SECTION TS 2. EARTHWORKS

2.1 GENERAL

This section of the Technical Specification covers the general and specific requirements of earthworks.

2.1.1 Character of Strata

The Contractor shall acquaint himself with all available data regarding earthworks and the character of strata and materials to be excavated and used as filling. He shall satisfy himself as to :

- the general circumstances at the Site of the Works
- any obstructions thereon
- the form of riverbeds and banks
- the flow of water in the river and channels
- the surface of the ground
- possible subsidence of soft ground
- poor materials
- possibility of floods
- his obligations for diversion and care of water under clause 1.13 of the General Specification
- slipping clay
- running sand
- gravel and boulders
- springs, subsoil and river water, loose or solid rock and stones
- trees, brushwood, timber and debris
- obstructions of any kind and material of whatever nature.

Rates entered in the Bill of Quantities shall reflect the Contractor's own assessment of risk and influence that these matters may have on his costs and no subsequent adjustments shall be made to rates for any reason.

2.1.2 Earthworks to Dimensions, Lines and Levels

All earthworks shall be carried out to the dimensions, lines and levels as shown on the Drawings, or to such other dimensions, lines and levels as may ordered by the Engineer. Dimensions and lines, which are based on or related to ground levels, shall be referred to the Engineer before commencing earthworks at any location.

For the purpose of the Specification the term original surface level shall refer to the ground or the river bed surface before the start of earthworks in accordance with the provisions provided for in clause 1.17 in the General Specification.

The Contractor shall be completely and solely responsible for setting out the works and establishing an adequate number of bench marks and reference

points. Surveys to be performed by the Contractor are described in clause 1.17 of the General Specification.

2.1.3 Method of Excavation

The Contractor shall carry out excavation in whatever material may be encountered and by any method or combination of methods he considers most suitable subject to any restrictions herein.

The Contractor shall give due consideration to the matters in clause TS 1.1.1 (Character of Strata), clause GS 1.13 (Diversion and Care of Water) of the General Specification, location and access to soil disposal areas, fill and stock pile areas and all other relevant factors.

2.1.4 Unsuitable Materials

Excavated materials which, in the opinion of the Engineer, do not meet required Specifications for fill, embankment or backfill shall not be used for such purpose and shall be transported to spoil dumps or stockpiles.

All spoil excavated from the bed of the Semarang and Asin Rivers is deemed as being unsuitable for other purposes and shall be regarded as contaminated soil which is to be treated as described elsewhere in this specification.

2.1.5 Transportation of Excavated Material

The transportation of excavated material to fill embankment, backfilling or stockpile site or disposal of excess or unsuitable materials shall be carried out in accordance with the approved schedule of earthworks operations. The Contractor shall transport material by the most appropriate route between excavation and placement or disposal areas using, as far as practical, access and haul roads within the site in order to minimise disruption to the population in the vicinity of the Works. Protective measures shall be made and maintained throughout for the safety of operations both on-site and off-site.

When hauling is done off-site loads shall be trimmed to prevent spillage. Wet materials to be hauled shall be dried sufficiently prior to loading to prevent spillage by leaking. Any damage or unsightly appearance on the surface of any road caused by the Contractor's hauling operation shall be reinstated by the Contractor at his own expense.

2.1.6 Disposal of Excavated Materials

Excavated material which, in the opinion of the Engineer, is suitable for use in filling, embankment or backfill may be transported directly to its final position, stock piled, or placed as otherwise approved by the Engineer.

Unsuitable soil or surplus excavated materials shall be disposed of in approved disposal areas as directed by the Engineer. The Contractor shall trim and grade spoil tips to profiles, heights and levels approved by the Engineer. He shall also maintain without interruption the flow of water courses affected by tips and comply with any other arrangement at the site existing between the Engineer and any other parties involved.

The requirement for treatment of contaminated soil in spoil disposal areas specified below is to be read in conjunction with this clause.

2.2 STRIPPING TOPSOIL

2.2.1 General

Stripping topsoil shall consist of the removal of all organic materials such as sod, topsoil and roots from areas where earth fill or embankment are to be constructed.

2.2.2 Method of Execution

Stripping of topsoil shall be to the depth and area limits shown on the drawings or as directed by the Engineer. All topsoil stripped, except that as may be used or saved in accordance with the Engineer's order, shall be disposed of in the manner described for soil unfit for reuse in clause 2.1.6. The minimum depth of topsoil stripping shall be 250 mm unless otherwise specified on the Drawings or directed by the Engineer.

2.3 EXCAVATION

2.3.1 Channel Excavation

2.3.1.1 General

The work covered by this clause relates to the excavation of the improved waterway channels of the Semarang River, the Asin River and the relocated portion of the Semarang River.

For the purposes of this Contract the following arbitrary definition shall apply:

Excavation Below Water Level

This sub-category of channel excavation shall mean excavation carried out in the existing channel of the Semarang River.

Common Channel Excavation

This category is not applicable to this package.

The Contractor shall carry out all channel excavation in whatever material may be encountered in accordance with these Specifications, the Drawings and any directions of the Engineer. The Contractor shall provide and operate all necessary excavating, lifting, hauling, transport and other equipment to deal with any type of material encountered. Excavation for the various works shall be carried out to such widths, lengths, depths and profiles as shown on the Drawings, or to such other dimensions as may be ordered by the Engineer in writing.

2.3.1.2 Trimming Tolerances

Excavated surfaces shall be trimmed to the lines and grades as shown in the Drawings or to other lines and grades as may be directed by the Engineer. Cross- sections on completion of excavation in waterway channels shall conform to the following tolerances :

a) Over-excavation of the depth of the low water channel	500 mm
b) Under-excavation of the depth of the low water channel	Nil
c) Over-excavation of the width of the river channel	500 mm
d) Under-excavation of the width of the river channel	Nil
e) Deviation of the shoulders of low and high water channels towards the channel centreline	Nil
f) Deviation of the shoulders of low and high water channels away from channel centreline	500 mm
g) Over-excavation of bed of the high water channel	200 mm
h) Under-excavation of the bed of the high water channel	Nil

Note that the above tolerances shall not apply when channel dimensions are specified to structures such as revetments or gate structures or where channel excavation is lined or has existing revetments which are to be retained.

2.3.1.3 Excavation Beyond True Line

The waterway channels shall be cut to the lines and level as shown in the Drawings and to the tolerances stated in clause TS 2.3.1.2 above.

For all parts of the waterway channels, with the exception of the low water channel, any over-excavation, for whatever reason and cause, unless as a result of the Engineer's direction, the Contractor shall, at his own expense, make good the excavation to the required line and level with approved material and in such a manner as the Engineer may approve. Where over-excavation is not detrimental to river flow and not unsightly, the Engineer may, at his sole discretion, waiver the requirement for making good such over-excavation.

2.3.1.4 Inspection and Survey

The Contractor shall measure work in progress by means of appropriate survey methods and in the presence of the Engineer or his representative.

The Engineer will carry out inspection of work progress and measurement of work completed assisted by the Contractor who shall provide boats, boatmen, labourers, materials and all other items necessary for the Engineer's use.

2.3.2 Common Excavation and Structural Excavation

2.3.2.1 General

This clause refers to all common excavation and structural excavation to be carried out under the Contract and shall be read in conjunction with clause TS 2.1.

The Contractor shall carry out all common and structural excavation in whatever material may be encountered in accordance with these Specifications, Drawings and any directions of the Engineer. The Contractor shall provide and operate all necessary excavating, lifting, hauling, transport and other equipment to deal with any type of material encountered. Excavation for the various works shall be carried out to such widths, lengths, depths and profiles as shown on the Drawings, or to such other dimensions as may be ordered by the Engineer in writing.

Where necessary the sides of all excavations shall be properly shored up and supported with strutting and planking, and the sides shall be close sheeted where necessary to prevent the entry of running sand, mud and the like. Sheet piling shall be used where site constraints preclude the use strutting and planking.

When any excavation has been completed and trimmed, the Engineer shall be informed so that he may make a formal inspection. No excavation shall be backfilled or covered with concrete until it has been inspected and the Contractor has been authorised to proceed.

2.3.2.2 Excavation Beyond True Line

Where any over-excavation occurs for whatever reason or cause, unless as a result of the Engineer's direction, the Contractor shall, at his own expense, make good those excavations to the required line and level with :

1) approved material and in such manner as the Engineer may direct where the excavation is other than for concrete work; or

2) concrete of the same grade as that to be used in the true excavated shape, unless directed otherwise by the Engineer, where the excavation is for concrete work.

2.3.2.3 Common Excavation

Common excavation shall mean any excavation works, other than that covered by Clause 2.3.1 (Channel Excavation), Clause 2.3.2.4 (Structural Excavation)

2.3.2.4 Structural Excavation

Except where otherwise shown on the Drawings on directed by the Engineer, Structural Excavation shall comprise excavation associated with the construction structures including, but not limited to, culverts, protection works, revetments, gabions, retaining walls, and any other works where the Engineer determines that Structural Excavation is appropriate.

Except where otherwise shown on the Drawings or directed by the Engineer the Contractor shall perform structural excavation to one of the two relevant typical profiles described below.

1) Where soil conditions do not require shoring, the side slope shall be at 1.0 unit vertical to 1.0 unit horizontal with a horizontal clearance at the underside of the proposed footing to the start of the excavation slope of 500 mm.

2) Where shoring is necessary owing to constricted working area, the need to prevent the entry of running sand or mud, shoring or sheet piling shall be placed such that there is a horizontal clearance of 1000 mm between the underside of the proposed footing and the inner face of the shoring.

The base and side slopes of excavation against which concrete is to placed shall be finished accurately to the dimensions shown on the Drawings or prescribed by the Engineer and the surface so prepared shall be thoroughly compacted with suitable equipment to obtain a satisfactory foundation. If at any point the natural foundation material is disturbed during the excavation process or otherwise, it shall be compacted in place to obtain a satisfactory foundation, or it shall be removed and replaced with approved compacted materials or concrete , all the Contractor's expense.

2.3.3 Treatment of Contaminated Soil

2.3.3.1 General

Sediments in the Semarang River and the Asin River are known to contain contaminants which include heavy metals. Thus all material excavated from the Semarang River and from the Asin River shall be hauled to a soil disposal area and treated by means of cement stabilisation as described below.

2.3.3.2 Method of Treatment of Contaminated Soil

Soil to be treated shall be spread in uniform layer not exceeding 200 mm within a spoil disposal area.

The soil shall be allowed to dry until the moisture content has lowered sufficiently such the soil has enough strength to support pedestrian weight.

The moisture content and layer depth shall be determined

The amount of ordinary Portland cement to give a 7% cement content (per unit dry weight of soil) shall be calculated using the parameters of soil density, moisture content and depth of layer. The required rate of cement shall be expressed as 1 bag per calculated area.

Cement bags shall be laid out according to the calculated spacing.

When the actual bag spacing has been approved by the Engineer or his representative, bags shall be opened and cement spread uniformly over the surface of the soil layer to be stabilised.

Cement shall be thoroughly mixed with the soil by means of a multi-disc plough which has an effective working width of not less than 2.5 m. The number of passes of the plough required to achieve thorough mixing shall be directed by the Engineer following observation of the first stabilising operation.

The elapsed time between the spreading of cement and completion of mixing shall not exceed 2 hours to ensure that that thorough dispersal of cement has been achieved before hydration of the cement has occurred.

To ensure that mixing can be achieved within the above time limit the Contractor shall limit the size of any area being treated to that which can be adequately handled by his mixing equipment.

The above procedure shall be repeated for successive layers to the extent and depth practicable. The surface of the final layer of treated soil shall be level and uniform.

Alternative methods of treatment by cement stabilisation may be proposed by the Contractor for the Engineer's approval. Any alternative proposal shall ensure that a verifiable 7% cement content (per unit dry weight of soil), uniformly mixed with the contaminated soil, is achieved.

2.4 FILL

2.4.1 General

The work described in this clause shall consist of the furnishing of necessary materials and selecting, stockpiling and blending if required, transporting, placing , spreading, adjustment of moisture content, compaction, shaping and doing incidental items of work to construct the finished fill to the lines,

grades and profiles as shown on the drawings or as directed by the Engineer.

The Contractor shall make due allowance for consolidation and settlement whether compaction is specified or not, such that the levels, widths and dimensions of the finished surfaces at the end of the Defects Liability Period shall not be less than the levels and dimension shown on the Drawings.

All filling and embankments shall be constructed to the lines and levels shown on the Drawings or established by the Engineer.

2.4.2 Materials

Materials to be used for the various types of fills shall conform to the requirements specified herein or as approved by the Engineer.

The Contractor shall submit to the Engineer for approval, samples and grading analyses (as applicable) of all materials proposed to be used for the various types of fill as specified below.

Earth Fill for Embankment, and Backfill with Selected Soil

Material to be used shall be extracted and selected from excavated material including that from common excavation, structural excavation or channel excavation (but excluding contaminated soil) and shall not contain roots, turf or clod exceeding 75 mm in size or organic matter of any kind and shall be approved by the Engineer.

Generally material shall not be used, unless permitted by the Engineer, where:

1) its 60% particle size is less than four times its 10% particle size.

2) it contains less than 8% passing 0.075 mm test sieve.

Gravel

Gravel for use in gravel bedding or gravel backfill shall consist of hard durable stone which will not break down or deteriorate in service and shall be clean and free from clay or other deleterious materials. Unless otherwise specified or directed, gravel shall be natural gravel or crushed stone with grading, by weight, determined in accordance with AASHTO test methods, conforming to the grading shown in the following table:

Sieve Size	Percentage Passing
2 inch	100
1½ inch	95-100
3/4 inch	50-100
1/2 inch	-
3/8 inch	15-55
No 4	0-25
No 8	0-5
No 200	0-3

Cobble

Cobble shall consist of hard durable natural or crushed stone which will not break down or deteriorate in service with particle size between 75 mm and 300 mm or as directed by the Engineer and shall be clean and free from organic or other deleterious material.

Sand

Sand for sand bedding and sand backfill shall be hard, clean, free of clay and mud and shall be well graded within following limits:

Sieve Size	Percentage Passing
9.52 mm	100
4.75 mm	95-100
2.36 mm	80 – 100
1.18 mm	50 - 85
600 mm	25 – 60
300 mm	10 - 30
150 mm	5 - 15
075 mm	1 - 10
Moisture Content	Less than 10 %
Clay Content	Less than 3 %

Sandy Soil

Sandy soil shall consist of natural soil free of clay lumps, organic matter or other deleterious material and shall be well graded with a maximum dimensions of 10 mm and not more than 5 percent smaller than 0.075 mm.

Blinding Stone

Blinding stone shall consist of clean, hard, durable natural or broken stone which will not break down or deteriorate in service and having a particle size of 200 mm + or – 20 mm measured along the major axis.

2.4.3 Placing, Compaction and Moisture Content of Filling

This clause relates to the earth fill used in backfill with selected soil and embankment as shown on the drawings.

Prior to commencement of filling, the Contractor shall carry out, under direct supervision and to the satisfaction of the Engineer, a series of field tests to determine optimum conditions and minimum number of passes of each type of equipment required to achieve the specified compaction for each type of fill material.

Fill material shall not be placed when, in the opinion of the Engineer, satisfactory results cannot be achieved due to heavy rain or other adverse conditions.

Fill shall be spread and compacted in approximately horizontal layers of uniform moisture content and uniform compacted thickness not exceeding 300 mm (or to lesser thickness as specified elsewhere). Filling, operations shall be such as to ensure that materials will be blended sufficiently to achieve the highest practicable dry density, and stability. Where the surface of any layer of filling is too dry or too smooth to bond properly with the next layer of material, it shall be moistened and/or scarified in an approved manner to provide a satisfactory bonding surface before the next layer is placed.

The moisture content of filling shall be carefully controlled, either by natural drying or wetting with a fine spray, to achieve optimum values. Fill material shall be compacted to a density of not less than 90% maximum standard dry density determined in accordance with AASHTO T 99. For portions of embankment upon which road pavements are to be constructed the upper 300 mm of fill material directly below the road pavement shall be compacted at optimum moisture content to a compaction of 90% maximum standard dry density in accordance with AASHTO T 99 for the full width of the roadway.

Where practical, as determined by the Engineer, moistening of the material shall be performed at the site of stockpiles but such moistening shall be supplemented by fine spraying at the time of compaction, if necessary. Where moisture content is beyond the optimum range, the operation shall not proceed except with the specific approval of the Engineer, until the material has been conditioned by wetting or drying to achieve a moisture content in the required range.

All compaction equipment shall be approved by the Engineer in writing before commencement of any filling operations.

At the end of each day, or whenever operations are suspended for any reason, the surface shall be rolled smooth and slightly crowned to shed water.

2.4.4 Preparation of Surface under Embankment

Filling shall not be placed on any portion of embankment foundation until such foundation has been cleared, stripped of topsoil, suitably prepared and has been approved by the Engineer. Tests pits, trenches and cavities resulting from the removal of unsound foundation materials or for inspection of sub-surface conditions shall be filled with selected materials.

Foundation material which does not have a density in the undisturbed condition as specified for the fill material to be placed upon it shall be moistened and compacted to specified dry density or shall be removed, filled and compacted or shall be treated in a manner as directed by the Engineer.

2.4.5 Filling Adjacent to Structures

Filling adjacent to structures shall be placed and compacted to avoid damage to such structures. Compaction adjacent to structures shall be carried out by hand or with suitable hand-operated equipment in horizontal layers not exceeding 150 mm thickness after compaction.

Unless otherwise specified or permitted by the Engineer, filling shall not be placed and compacted adjacent to concrete until at least fourteen (14) days after the placing of the concrete.

2.4.6 Embankment Construction

Filling for embankment construction shall mean completion of all filling constructed in accordance with the requirements of clause 2.4.3 and to the lines, levels and profiles shown on the Drawings or as directed by the Engineer and shall include the following :

- construction of embankments for earth dikes
- construction of embankments for roads
- construction of any other embankments shown on the drawings or as directed by the Engineer

2.4.7 Soil Tests

Tests on materials for use as filling shall be performed by the Contractor and shall enable determination of soil characteristics, suitability, dry density/moisture content relationships and the like. A formal report of all tests shall be prepared by the Contractor and approved by the Engineer. Tests shall be performed by the Contractor prior to commencement of

earthworks, and every time soil characteristics change. Tests shall include but not be limited to the following :

a) Compaction (AASHTO T 99) (Dry Density)

b) Particle size distribution

c) Specific gravity

d) Moisture content

e) Plastic limit

f) Direct shear

Test results shall be submitted to the Engineer for approval.

Field moisture content tests of compacted filling shall be made on each layer and at a frequency of one test for every 200 m².

The Contractor shall prepare a soil test programme in conjunction with his earthworks operation schedule and submit it to the Engineer for approval.

For gravel, only particle size distribution tests are required.

2.4.8 Backfill

Backfill comprising approved materials complying with the specification for filling provided in clause 2.4.2, shall be placed and compacted adjacent structures as shown on the Drawings or as directed by the Engineer.

Prior to commencement of backfilling adjacent to structures, the area shall be cleared of all formwork and other temporary works. Compaction shall be carried out by hand or with suitable hand operated equipment so as to achieve specified compaction without damage to structures. Backfilling material shall be wetted or allowed to dry in order achieve optimum moisture content for compaction.

Backfilling shall be placed and compacted in continuous horizontal layers of not more than 150 mm compacted thickness. Unless otherwise specified, backfilling shall be compacted to 90% of the maximum dry density as determined in the laboratory compaction test referred to in clause TS 2.4.7.

Unless otherwise specified or permitted by the Engineer, backfilling shall not be placed and compacted adjacent to concrete until at least fourteen (14) days after the placing of concrete.

Compaction of backfilling material placed above buried concrete, however, shall not be permitted to be carried out with vibrating equipment except with the prior approval of the Engineer.

2.5 MEASUREMENT AND PAYMENT

2.5.1 Channel Excavation

Measurement of the volume of channel excavation will be made using the average end area method of calculation for the respective portions of the channel excavation as defined in clause TS 2.3.1.

Measurement for payment shall not be made of over-excavation beyond the lines, levels and profiles shown on the drawings.

Payment shall be made at the rates entered in the Bill of Quantities and shall include the entire cost of completing the excavation from the approved original surface levels down to the lines, levels and profiles shown on the

drawings including materials, labour, equipment, transportation and any other associated costs.

Payment shall be deemed to include allowance for the cost of:

1) excavation through any material and to any depth

2) trimming to the correct profiles, lines and levels as shown in the Drawings

3) separating and setting aside those excavated materials suitable for re-use for other purposes and transporting to spoil those materials unsuitable for re-use

4) transporting, for a distance of up to three (3) kilometres one-way, excavated materials to spoil dumps, spoil disposal areas, stockpiles or to areas where contaminated soil is to be treated and further handled.

5) treating contaminated soil in accordance with the Specification.

6) preparation, clearing and operation of spoil disposal areas as described in this Specification

Categories of work to be paid under this clause are as follows:

Description	Unit of Measurement
Excavation below Water Level including Hauling and Treatment of Contaminated Soil	m^3

2.5.2 Structural Excavation

Measurement shall be made of the volume of materials acceptably removed, measured in the cubic meters in its original position and computed by the average end area method. Measurement shall include authorised excavation of unsuitable material below grade. Measurement shall also include the volume of the clearance and the side slope specified in clause TS 2.3.2.4.

Payment shall be made for the quantity of work, accepted and measured as provided above, at the rate entered in the priced Bill of Quantities, and shall include the entire cost for furnishing all shoring, and other related temporary work except work items measured separately in the Bill of Quantity and for all materials, labour, plant, tools and incidentals necessary to complete the work in accordance with the Drawings and these Specifications and as directed by the Engineer.

For structural excavation in waterway channels or retarding ponds, separate payment will be made for coffering and dewatering which is paid elsewhere and the rate for structural excavation will not include for such.

For structural excavation outside waterway channels or retarding ponds where coffering and dewatering is not provided as a separate pay item, the price shall include the cost of the necessary coffering and dewatering to complete the structural excavation.

Categories of work to be paid under this clause are as follows:

Description	Unit of Measurement
Structural Excavation	m^3

2.5.3 Backfill

Measurement shall be made of the volume of the backfill for backfill with the various materials as described in clause TS 2.4. Measurement will not be made of the volume of backfilling of structural excavation beyond the limits described in clause TS 2.3.2.4 of the Technical Specification.

Payment will be made at the rate entered in the Bill of Quantities and shall include the entire cost of completing the work including material, labour, equipment, transportation and any other associated costs.

Categories of work to be paid under this clause are as follows:

Description	Unit of Measurement
Backfill with Selected Soil	m^3

2.5.4 Sand Bedding

Measurement shall be made of the volume of Sand Bedding, as described in clause TS 2.4.

Payment will be made at the rate entered in the priced Bill of Quantities and shall include the entire cost of completing the work including material, labour, equipment, transportation and any other associated costs.

Categories of work to be paid under this clause are as follows:

Description	Unit of Measurement
Sand Bedding	m^3

TABLE OF CONTENTS

SECTION TS 3. CONCRETE WORK

SECTION TS 3. CONCRETE WORK

3.1 GENERAL

3.1.1 Scope

This section of the Technical Specification covers the general and specific requirements of concrete. It relates to the concrete in the Asin Pumping Station, bridges, gate works, buildings, channel works, culverts, revetments and all other parts of the Works which contain concrete.

This section particularly covers the supply and mixing of materials, the forming, placing, curing and finishing of the concrete, the quality of concrete required, and the supply, handling and placing of steel reinforcement for concrete.

Special requirements for concrete with respect to prestressed, precast or other types of concrete are specified in the relevant sections of the Technical Specification.

3.1.2 Description of Concrete, Mortar and Grout

3.1.2.1 Concrete

Concrete shall be composed of water, cement, fine aggregate and coarse aggregate and of any admixture that may be specified or consented to by the Engineer.

The consistency is to be in accordance with Clause 3.2.5.2

Testing is to be witnessed by the Engineer unless otherwise directed by the Engineer.

3.1.2.2 Cement Mortars

Cement mortar shall be composed of one part of cement to one part of fine aggregate by volume, or such other proportions as shall be directed by the Engineer, or as shown on the Drawings but not exceeding three parts by volume of fine aggregate to one part of cement mixed with water so that the water-cement ratio does not exceed 0.45 by weight.

Stiff cement mortar shall be as above, but with a water-cement ratio not exceeding 0.35, or to a consistency consented to by the Engineer.

Dry pack cement mortar shall be as above, but with water just sufficient to ensure full hydration of cement.

Mix proportions for mortar for wet stone masonry are specified in the technical specification for wet stone masonry in this specification.

3.1.2.3 Grout

Grout for sealing prestressing tendon ducts of other purposes shall be composed of cement, fine aggregate, water and admixtures as consented to or directed by the Engineer. The proportion of fine aggregate in the mix shall be as determined by the Engineer, who may direct that it be omitted altogether. The admixtures may be expanding and/or flow promoting agents. If aluminium powder is used as an expanding agent, the proportion shall be fifty parts per million of the cement by weight and the powder shall be mixed

with ground pumice stone and/or dry cement prior to adding to the cement dry. The proportion and colour of the pumice used shall be as consented to by the Engineer and shall ensure that accurate and uniform mixing with the cement is obtained.

The water-cement ratio shall be between 0.40 and 0.50 by weight. When used for sealing ducts in prestressed concrete, the grout shall be mixed to the stiffest consistency that can be forced through the ducts at as pressure consented to by the Engineer, generally not more than 700 kPa (7 kg/cm^2).

Grout for sealing ducts shall not be fed to the grout pump until the whole batch is thoroughly mixed. The grout shall be free of lumps and shall be strained, using a suitable filter.

Where non-shrink grout is specified for use, the Contractor shall submit technical data of the particular product proposed to be used for the Engineer's review and approval.

3.1.3 Classes of Concrete

The class or strength grade of concrete used in each part of the Works shall be that called for on the Drawings or ordered by the Engineer.

Where not shown on the Drawings or ordered by the Engineer the use of each class of concrete shall be as shown in Table 3.1. Attention is drawn to the alternative notation for concrete class. The upper designation C1, D etc. refers to the notation shown on the drawing and in the Bill of Quantities whilst the lower designation (K250 etc) refers to the notation used throughout this specification and the Indonesian Concrete Code.

Table 3.1: Classes of Concrete

Class of Concrete	28-day Compressive Strength MPa	kgf/cm^2	Max. Size of Aggregate mm	Application
A-1 K500	50	500	-	Prestressed concrete piles from commercial suppliers
A-2 K400	40	400	25	Prestressed concrete for bridge beams and prestressed concrete piles
A-3 K350	35	350	25	Prestressed concrete slabs, precast concrete piles
B K250	25	250	25	Reinforced concrete bridge beams
C1 K225	22.5	225	25	General use for reinforced concrete
C2 K225	22.5	225	15	Secondary concrete for blockouts.
D K175	17.5	175	40	Plain concrete for structures
E K125	12.5	125	25	Plain concrete for levelling

The class of concrete is defined as the Characteristic Strength at 28 days as defined in the Indonesian Concrete Code, (PBI 71), for samples tested in accordance with the requirements of AASHTO T 22 (ASTM C 39) using standard cubes of 150 mm.

Air - entrained is not required unless called for in the Drawings.

3.1.4 Strength Requirements

The mean compressive strength of the concrete shall be determined on the specimens obtained in prepared in accordance with AASHTO T 141 (ASTM C 172) and AASHTO T 23 (ASTM C 31). Test specimens made and cured in the laboratory shall conform to AASHTO T 126 (ASTM C 192). The compression test shall be performed on specimens according to specification AASHTO T 22.

The Characteristic Strength of the various classes of concrete, an accordance with the Indonesian Concrete Code (PBI 71), is obtained as defined as being the strength below which only 5 percent of specimens fall for a minimum of 20 specimens tested.

The mean compressive strength of concrete after 28 days shall be equal to or greater than the sum of the relevant Characteristic Strengths, as shown in Table 3.2, plus the strength margin as defined in Clause 3.2.1.2 below, while the mean compressive strength at 7 (seven) days shall, unless otherwise shown on the Drawings or directed by the Engineer, be 75 % (seventy five percent) of the prescribed values at 28 (twenty eight) days.

Table 3.2- Strength Requirements

Classes of Concrete	Characteristic Strength at 28 days (kg/cm^2)	
	Cube[1]	Cylinder[2]
K500	500	-
K400	400	-
K350	350	290
K225	225	185
K175	175	145
K125	125	100

(1) Cube of 15 cm size (2) Cylinder of 15x30 cm size

3.2 SUPPLY AND DELIVERY OF CONCRETE

3.2.1 Mix Design

3.2.1.1 General

The concrete shall consist of a mixture of cement, fine aggregate, coarse aggregate and water.

The concrete may also contain admixtures where these have been consented to by the Engineer.

3.2.1.2 Target Strength

The concrete mix shall be designed for a target strength in excess of the specified Characteristic Strength. The target strength shall be selected

having regard to the degree of quality control which the Contractor can expect over the materials and handling of concrete in the field.

For water cured concrete the target strength shall not be less than T, where:

$$F_c = T - 1.64\ s$$

and F_c is the specified Characteristic Strength at 28 days, and is the standard deviation as defined below.

For other methods if curing the Contractor shall submit the method of calculation of T.

3.2.1.3 Standard Deviation

For classes of concrete with the Characteristic Strengths less than or equal to 35 MPa (350 kg/cm^2) the estimated standard deviation of the compressive strengths of the concrete produced shall not be less than 4.5 MPa (45 kg/cm^2) nor greater than 8.5 MPa (85 kg/cm^2).

For classes of concrete with the Characteristic Strengths above 35 MPa (350 kg/cm^2) the estimated standard deviation of the compressive strengths of the concrete produced shall not be less than 25 MPa (250 kg/cm^2) nor greater than 5.0 MPa (50 kg/cm^2).

The Contractor shall nominate the target strength for the Engineer's consent. The standard deviation shall be determined for the concrete batch plant used and shall allow for variability of materials, batching, mixing, sampling and delivery operations. The target strength nominated shall take into account that the characteristic minimum compressive strength of concrete is based on the testing of samples taken at the point of use. Table 3.3 may be used as an initial guide in the determination of the estimated standard deviation.

Table 3.3 – Initial Estimate of Standard Deviation

Job	Standard of Control	Estimated Standards Deviation (MPa) – (kg/cm^2)		Margin by which target should exceed specified strength (MPa) - (kg/cm^2)	
		F'c < 35 (MPa) – (350 kg/cm^2)	F'c > 35 (MPa) – (350 kg/cm^2)	F'c < 35 (MPa) - (350kg/cm^2)	F'c < 35 (MPa) - (350 kg/cm^2)
Weigh batching of all materials, aggregate moisture and slump checks, uniform materials, very good methods of transport and placement and complete freedom from contamination of the concrete, constant supervision.	Excellent (automated control)	3.5 – 4.5 (35-45)	2.5 – 3.5 (25-35)	6.0 – 7.5 (60-75)	4.0 – 6.0 (40-60)
Weigh batching of all material, slump checked, occasional changes in production and slump, good methods of transport and placing and regular supervision	Very Good	4.5 – 5.5 (45-55)	3.5 – 5.0 (35-50)	7.5 – 9.0 (75-90)	6.0 – 8.0 (60-80)
Weigh batching of all materials or volume batching of aggregates plus allowance for moisture bulking, regular supervision of mixing and placing of concrete	Fair	5.5 – 7.5 (55-75)	Not Applicable	9.0 – 12.0 (90-120)	Not Applicable

In the design of a mix the Contractor shall take into account the slump requirements and the grading and maximum size of aggregates specified.

3.2.1.4 Proportions of Mix

i. Design submitted by the Contractor

The Contractor shall submit to the Engineer for his consent details of the concrete mix design, including the water-cement ratio proposed to be used for each class of concrete. These details shall be supplied six (6) weeks in advance of placing that particular class of concrete in the work so as to permit strength test to be made from trial mixes. The trial mixes will be carried out using samples of the materials submitted, and in the proportions proposed, by the Contractor. Alternatively the Engineer may request the Contractor to prepare, at the Contractor's expense, a trial mix of each class of concrete proposed to be used incorporating only such materials as have been tested and their use consented to by the Engineer. The trial mixes shall be made in the presence of the Engineer or his representative using the plant and the degree of quality control proposed for the work. Each mix shall be tested for slump, workability and strength.

If the coarse aggregate of fine aggregate is composed of more than one material of size of material the mix proportions of each shall be specified separately. Samples of each type of material and/or each size of material shall also be supplied by the Contractor as specified in Clauses 3.2.2.2 and 3.2.2.3

The Proportions of the concrete mixes shall be designed by the Contractor to satisfy the specified requirements of strength, grading and consistency.

Unless otherwise specified or consented to the Engineer, slump, water cement ratio and cement content shall conform to the values in Table 3.3.

Table 3.4- Properties of Concrete Mix

Class	Characteristic Minimum Strength (MPa)		Minimum Cement Content 3) (kg/m^3)	Maximum Water/Cement Ratio by mass	Maximum Slump[4] (mm)
	Cube[1]	Cylinder[2]			
K125	12.5	10.0	200	0.60	100
K175	17.5	14.5	240	0.60	100
K225	22.5	18.5	280	0.60	100
K350	35.0	29.0	360	0.50	100
K400	40				
K500	50				

Note:

1) Compressive strength based on 150 mm cube

2) Compressive strength based on 150 mm diameter x 300 mm high cylinder.

Concrete to be paced under water shall have a minimum cement content of 400 kg/cm3.

Slump will be determined in accordance with Clause 3.2.5.2

The maximum cement content in any concrete mixture shall not exceed 450 kg/m^3.

ii. Trial Mix Results

Prior to consent being given to a mix by the Contractor its compressive strength and shrinkage at 28 days will be checked from trial mixes.

A minimum of 20 Specimens shall be cast for the purpose of ascertaining the compressive strength of the trial mix.

In the case of urgency or for mixes which contain special admixtures, or are stream cured the Engineer may give a provisional consent based on test at an earlier age than 28 days but tests at age 28 days shall be the basis of final consent.

After the Engineer has consented to the use of a certain mix design of a particular class of concrete this mix shall be used for the work. In the event of changes in either properties or sources of materials or in their relative proportions the Engineer may require changes in the proportion of the materials and further testing.

iii. Control of Mix During Contract

In order to determine any need for mix adjustment the progress of the work, a statistical check may be made of the compressive strength of concrete, using consecutive 28 days test result representing concrete placed in the work, and making separate checks of each mix.

For each separate class of concrete, the concrete mix and its method of productions will be considered satisfactory should the following requirements be met:

i. Not more than one specimen from a group of twenty (20) consecutive specimens shall have a compressive strength at 28 days less than the Characteristic Strength for that class of concrete.

ii. The average of compressive strength at 28 day of any four (4) consecutive specimen shall not be less than the Characteristic Strength for that class of concrete plus 0.82 times the standard deviation as defined below.

iii. The difference in the values of compressive strength at 28 days between the highest and lowest value of any four (4) consecutive specimen shall be less than 4.3 times the standard deviation defined below.

The standard deviation shall be taken as the initial estimate (Clause 3.2.1.3 refers) until 20 specimens from concrete in the structure have been tested. At this stage the value of standard deviation shall be calculated from the result of the 20 strength tests this review process shall be repeated after every successive 20 test result and the requirement i, ii, and iii above applied succeeding batches of concrete.

In any case the standard deviation shall not exceed 8.5 MPa (85 kg/cm^2) for classes of concrete with Characteristic Strengths less than or equal to 35 MPa (350 kg/cm^2) or 5.0 MPa (50 kg/cm^2) for classes of concrete with Characteristic Strength above 35 MPa (350 kg/cm^2).

Notwithstanding consent by the Engineer to a proposed mix, the Contractor shall be solely responsible for producing concrete with satisfies the requirements of this Specification.

Should the Contractor propose to place concrete by pumping and the design of a mix suitable for pumping requires cements additional to that specified above, the cost of the additional cement shall be borne by the Contractor.

3.2.2 Materials

3.2.2.1 Supply of Cement

Cement shall be supplied by the Contractor and shall conform to the requirements of AASHTO M 85 (ASTM C 150). The Contractor shall not use low heat cement (Type IV) unless ordered or consented to by the Engineer. Cement shall be from one manufacturer and of one brand, type and grind and shall not be changed during the duration of the Contract without the consent of the Engineer. Sulphate resistant cement shall comply with the requirements of AASHTO M 85 for Type II cement. High sulphate resistant cement (AASHTO M 85 Type V) shall not be used unless otherwise ordered or consented to by the Engineer.

High alumina cement (Ciment Fondu) shall not be used without the written consent of the Engineer.

Air Entraining cement shall only be used with the prior consent of the Engineer and shall comply with the requirements of AASHTO M 85 (ASTM C150) and this Specification.

Blast Furnace cements shall only be used with the prior consent of the Engineer and shall comply with the requirements of AASHTO M 240 (ASTM C 595) and this Specification.

Fly Ash shall only be used with the prior consent of the Engineer and shall comply with the requirements of ASTM C 618 "Specification for Fly Ash and Raw or Calcined Natural Pozzolans for use in Portland Cement Concrete" and this Specification.

When not otherwise specified, the Contractor may use any type of Portland cement conforming to AASHTO M 85 except type IV or type V. When an air-retraining type is used, the Contractor shall maintain a supply of non-air-retraining cement As well as air retraining admixtures, for use where adjustment of air content may be required.

Cement shall be used in the order in which it is received by the Contractor. Cement shall not be used in this Contract more than ten (10) weeks after the date of dispatch from the cement works. The quality of the cement may be tested at any time by the Engineer.

The Engineer will select the sample which shall be supplied by the Contractor, free of charge, in accordance with AASHTO T 1217 (ASTM C 183).

3.2.2.2 Fine Aggregate

Fine aggregate for concrete shall consist of natural sand or, subject to the consent of the Engineer, other inert materials with similar characteristics, having durable particles. Fine aggregate from different sources of supply shall not be mixed or stored in the same pile nor used alternatively in the same class of construction without the consent of the Engineer.

The fine aggregate shall not contain deleterious substances in excess of the following percentages:

Percentage	AASHTO Test method	by weight
Clay lumps	T 112	1
Coal and lignite	T 113	1
Material passing No. 200 (75 micron) sieve .	T 11	3

Materials which contain other deleterious substances (such as shale, alkali, mica, coated grains, soft and flaky particles) shall be subject to the Engineers review and approval.

When the fine aggregate is subjected to five alternations of the sodium sulphate soundness test, using AASHTO T 04 (ASTM C 88), the weighted percentage of loss shall be not more than 10 percent. Fine aggregate failing to meet the requirements for soundness may be accepted provided it can be shown by evidence satisfactory to the Engineer that concrete of comparable proportions made from similar aggregate from the same source has been exposed to similar conditions of weathering for a period of at least 5 years without appreciable disintegration. The requirements for soundness may be waived in the case of aggregate for use in structures or portions of structures not exposed of weathering.

All fine aggregate shall be free from injurious amounts of organic impurities. Aggregates subjected to the colorimetric test for organic impurities, AASHTO T 21 (ASTM C 40), and producing a colour darker than the standard shall be rejected unless they pass the mortar-strength test. Should the aggregate in tests conducted during progress of the work show a colour darker than that of samples originally approved for the work, its use shall be discontinued until tests satisfactory to the Engineer have been made to determine whether the increased colour is indicative of an injurious amount of deleterious substances.

Mortar specimens containing the fine aggregate, when tested according to AASHTO T 71 (ASTM C 87), shall develop a compressive strength at the age of 3 days, when using type III cement, or at 7 days when using type I or II cement of not less than 90 percent of the strength developed by a mortar prepared in the same manner with the same cement and graded Ottawa sand having a fineness modules of 2.40 $\pm$ 0.10. Type I, II and III cements shall conform to AASHTO M 85.

The fine aggregate shall be uniformly graded and shall meet the following grading requirements:

Sieve designation	Percentage by weight passing square-mesh sieves (AASHTO T 27)
3/8 inch	100
No. 4	95-100
No. 16	45-80
No. 50	10-30
No. 100	2-10

Fine aggregate failing to pass the minimum requirement for material passing the No. 50 and No. 100 sieves may be used provided an approved inorganic fine inert material is added to correct the deficiency in grading.

The gradation requirements given above are the extreme limits to be used in determining the suitability of material from all possible sources of supply. The gradation of materials from any one source shall not vary in composition beyond the range values that govern the selection of a source of supply. For the purpose of determining the degree of uniformity, a fineness modulus determination shall be made upon representative samples, submitted by the Contractor, from such sources as he proposes to use. Fine aggregate from any one source having a variation in fineness modulus greater than 0.20, plus or minus, from the average fineness modulus of the representative sample submitted by the Contractor shall be rejected or may be accepted subject to such changes in the proportion of the concrete or such changes in storing or loading of sands as the Engineer may direct.

The fineness modulus of fine aggregate shall be determined by adding the cumulative percentages, by weight, of material retained on each of U.S. Standard Sieves No. 4, 8, 16, 30, 50 and 100, and dividing by 100.

3.2.2.3 Coarse Aggregate

The coarse aggregate for concrete shall consist of crushed stone, gravel, blast-furnace slag, or other approved inert material of similar characteristics having durable pieces, free from undesirable adherent coatings.

Crushed stone or crushed gravel shall be used for class K250 and class K350 or stronger concretes.

Unless otherwise consented to by the Engineer, concrete in various parts of the structures shall contain coarse aggregate with the effective maximum sizes as shown in table 3.1.

The effective minimum size shall be ten (10) mm for crushed material and five (5) mm for rounded materials unless otherwise directed by the Engineer.

The coarse aggregate shall not contain deleterious substances in excess of the following percentages:

Percentage	AASHTO Test method	by weight
Clay lumps	T 112	0.25
Material passing No. 200 (75 m) sieve	T 11	1
Thin or elongated pieces (length greater than 5 times maximum thickness)....	-	10

Materials which contain other deleterious substances shall be subject to the Engineers review and approval.

The coarse aggregate shall not have a percentage of wear more than 50 at 500 revolutions as determined by AASHTO T 96 (ASTM C 131).

When the coarse aggregate is subjected to five of the sodium sulphate soundness test, using the samples described as alternate B of AASHTO T 104, the weighted percentage of loss shall be not more than 12 percent. Coarse aggregate failing to meet the requirement for soundness may be accepted provided it can be shown by evidence satisfactory to the Engineer that concrete of comparable proportions made from similar aggregates from the same source has been exposed to weathering under conditions similar to those occurring at the site of the structure for a period of at least 5 years without appreciable disintegration. The requirements for soundness may be

waived by the Engineer when the aggregate is to be used in structures or portions of structures not exposed to weathering.

Coarse aggregate shall conform to the requirements of Table 3.5 for sizes designated and shall be uniformly graded between the limits specified.

Lightweight aggregate, if required or permitted by the Special Specifications, shall conform to the requirements of AASHTO M 195 (ASTM C 330) for grading specified.

Table 3.5 – Requirement for Grading of Coarse Aggregate

Percentages by weight (AASHTO T 27)	Nominal Size Range								
	12 mm	19.5 mm	25 mm	37.5 mm	50 mm	62.5 mm	19 mm – 37.5 mm	25 mm – 50 mm	37.5 mm – 62.5 mm
75 mm						100			100
62.5 mm					100	95-100		100	90-100
50 mm				100	95-100	-	100	95-100	35-70
37.5 mm			100	95-100	-	35-70	90-100	35-70	0-15
25 mm		100	95-100	-	35-70	-	20-55	0-15	-
19 mm	100	90-100	-	35-70	-	10-30	0-15	-	0-5
12 mm	90-100	-	25-60	-	10-30	-	-	0.50	0
10 mm	40-70	20-55	10-30	-	-	0.5	-	-	-
4.75 mm	0-15	0-10	0-10	0-5	0-5	0-5	-	-	-
2.36 mm	0-5	0-5	0-5						

3.2.2.4 Admixtures

Admixtures may only be used if consented to by the Engineer and then only in such quantities and manner as he may consent to in writing.

Such admixtures shall conform with the requirements of:

- AASHTO M 194 (ASTM C 494) "Specification for Chemical Admixtures for Concrete":
  - Type A - Water-reducing
  - Type B - Retarding
  - Type C - Accelerating
  - Type D - Water-reducing and retarding
  - Type E - Water-reducing and accelerating
  - Type F - Water-reducing (high range) and
  - Type G - Water-reducing(high range) and retarding
- AASHTO M 154 (ASTM C 260) "Specification for Air-entraining Admixtures for Concrete".

Admixtures shall not reduce the strength of concrete below that specified. Shrinkage and dosage sensitivity characteristics will be taken into account, if relevant.

Admixtures shall not contain chlorides, chlorine, sulphides or sulphites, or any other substance which may be detrimental to concrete or steel.

Use calcium chloride or admixtures containing calcium chloride will not be permitted.

3.2.2.5 Water

Concrete shall not be mixed unless the water to be used is approved by the Engineer. Water shall meet the suggested requirements of AASHTO T 26. Water known to be of potable quality may be used without test. The water shall be clear, neither salty nor brackish and free of all substances harmful to concrete and reinforcement. Harmful substances include oils, organic substances, vegetable matter, acids, alkalis and dissolved salts. The amounts of chloride and chlorine in the water shall be not greater than 0.1 percent.

3.2.2.6 Rubble Stone

Stone for cyclopean concrete, mortar rubble, dry rubble masonry or wet stone masonry shall be of suitable quality, sound and durable, and free from segregation, seams, cracks and other structural defects, or imperfections tending to destroy its resistance to the weather. It shall be free from rounded, worn, or weathered surfaces. All weathered stone shall be rejected. The stone shall be kept free from dirt, oil or any other injurious material which may prevent the proper adhesion of mortar.

3.2.2.7 Samples and Tests

At least six (6) weeks prior to commencement of concreting and on request at any other time during the Contract, the Contractor shall prepare and make

available to the Engineer any or all of the following materials proposed to be used on the Contract:

1) A 50 kilogram sample of source rock from each source. The sample shall be in the form of spalls of 100 to 800 mm size.

2) A 30 kilogram sample of each component aggregate together with a statement of the proportions in which it is proposed to use them in concrete.

3) A 10 kilogram bulk sample of cement sampled in accordance with ASTM C 183, Methods of Sampling Hydraulic Cement.

4) A 5 litre sample of water.

Samples shall be supplied by the Contractor free of charge to the designated office or laboratory. Sampling procedure supplied for the above series of tests on aggregates shall be as set out in AASHTO T 2 (ASTM D 75). If so directed by the Engineer, additional quantities of aggregates shall be submitted for the preparation of trial mixes.

If the Contractor proposes to place concrete by pumping he shall advise the Engineer at the time he submits samples for testing.

During the progress of the work further deliveries of a previously accepted material will be accepted subject to their satisfactorily passing the requirements of Clause 3.2.2.2 and 3.2.2.3, and/or compressive tests of the designed concrete mix as specified in Clause 3.3.7

3.2.2.8 Handling and Storage

i. Aggregates

Concrete aggregates shall be stored on firm, relatively level well drained ground so as to prevent mixing of foreign materials with the aggregates. Aggregates shall be delivered to the plant in one or more separate size ranges corresponding to the constituents of the Submitted Samples and shall be stored in separate areas to avoid intermixing. Each aggregate shall be the product of a single screen and shall not be obtained by mixing two or more sizes.

ii. Cement

Bulk cement shall be stored in bins and silos which are weather and designed to allow complete discharge.

Bagged cement shall be stored clear of the ground in a waterproof building. Different types, brands and deliveries of a cement shall be stored and handled to avoid intermingling and contamination and so that the cement in used in the sequence received. Cement from bags which have split will be condemned.

Any cement that becomes contaminated, wet or otherwise defective will be condemned.

Cement condemned for any reason shall not be used in the work of this Contract and, if at the site of the works, shall be removed immediately from the works by the Contractor who shall bear all costs of its removal and replacement with fresh cement.

iii. Admixtures

Where the use of admixtures has been consented to buy the Engineer they shall be stored in such a manner as to prevent contamination or freezing.

Liquid admixtures shall be stored in containers which provide for adequate stirring prior to discharge into the concrete mixer.

3.2.3 Batching

3.2.3.1 Batching

Unless otherwise consented to by the Engineer the measurement and batching of materials shall be done at a batching plant.

All materials shall be measured by weighing except when volume batching is authorised in writing by the Engineer and liquid admixtures may be measured in adjustable liquid measuring device, and cement may be measured by bags as packed by the manufacturer, in which case batches shall be proportioned on the basis of one or more unbroken bags of cement.

Batch hoppers, scales, water meters and admixtures dispensers shall be capable individual materials to within one (1) percent. Certified tests of the accuracy of weighing and measuring equipment shall be carried out annually or as directed by the Engineer and the results made available for inspection by the Engineer.

3.2.3.2 Classification of Plants

The Contractor shall nominate, at the same time as the samples of material referred to in Clause 3.2.2.1 are furnished, the manufacturer and model number of the batch plant(s) proposed to be used for the production of concrete under this Contract. In addition the methods of batching and the quality control to be exercised shall also be supplied. If the Contractor proposes to use portable mixers he shall provide full details of the mixing plant.

Table 3.3 lists the classification of concrete mixing plants and the expected standard deviation of the compressive strength test results required under Clause 3.3.7.

The Contractor shall satisfy the Engineer that the plant(s) proposed for use is compatible with the pour sizes shown on the Drawings and that sufficient stand-by capacity, if required by the Engineer, is available.

3.2.3.3 Handling of Materials

i. Cement

Either bagged or bulk cement may be used. No fraction of a bag of cement shall be used in a batch of concrete unless the cement is weighed.

All the bulk cement shall be weighed on a suitable weighing device. The bulk cement weighing hopper shall be properly sealed and vented to prevent the escape of cement dust during the operation. The discharge chute shall not be suspended from the weighing hopper and shall be so arranged that cement will not lodge in it nor leak from it.

ii. Water

Unless the water is to be weighed the water measuring equipment shall include an auxiliary tank from which the measuring tank shall be filled. The measuring tank shall be equipped with a tap and valve to provide for checking then setting, unless other means are provided for readily and accurately determining the amount of water in the tank. The volume of the auxiliary tank shall be at least that of the measuring tank.

Any admixtures whose use has been consented to by the Engineer shall be added to the water prior to the addition of water to the dry batched materials.

iii. Aggregates

Stockpiling of aggregates shall be in accordance with Clause 3.2.2.8. All aggregates produced or handled by hydraulic methods, and washed aggregates, shall be stockpiled or binned for at least 12 hours before being batched. Rail shipment requiring more than 12 hours will be accepted as adequate binning only if the car bodies permit free drainage. Should the aggregates contain a high or non-uniform moisture content, a storage or stockpile period in excess of 12 hours may be required by the Engineer.

iv. Bins and Scales

Where central batching plants are employed the plant shall include bins, weighing hoppers, and scales for the fine aggregate and for each size of coarse aggregate. The shape of the bins shall be such as to ensure that all materials are able to the outlet of the bin and no shovelling is required. If cement is used in bulk, a bin, hopper and, unless otherwise indicated, a scale shall be included. Bins with adequate separate compartments for fine aggregate and for each size of coarse aggregate shall be provided in the batching plant. Where directed by the Engineer suitable screens shall be fitted to the bins.

The Contractor shall furnish acceptable scales or other weighing devices. Weighing hoppers and scales shall be capable of determining the mass of individual materials to within one (1) percent accuracy.

3.2.3.4 Batching of Concrete Remote from the Mixer

Where batches need to be hauled to the mixer, bulk cement shall be transported either in waterproof compartments or between the fine and coarse aggregates. When cement is placed in contact with the moist aggregates, batches will be rejected unless mixed within one and one half (11/2) hours of such contact. Bagged cement may be transported on top of the aggregates.

Batches shall be delivered to the mixer separate and intact. Each batch shall be dumped cleanly into the mixer without loss, and when more than one batch is carried on the truck, shall be dumped without spilling of material from one batch compartment into another.

3.2.3.5 Mix Adjustment for Aggregate Moisture Content

The moisture content of the fine and coarse aggregates shall be determined as frequently as requested by the Engineer either by a moisture meter or by methods consented to by the Engineer. Corresponding corrections shall be made to the quantities of all aggregates as well as to the quantity of water used.

3.2.4 Mixing and Delivery

3.2.4.1 General

Concrete may be mixed at the site of construction at a central point or by a combination of central point and truck mixing. Truck mixing shall be in accordance with the appropriate requirements of AASHTO M 157.

For mixing at the site or at a central point, concrete shall be mixed in a batched mixer of an approved type. No mixer having a rated capacity of less

than a one-bag batch shall be used. The volume of concrete mixed per batch shall not exceed the mixer's nominal capacity as shown on the manufacturer's standard rating plate on the mixer except that an over-load of up to 10 percent above the mixer's nominal capacity may be permitted, provided concrete test data for strength, segregation, and uniform consistency are satisfactory and provided no spillage of concrete takes place. The batch shall be so charged into the drum that a portion of the water shall enter in advance of the cement and aggregates. The flow of water shall be uniform and all water shall be in the drum by the end of the first 15 seconds of the mixing procedure. Mixing time shall be measured from the time all materials, except water, are in the drum. Mixing time shall be not less than 60 seconds for having a capacity greater than 1.50 cubic meters, the mixing time shall be not less than 90 seconds. If timing starts the instant the skip reaches its maximum raised position, 4 seconds shall be added to the specified mixing time. The mixing time ends when the discharge chute opens.

The mixer shall be operated at the drum speed as shown on the manufacturer's name plate on the mixer. Any concrete mixed less than the specified time shall be discarded and disposed of by the Contractor at his own expense.

The timing device on stationary mixers shall be equipped with a bell or other suitable warning device adjusted to give a clearly audible signal each time the lock is released. In case of failure of the timing device, the Contractor will be permitted to continue operations while it is being repaired, provided he furnishes an approved timepiece equipped with minute and second hands. If the timing device is not placed in good working order within 24 hours, further use of the mixer will be prohibited until repairs are made.

3.2.4.2 Retempering of Concrete

Retempering concrete by adding water or by other means will not be permitted. Water shall only be added to bring the slump to the specified value provided that water content does not cause the design value of the water-cement ratio to be exceeded. Concrete that is not within the specified slumps limits at the time of placement shall not be used.

3.2.4.3 Mixing in an Emergency

Remixing of concrete which has become partially hardened will not be permitted. Such shall not be used in the Works.

Where, by reason of delay, it is desired to hold a batch in the mixer, mixing may be continued for a maximum of ten (10) minutes. For longer periods the batch may be held in the mixer and turned over at intervals as directed by the Engineer.

In the case of breakdown of the mechanical mixing equipment the Engineer may give consent to hand mixing, in small quantities (for mass or reinforced concrete only) so as to reach a support or a suitable location for a construction joint. Hand mixing may only be carried out under the supervision of the Engineer or his representative.

Hand mixing will not be permitted for prestressed concrete.

Where mixing by hand is permitted, the following procedure shall be adopted:

- Hand mixing shall be done on a suitable watertight platform of sufficient size to allow the mixing of at least two batches simultaneously.
- The amount of cement used shall be ten (10) percent more than the amount specified for machine mixed concrete of the same class.
- The fine aggregate and cement shall first be mixed until a uniform colour is obtained and then spread on the mixing platform in a thin layer.
- The coarse aggregate, which shall have been previously drenched with water, shall then be spread over the fine aggregate and cement in a thin layer, and the whole mass turned as further water is added with a rose sprinkler.
- After the water is added, the mass shall be turned at least three times, not including shovelling into barrows or forms, until the mixture is uniform in colour and even in appearance.
- Hand mixing of batches shall not exceed 0.2 cubic metres per batch.
- At least two test specimens shall be moulded for 28 days acceptance test from hand mixed concrete. These tests shall be additional to those required in accordance with Clause 3.3.7

3.2.5 Acceptance of Concrete

3.2.5.1 Concrete Control - General

The Contractor will be fully responsible for the supply and delivery of concrete under this Contract.

Concrete shall be produced from a mixing plant which has been consented to by the Engineer for the particular strength grade of required. Where concrete is to be mixed away from the site, it will be supervised by the Engineer or his representative.

The Contractor shall not obtain supplies of concrete from a plant for use in the Works without giving 24 hours notice to the Engineer on each occasion. The Engineer will not accept responsibility for any loss or delay to the Contractor by his failure to provide notice to the Engineer.

Concrete shall not be mixed until consent to do so has been given by the Engineer. Such consent may be withheld or withdrawn for any reason deemed sufficient by the Engineer, including unclean excavation or formwork, unsatisfactory formwork, incorrect reinforcement, inadequate transporting or compacting equipment, insufficient Contractor's labour, inclement weather or conditions which are unsafe.

3.2.5.2 Consistency of Concrete

The concrete to be placed in the work shall be of such consistency that it can be placed, compacted and worked readily into all corners, angles and narrow sections of the forms and around reinforcement without causing segregation of the materials or excess free water to collect on the surface.

The Contractor shall state (when submitting details of the proposed mix design) the slump value proposed for each mix within the limits contained in Clause 3.2.1

The consistency of the concrete shall be determined by a slump test in accordance with AASHTO T 119 (ASTM C 143). The Contractor shall provide at his own cost all equipment and facilities for the taking of the slump tests. The tests shall be made in the presence of the Engineer or his Representative.

Unless otherwise consented to by the Engineer, the slump of the concrete shall not exceed 100 mm for strength grades up to 35 MPa (350 kg/cm^2) and 80 mm for strength grades of 35 MPa and above.

3.3 CONCRETE IN STRUCTURES

3.3.1 Responsibility of the Contractor

The Engineer may request that the Contractor submits, for consent, drawings, Specifications, calculations and other information as shall be necessary to satisfy the Engineer as to the suitability and adequacy of the falsework, scaffolding and formwork that the Contractor intends to use on the works of the Contract.

Consent of the Engineer shall not relieve the Contractor of any of his responsibilities under the Contract.

3.3.2 Formwork

3.3.2.1 Design

Formwork shall be provided to produce hardened concrete to the lines, levels and shapes shown on the Drawings or specified elsewhere. It shall have adequate strength to carry all applied loads, including the pressure of fresh concrete, vibration effects, weight of workmen and equipment, without undue loss of shape. Forms shall be mortar tight and designed to allow removal without risk of damage to the completed structure. Joints in the formwork shall be perpendicular to the main axis of the shape of the concrete, unless otherwise directed or approved by the Engineer.

If required by the Engineer, detailed drawings, design calculations, including design assumptions such as rate of pouring and concrete temperature, description and/or samples of materials proposed for use shall be submitted for the Engineer's consent, before manufacture of the formwork is commenced.

Formwork shall be so constructed and be sufficient to tolerate high frequency vibration and shall be uniform stiffness to avoid causing varying vibration amplitudes over the formwork surfaces during compaction of the concrete.

Design of formwork shall be such that it shall not be necessary to drop concrete freely from a greater height than two (2) metres or to move concrete along the formwork after deposition.

For beams, girders and similar members the design of the formwork shall allow removal of the side forms, without interference with other forms and/or falsework. Removal of all forms shall be possible so that the load is transferred from the forms and falsework to the structure smoothly and gradually.

Provisions shall be made for the accurate location and firm support of fittings, bolts, ducts, anchorages and formers and holes as shown on the

Drawings. Temporary fittings used for the support of the formwork shall be arranged to permit removal without damage to the concrete.

Forms for edges of concrete shall provide chamfers and for re-entrant angles fillets as shown on the Drawings, or if not shown, of 25 mm on each side with equal angles in all cases. Where shown on the Drawings corners shall be formed with fillets or curves.

Where formwork is intended for re-use several times, the design shall allow for the deterioration of the materials in handling.

The use of non-removable formwork will not be permitted unless shown on the Drawings or ordered by the Engineer.

3.3.2.2 Construction

Forms shall be of timber, steel, precast concrete, polystyrene or other approved material. Materials used for formwork shall be sound, clean, free from imperfections and sufficiently uniform so that the specified surface finish can be attained. All timber shall be free from knotholes, loose knots, cracks, splits, warps and other defects which would affect the strength of the formwork or the appearance of the finished concrete surface.

Timber forms for exposed surfaces shall be constructed from plywood or particle board with hardwood or approved softwood studs and wales. Dressed timber forms may be used only with the consent of the Engineer.

The type and quality of material selected for formwork and workmanship used in construction shall be such that the surface specified shall be obtained. (See Clause 3.3.8). Forms shall be constructed in such a manner that stripping shall not result in damage to the concrete.

Formwork for all exposed surfaces shall be made from panels having uniform widths of not less than one metre and uniform lengths of not less than two metres, except where the dimensions of the members of the member formed are less than the specified panel dimensions. Plywood panels shall be placed with the grain of the outer plies perpendicular to the studding or joists, unless otherwise permitted by the Engineer. Where plywood form panels are attached directly to the studding or joints the panel shall be not less than 15 mm thick. Plywood from panels less than 15 mm thick, otherwise conforming to these requirements may be used with a continuous backing of dressed material of 20 mm minimum thickness. All form panels shall be placed in a neat, symmetrical pattern subject to the consent of the Engineer.

Forms for all surfaces which will be completely or permanently hidden below the ground may be constructed from dressed or undressed timber, steel, plywood or particle board.

The use of wires or bolts extended to the surface of the concrete will not be permitted except where shown on the Drawings, or if consented to by the Engineer.

Any embedded ties shall remain embedded and shall terminate not less than twenty five (25) mm back from the formed surfaces. Ties shall be constructed so that the removal of the end fasteners can be accomplished without spalling the concrete faces. All recesses shall be filled in accordance with the requirements of Clause 3.6.3 of this Specification.

Ties embedded in parts of the structure below the water shall have stainless steel tips. Stainless steel sections of the tie rods shall extend not less than

seventy five (75) mm into the concrete from the face of the face recess formed by the inner spacer.

3.3.2.3 Erection of Formwork

Dimensions and position of forms, especially those affecting the construction of subsequent portions of the work, shall be carefully checked after the forms are erected. Forms shall be aligned accurately and the location of all fittings, hole formers, etc. checked prior to placing concrete. Overall accuracy of the formwork shall be to the satisfaction of the Engineer and shall ensure that the requirements of Clause 3.3.9 Tolerances are met.

The interior surface of the forms shall be treated with the lightest practical coating of an approved non-staining release agent before the steel reinforcement or other insertions are placed to ensure non-adhesion of the mortar.

The formwork shall be inspected by the Engineer and the placing of reinforcement in the spaces formed shall not commence until consent is given by the Engineer.

The formwork shall be again inspected by the Engineer before placing of concrete is commenced. Before consent to commence concreting is given, all dirt, chips, hardened concrete or mortar and all foreign matter shall be removed from the forms.

Such consent will not relieve the Contractor of responsibility for any defects in the formwork, reinforcement, embedded components, or the formed concrete surface which may become apparent during or after casting the concrete.

When an inspection is requested by the Contractor, a notice of not less than 24 hours shall be given to the Engineer.

3.3.2.4 Removal of Formwork

All formwork shall remain in place until removal is authorised by the Engineer. The formwork shall be undisturbed until the concrete has adequately hardened and has attained the necessary strength to carry its own weight and construction loads. When required forms shall remain in place to protect the concrete against the effects of low temperature or excessive evaporation. Unless otherwise specified or directed by the Engineer in writing, forms shall not be removed from the concrete until the times specified in Table 3.6 have elapsed. These periods may be extended by the Engineer.

Forms for columns and other load bearing members shall always be stripped to determine whether they are satisfactory before removing falsework from any structural members they support.

In the case of complicated shapes where shrinkage stresses could cause cracking, the Engineer may permit side forms to be loosened at an earlier stage.

In the case of concrete containing special admixtures, stripping times shall be as determined by the Engineer who will take into consideration the age which such concrete would have the same strength as that containing ordinary Portland Cement without additives.

To permit the satisfactory finishing of kerbs, crash barriers, posts etc. forms for such members shall be removed in not less than 12 hours nor more than 48 hours after placing concrete, depending on weather conditions. The

forms for adjacent parts of the structure shall be specially designed to permit this being done without injury to the concrete.

All recesses shall be filled in accordance with the requirements of Clause 3.5.3 of this Specification.

Table 3.6 – Times for Removal of Formwork

Position of Form	For Concrete Mix designed on Use of :	
	Ordinary Portland Cement (moisture curing)	High Early Strength Portland Cement
Sides of beams, columns, wall etc. when the height of each day's pour is:		
• Under 0.6 m	1 day	18 hours
• 0.6 to 3.0 m	2 days	1.5 days
• 3.0 to 6.0 m	3 days	2.5 days
• 6.0 to 9.0 m	5 days	4 days
Sides of Square Piles	12 hours	8 hours
Sides of Octagonal Piles	24 hours	18 hours
Supporting forms and falsework:		
• Under deck slabs of girder bridges	7 days	7 days
• Under simply supported slab spans	10 days	10 days
• Under the stems of simply supported girders and single span arches	21 days	21 days
Supporting forms and falsework under prestressed concrete members	Until 70 percent of the prestressing force is applied to the concrete unless otherwise directed	

3.3.2.5 Precast Deck Formwork

Where shown on the Drawings deck formwork shall comprise precast concrete slabs. The slabs span between the tops of the beams, are completely self-supporting, and are not recoverable. The Contractor shall supply and erect conventional formwork for the deck overhanging he outer beams and where required elsewhere, such as at the end of the spans. Unless otherwise specified or shown on the Drawings, the slabs shall be manufactured by the Contractor.

Before placing slabs, the seating along the top flanges of the beams shall be brushed clean, then cement mortar placed in a thin layer along each seating to improve the bearing of the slabs. The slabs shall be laid before the mortar commences to set, and shall be butted tightly together. After placing slabs and before placing reinforcement, all joints between slabs, and between beams and slabs, shall be filled with mortar. Immediately before concrete in placed in the deck, the whole of the formwork slabs and tops of beams shall be thoroughly wetted and kept wet until covered with concrete. All costs of handling, setting, and stopping for formwork slabs shall be deemed to the included in the schedule item for deck concrete.

Note: The use of precast deck formwork is not applicable to this contract.