien für das Einpressen von Zement-  
mörtel in Spannkannäle (Juni 1973).

Code of practice for the grouting of  
tendon ducts.

Vorläufige Richtlinien für die Prüfung bei  
Zulassung, Herstellung und Überwachung von  
Spannstählen für Spannbeton nach DIN 4227  
(Dezember 1965).

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 Specifications are available through "Beuth Verlag GmbH", Burggrafenstrasse 4-7, 1000 Berlin 30, and/or "Dorsch Consult", Postfach 210243, 8000 München 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.in 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 in: in diameter or for non-circular section, with at least 20 "sq.in" 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 supplier shall furnish. The certificate of analysis shall show the all in specified 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, which shows the manufacturer's 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, 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-tensioned tendons.

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 furnished by means of flexible metal conduit, metal tubing or other approved means and shall be stiff enough to positively maintain the desired profile between points of supports during operation work. The end of the duct shall be made so as to provide free movement of tendon at 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 be 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.

Anchorage 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 their proper position from the beginning and will not have to be moved to their final 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 the prescribed carrying capacity of the structural members. The use of chairs and spacer racks is necessary for this purpose. Chairs must be applied immediately behind all anchorages. The anchorages shall not carry the weight of a tendon. Spacer racks in girder 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 displacement 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 means of hardening tests in accordance with Clause 7.4.4 of DIN 1045 ; that the cube strength  $S_{cm}$  has attained the values indicated in column 2 of the table overleaf.

In regard to obviating shrinkage cracks, and temperature cracks\* -and also for the sake of early stripping of form work from individual parts of a structures it- may be advantageous to apply part 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, so that the (partial) 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 15 of 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 determined by linear interpolation.

Approval by the Engineer's Representative of such partial pre-stressing and moving shall in no way relieve the Contractor of full responsibility for successfully constructing the prestressed members,

The concrete strength class  $S_{cm}$  envisaged, here is the strength class needed to resist the stresses and forces (including the anchorage forces) occurring 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 prestress at 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 and 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 tensioning 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 PROCEDURES AND MEASUREMENTS DURING TENSIONING

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 tensioning and lowering of falsework should be so chosen that no inadmissible stresses will develop,

All measurements performed during tensioning should be recorded by the 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) extension for an individual tendon, the Engineer's Representative shall be informed of this if the deviation from the desired prestressing force or from the desired extension totals more than 5% for all the tendons 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 tensioning. Care shall be taken that no dirt and water can enter the prestressing ducts.

During the prestressing process it is forbidden to stand behind jacks or under the jack so that should a break occur, no one will be injured by the flying 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 50-- percent of the specified / minimum, ultimate 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 composition production and handling of this grout is regulated by the German "Richtlinien für das Einpressen von Zementmörtel in Spannkanele (June 1973)" - code of practice for the grouting of tendon ducts (June 1973), and shall be approved by the Engineer'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 time (40 - 45 sec.) should be aimed at,	
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 occurred) 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  $\geq$  300 kg/sq.cm  
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 harden 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 grout 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 freezing operation to - 20°C (+ 1°C).

Particular attention 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 be 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 agitated so 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 35 °C or as directed by the engineer's Representative.

When grouting under high temperatures, suitable measures 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 remains 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 rid 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 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 duct must not be re-used,, It is not permissible to use grout which has remained unused for half an 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 principle 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 days.

If it is unavoidably necessary to grout at air temperatures below +5°C, the structure must be kept sufficiently-warm for up to 5 days after; grouting. More particularly in the part where the tendons are located 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 (+5°C), 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  $t = t_0$  , 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  $\pm 1.0$  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 payment 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 prestressing forces<sup>5</sup> 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 steel<sup>9</sup> as well as type of anchorages, and the tendon forces at time  $t = 0$  and  $t = t_{co}$ .

It shall be quoted in the calculation which losses from friction, shrinkage, creep 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 above 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 anchorages 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 of 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 anchorage 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 clause 5708, and all other incidentals which are used on installed when completing the work by the contractor or which are order by the Engineer's representative and as specified herein.

#### 5712 PAYEMENT

Payment for prestressing steel will be made at the price tendered per metric ton for steel in place 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 must in their material, dimension and method of execution be executed and mounted exactly according to the drawings and prescriptions of this section.

Prior to the manufacture workshop drawings shall be made and submitted 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 glue 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, he shall perform pull-out tests according 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 inclued arrangement of the base plates or by stirrs.

## 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-place 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 tolerance not to exceed 3mm in 1mm. Steel bridge railing shall be completely reacted in the shop and checked for alignment and grade. Adjacent railing panels shall align 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, except that railing noted on the plans 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 of the anchors must be done exactly in accordance with the manufacturer's specifications and with bias test certificates or as directed by the Engineer's Representatives.

Between base plate and concrete surfaces of the sidewalk concrete a shim has to be applied as required.

The safety cable is to be primarily 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 MEASUREMENT

Measurement of bridge railing shall be the number of linear meters constructed and accepted in place. Measurement of each continuous 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 alosttomic 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									
Code number	Material number	Type of deoxidation	Treatment conditions	Similar steel grades according to Euronorm253	Tensile strength 4) 5) kg/mm <sup>2</sup>	Yield Point 6) Kg/mm <sup>2</sup> Minimum	Elongation 7) 8) Lo=5do % minimum	Average value from 3 specimens 9) Kg/cm <sup>2</sup> Minimum	At α	Aged DVMF Specimens 10) At + 20 °C		DVM specimens At + 20 °C		Mandrel diameter for bending test 11)
										Average value from 3 specimens	Sing le value	Average value from 3 specimens	Sing le value	
St 33-1	1.0033	-	-	Fe33-0	33	19 <sup>14)</sup>	18 <sup>14)</sup>	-	-	-	-	-	-	3c
St 33-2	1.0035	-	-	-	To 50		(14)	-	-	-	-	-	-	
UST 34-1	1.0100	U	U,N	Fe34-A	34 To 42	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 <sup>15)</sup>	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 <sup>15)</sup>	10	6	-	-	
St 37-3	1.0116	RR	U N	Fe37-C3 Fe37-D3				3,5	+0	-	-	7	3,5	29
UST 42-1	1.0130	U	U,N	Fe42 A(Fe45-A)	42 To 50	26	22 (16)	3,5	-20	-	-	9	4,5	
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 N	Fe42-C3 Fe42-D3				3,5	+0	-	-	7	3,5	29
RST 46-2 <sup>17)</sup>	1.0477	R	U,N	-	44 To 54	29	22 (16)	3,5	+20	8	-	-	-	
St 46-3 <sup>18)</sup>	1.0483	RR	U N	-				3,5	+0	-	-	7	3,5	
								3,5	-20	-	-	9	4,5	
St 52-3 <sup>19)</sup>	1.0841	RR	U N	Fe 52-C3 Fe 52-D3	52 To 62	36 <sup>20)</sup>	22 (16)	3,5	+0	-	-	7	3,5	29
								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/mm<sup>2</sup> 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/mm<sup>2</sup> 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/mm<sup>2</sup> the for thicknesses >40 ≤100 mm by 2 kg/mm<sup>2</sup>. 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 <sup>12)</sup>	P	S	N <sup>11)</sup>	C	P	S	N <sup>12)</sup>	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	.063	.063	.009	UQST34-2	1.0104	UZST34-1	1.0151	UPST34-2	1.0177
				.17	.055	.055	.008	RQST34-2	1.00109	-	-	RPST34-2	1.0178
0.20	.07	.050	-	.25	.090	.063	-	-	-	UZST37-1	1.0120	UPST37-1	1.0118
				.25	.080	.055	-	-	-	-	-	-	-
.18 <sup>16)</sup>	.050	.050	.007	.22 <sup>16)</sup>	.063	.063	.009	UQST37-2	1.0121	UQST37-2	1.0161	UPST37-2	1.0160
.17				.19	.055	.055	.008	RQST37-2	1.0122	RQST37-2	1.0165	RPST37-2	1.0182
.17				.045	.095	.009	.19	.050	.050	.010	QST37-3	1.0123	-
.25	.080	.050	-	.31	.10	.063	-	-	-	UZST42-1	1.0140	-	-
				.25	.088	.055	-	-	-	RZST42-1	1.0139	-	-
.25	.050	.050	.007	.31	.063	.063	.009	UQST34-2	1.0141	UZST42-2	1.0181	-	-
.23				.26	.055	.055	.008	RQST34-2	1.0142	RZST42-2	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 <sup>22)</sup>	.045	.045	.009	.22 <sup>22)</sup>	.050	.050	.010	QST52-3	1.0833	-	-	PSt52-3	1.0888
.25 <sup>23)</sup>	.080	.050	-	-	.088	.055	-	-	-	ZST50-2	1.0531	-	-
30 <sup>33)</sup>	.050	.050	.007	-	.055	.055	.008	-	-	ZST50-1	1.0533	PSt52-2	1.0539
35 <sup>22)</sup>	.080	.050	-	-	.088	.055	-	-	-	-	-	-	-
40 <sup>23)</sup>	.050	.050	.007	-	.055	.055	.008	-	-	ZST60-2	1.0543	-	-
50 <sup>23)</sup>	.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-chlorobutadiene. The elastomer 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 manufacturer's and independent quality control (rules of the specialist panel on "Bearings" of the Institute 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 polychloroprene 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 STEEL FOR SPECIAL 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.		Proof method according to DIN
	2416	2413	
	Mechanically high quality for abrasion-proof surfaces	Shear-soft inner parts	
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		53516
		Not measurable, rubber being too	
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) Composition	
See title 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 polytetrafluorethylene (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 freely 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 μm.

The cover of the carrier plates may also be of acetal resin (POM) tough fabric 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-chromium 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 CONSTRUCTION REQUIREMENTS

##### 5904.1 CONSTRUCTION REQUIREMENTS

###### FOR STANDARD BEARINGS

All dimensions of the standard bearings must be in exact conformity with the data contained in the drawings.

The embodied reinforcing steel 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

$$\tan \gamma = \frac{\text{horizontal displacement}}{\text{thickness } T \text{ of elastomer}}$$

$T$  = total thickness of all the layers  
Of elastomer in unstressed state

- permissible stress  $\sigma = 125 \text{ kp/sq.cm}$
- permissible range of temperature between  $-30^{\circ}\text{C}$  +  $50^{\circ}\text{C}$  and  
for short - term exposure +  $70^{\circ}\text{C}$

#### 5904.2 CONSTRUCTION REQUIREMENTS FOR SPECIAL BEARINGS

Special bearing are:

GHH sliding line rocker bearing

(Gutehoffnungshuttee Sterkrade AG, Esslingen, Nest-Germany)

Type LGa and

Type LGe

or equivalent 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  $\mu I = \leq 0.030$
- Load condition II  $\mu II = \leq 0.025$

At low temp (-35°C)

The permissible angles of tilt shall be in

Longitudinal direction  $\tan \delta 1 = 10 \text{ } 0/100$

Transverse direction  $\tan \delta 2 = 0$

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 <b>-0.1</b>

A special kind of silicone grease is to be used as lubricant, which neither resinifies nor affects the sliding plates.

On each bearing, an indicator shall be supplied to check movements.

The sliding surface must be completely protected against dirt and weather.

The sliding device as well as the line rocker elements must be replaceable.

#### 5904.3 CONSTRUCTION REQUIREMENTS 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 make up any length. All units shall be butted together by means of tongue and groove interlock as given in 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 RUSTPROOFING.

All steel parts, shall be supplied as follows:

Sadblasted; Sprayplated to a thickness of 60 to 100 myimeters coated with two layers of chlorinated rubber paint to a 40 myimeter 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 occurs.

#### 5906.3 PLACING OF JOINTS

Before placing standard expansion joints, the concrete surfaces shall be trowelled perfectly smooth. The required level of accuracy is  $\pm 1$  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

Bearings and 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.



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