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SECTION TS 2. EARTHWORKS

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 1.1.1 (Character of Strata), clause 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.

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.

2.2 CLEARING AND GRUBBING

2.2.1 Scope

The work covered under this clause shall include the supply of all labour and materials and the Contractor's equipment for the performance of all works necessary for clearing the Site occupied by the Works.

Such clearing shall include cutting down and uprooting of trees, shrubs and bushes, grubbing and removal of roots and stumps, removal of vegetation, structures and other obstructions to the extent required by the Engineer.

All combustible materials from Site Clearing shall be burned, removed from the Site or otherwise disposed of all to the satisfaction of the Engineer. Such materials shall, when dry, be burned completely and reduced to ashes. The Contractor shall at all times take precautions to prevent the spread of fire. On-site burning of combustible material shall be subject to the prior approval of the Engineer.

Holes resulting from Site Clearing shall be filled with approved materials, and compacted in layers to the dry density of the surrounding soil.

The Contractor shall obtain the Engineer's written approval prior to commencement of any Site Clearing.

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 West Floodway and the Garang River within the Site boundaries.

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

Excavation Below Water Level

This sub-category shall mean channel excavation carried out below EL -0.23 in the West Floodway downstream of Simongan Weir.
Upstream of Simongan Weir, it shall mean channel excavation below EL +5.20.

Excavation Above Water Level

This sub-category shall mean channel excavation carried out above the upper surface of "Excavation Below Water Level" as defined above.

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 parts of weir structure.

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 2.3.1.2.

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

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) or Clause 2.3.3 (Soft Rock Excavation).

2.3.2.4 Structural Excavation

Except where otherwise shown on the Drawings or directed by the Engineer, Structural Excavation shall comprise excavation associated with the construction of structures including, but not limited to, weir, flood walls, protection works, revetments, gabions, retaining walls, ground sills, service stairs 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 average depth of excavation, as determined by the Engineer, is less than or equal to 1.2 m then 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 250 mm.

2) Where average depth of excavation, as determined by the Engineer, is greater than 1.2 m, then the slope shall be at 1.0 unit vertical to 0.5 unit horizontal with a horizontal clearance at the underside of the proposed footing to the start of the excavation slope of 1000 mm.

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 Soft Rock Excavation

Soft rock excavation shall mean the excavation of soft rock from areas to be excavated to the lines, levels and profiles as shown on the drawings.

This clause shall be read in conjunction with clauses 2.1.

When the Contractor considers that soft rock has been encountered, Contractor shall notify the Engineer who shall confirm or otherwise the presence of soft rock for the purposes of payment. The interface between soft rock and other materials to be excavated shall be determined by survey in the presence of the Engineer or his representative.

For the purposes of this Contract, soft rock shall be defined as rock which is capable of being broken and excavated by excavating equipment or rippers attached to dozers without requiring the use of explosives.

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.

Accumulation of material at the base of embankment slopes will not be permitted.

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.

Earth Fill for Embankment, Earth Fill, Soil Filling 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 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.

Soil Filling
Material to be used shall be extracted and selected from excavated material including that from common excavation, structural excavation or channel excavation and shall not contain roots, turf or clod exceeding 75 mm in size and shall be approved by the Engineer.

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

The Contractor shall submit to the Engineer for approval, samples and grading analyses of potential materials for use as gravel.

Rubble Stone

Rubble stone to be used for rubble stone bedding or rubble stone filling shall be clean and free from other deleterious materials. Unless otherwise specified or directed rubble stone shall be hard, natural stone or crushed stone with particle size between 250 mm and 400 mm or as directed by the Engineer.

2.4.3 Placing, Compaction and Moisture Content of Filling

This clause relates to the earth fill used in earth fill, 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, impermeability 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 molstened 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 2,5.3 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 associated with floodwall construction or raising
- construction of any other embankments shown on the drawings or as directed by the Engineer

2.4.7 Trial Embankment

Before full-scale filling is started, the Contractor shall demonstrate to the Engineer, using a trial embankment, the construction equipment to be used and its capability for spreading and compacting at least three contiguous layers of filling in which tests of standard and field compaction shall be conducted. Where different kinds of material are encountered during the course of subsequent work then further trials shall be conducted as directed by the Engineer.

The Contractor shall be permitted to build and incorporate trial embankments on the alignment and in the lower layers of any final embankments provided that all specification requirements are satisfied. Where any trial embankments do not meet minimum specification requirements they shall continue to be completely removed and reconstructed until minimum specification requirements are achieved.

The minimum length of trial embankments shall be 300 m and their width shall be the full width of the particular embankment at the selected locations. Trial embankments shall be allowed to be incorporated in final embankments only after written permission of the Engineer.

2.4.8 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 and rubble stone, only particle size distribution tests are required.

2.4.9 Backfilling with Selected Soil

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 2.4.8.

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.

2.4.10 Gravel Backfill

Gravel backfill shall be placed adjacent to structures or footings in the special locations shown on the Drawings or as directed by the Engineer. Selected soil shall comprise imported or otherwise approved material as specified in clause 2.4.2.

Prior to commencement of backfilling adjacent to structures, the area shall be cleaned of all formwork and other temporary works. Compaction shall be carried

out by hand or with suitable hand operated equipment so as to achieve a dense stable matrix without damage to structures. Backfilling material shall be wetted or allowed to dry in order achieve optimum moisture content for compaction.

Gravel Backfill shall be placed and compacted in continuous horizontal layers of not more than 200 mm compacted thickness. Each layer shall be compacted until it is stable and dense and shows no movement under compaction.

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.

2.4.11 Gravel Bedding and Filling

Gravel bedding and gravel filling shall be placed in the locations shown on the Drawings or as directed by the Engineer. Gravel material shall comprise imported or otherwise approved material as specified in clause 2.4.2.

Gravel bedding shall be placed and compacted using mechanical compaction equipment in continuous horizontal layers of the compacted thickness specified on the drawings. Each layer shall be compacted until it is stable and dense and shows no movement under compaction.

2.4.12 Rubble Stone Bedding and Filling

Rubble stone, as specified in clause 2.4.2 shall be placed in the locations and to the lines, levels and profiles as shown on the drawings. Stones shall be placed by machine or hand placed with smaller stones placed in the spaces between the larger stones so as to form a stable matrix.

2.4.13 Soil Filling

Soil filling for the purposes of this specification shall mean the placement of soil as specified in clause 2.4.2 around cylindrical gabions.

Soil filling shall be placed in layers not exceeding 150 mm thick and compacted with hand tampers or by mechanical equipment until soil the soil filling ceases to penetrate the voids in the adjacent cylindrical gabions and is firm and stable.

2.5 SODDING

2.5.1 General

This work shall consist of furnishing, placing and compacting topsoil and laying grass sods in accordance with the Specification where shown on the Drawings or ordered by the Engineer.

2.5.2 Material Requirements

2.5.2.1 Topsoil

Topsoil shall be clean friable soil free of stones larger than 20 mm and free of weed or other deleterious matter.

2.5.2.2 Grass Sod

The sod shall consist of a healthy, dense and well rooted growth of living grass with roots surrounded by topsoil and shall not contain weeds or other undesirable plants.

The grass sod shall be cut into uniform squares approximately 300 mm and shall have a minimum thickness of 50 mm (excluding grass blades). The type of grass to be used shall be subject to the approval of the Engineer.

2.5.3 Method of Construction

2.5.3.1 Sodding

The surface of the area to be sodded shall be trimmed to the profile as shown on the drawings to the approval of the Engineer.

Units of grass sod shall be placed in uniform rows with the sides of adjacent sods in close contact to each other.

Unless otherwise required, the sod on slopes shall be laid horizontally, beginning at the bottom of the slopes and working upwards.

The areas to be sodded shall be as shown on the Drawings or as specified by the Engineer. The surface of the areas to be sodded shall be loosened and brought to a reasonably fine texture to a depth of approximately 20 mm. The bed upon which the sod is to be placed shall be moistened to the loosened depth, if not naturally sufficiently moist, and the sod shall be placed thereon within 24 hours after having been cut.

On all slopes steeper than one vertical to three horizontal the sod shall be pegged with stakes, 200 - 300 mm in length, spaced as required by the nature of the soil and steepness of slope. Stakes shall be driven into the sod at right angels to the slope until flushed with the bottom of the grass blades.

After the placement has been completed, the surface shall be cleared of loose sod, excess soil, or other foreign material, whereupon a thin layer of topsoil shall be scattered over the sod as a top dressing and the areas shall then be thoroughly moistened by sprinkling with water.

The Contractor shall regularly water and maintain sodded areas in satisfactory condition for the duration of the Contract and until final acceptance of the work by the Engineer.

2.6 MEASUREMENT AND PAYMENT

2.6.1 Excavation

2.6.1.1 Excavation below Water Level

Measurement of the volume of Excavation below Water Level will be made using the average end area method of calculation for that portion of the volume of channel excavation below the nominal water level as defined in clause 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 rate 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.
No payment shall be made for over-excavation

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 six (6) kilometres one-way, excavated materials to spoil dumps, spoil disposal areas, stockpiles or to areas to be filled with approved material
5) preparation, clearing and operation of spoil disposal areas as described in this Specification

The following pay items shall be measured and paid under this clause:

Pay Item No.	Description	Unit of Measurement
C.1.1	Excavation below Water Level (Low water level shown on the cross sections)	m^3

2.6.1.2 Excavation above Water Level

Measurement of the volume of Excavation above Water Level will be made using the average end area method of calculation for that portion of the volume of channel excavation below the nominal water levels as defined in clause 2.3.1. Measurement for payment shall not be made of over-excavation beyond the lies, 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 above water level 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 six (6) kilometres one-way, excavated materials to spoil dumps, spoil disposal areas, stockpiles or to areas to be filled with approved material
5) preparation, clearing and operation of spoil disposal areas as described in this Specification

No payment shall be made for over-excavation

The following pay items shall be measured and paid under this clause:

Pay Item No.	Description	Unit of Measurement
C.1.2	Excavation above Water Level (Low water level shown on the cross sections)	m^3

2.6.1.3 Soft Rock Excavation

Measurement of the volume of Soft Rock Excavation based on survey data, drawings and computations approved by the Engineer.

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

The following pay items shall be measured and paid under this clause:

Pay Item No.	Description	Unit of Measurement
C.2.2	Soft Rock Excavation	m^3

2.6.1.4 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. An allowance, not exceeding 600 mm, unless otherwise shown in the Drawings, may be provided outside the neat lines shown on the Drawings, where formwork for structures is necessary.

Payment shall be made for the quantity of work, accepted and measured as provided above, at the rate entered in the 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 channel, 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 of the river channel 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.

The following pay items shall be measured and paid under this clause:

Pay Item No.	Description	Unit of Measurement
C.2.1	Structural Excavation	m^3
C.3.1	Structural Excavation	m^3
K.1.2	Structural Excavation	m^3
L.2.1	Structural Excavation	m^3

2.6.2 Fill

2.6.2.1 Embankment and Earth Fill

Measurement of the volumes of the various items of earth fill and embankment shall be made of the actual volume in cubic meters as determined by the measurement taken before and after filling operation. No measurement and payment shall be made for unauthorised filling outside the lines shown on the Drawings.

Payment shall include the cost of quarrying (in case of borrow), sorting, grading, handling, hauling, placing, watering, levelling, compacting and testing of the materials of in-place fill. Payment shall also include cost of preparation for surface and trimming of slopes and all labour, materials and equipment necessary to complete the work.

The following pay items shall be measured and paid for under this clause:

Pay Item No.	Description	Unit of Measurement
C.2.3	Earth Fill on Riverbed with Selected Soil	m^3
C.2.5	Embankment for Dike	m^3
C.3.4	Embankment for Road	m^3
L.2.2	Earth Fill	m^3

2.6.2.2 Backfill

Measurement shall be made of the volume of the backfill for backfill with the various materials as described in clause 2.4.9 and 2.4.10. Measurement will not be made of the volume of backfilling of structural excavation beyond the limits described in clause 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.

The following pay items shall be measured and paid for under this clause:

Pay Item No.	Description	Unit of Measurement
C.2.4	Backfill with Selected Soil	m^3
C.3.3	Backfill with Selected Soil	m^3
C.3.2	Backfill Gravel	m^3
F.2.2	Backfill Gravel	m^3
K.1.3	Backfill with Selected Soil	m^3
L.2.3	Backfill with Selected Soil	m^3

2.6.2.3 Gravel and Rubble Stone Bedding and Filling

Measurement shall be made of the volume of gravel or rubble stone bedding or filling as described in clauses 2.4.11 and 2.4.12 respectively.

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.

The following pay items shall be measured and paid for under this clause:

Pay Item No.	Description	Unit of Measurement
C.3.5	Gravel Bedding	m^3
F.2.1	Gravel Bedding	m^3
F.2.3	Rubble Stone Filling	m^3
K.1.8	Gravel Bedding	m^3
L.2.4	Gravel Bedding	m^3
L.2.5	Rubble Stone Bedding	m^3
L.2.6	Backfill with Gravel	m^3

2.6.2.4 Soil Filling

Measurement shall be made of the volume of soil filling as described in clauses 2.4.13.

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.

The following pay items shall be measured and paid for under this clause:

Pay Item No.	Description	Unit of Measurement
F.2.9	Soil Filling	m^3

2.6.3 Sodding

Measurement shall be made of the area of solid sodding completed in accordance with clause 2.5 of the Technical Specification.

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 materials, labour, equipment, transportation, maintenance and any other associated costs.:

Payment will be made as follows:

- Payment will be made at 60% of the rate in the Bill of Quantities.
- The remaining 40% shall be paid on satisfactory establishment of the sodding.

The following pay items shall be measured and paid for under this clause:

Pay Item No.	Description	Unit of Measurement
C.2.6	Sodding	m^2

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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 Simongan Weir, bridges, sluiceways, buildings 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's Representative 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's Representative, 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		Max. Size of Aggregate mm	Application
	MPa	kgf/cm^2		
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.
3. Concrete to be paced under water shall have a minimum cement content of 400 kg/m^3.
4. 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/cm^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:

	AASHTO Test method	Percentage 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:

	AASHTO Test method	Percentage 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.