

ANNEXES

ANNEX 1 - BILL OF QUANTITIES

ANNEX 2 - SPECIFICATIONS

ANNEX 3 - DRAWINGS

ANNEX 1

BILL OF QUANTITIES

Proposed Construction of RC Drains and Absorption Pits at SSR International Airport

Main Summary

Bill	Description	Amount
1.0	Preliminaries and General Costs	
2.0	LOT A	
3.0	LOT B	
4.0	LOT C	
	Sub-total	
	Provisional Sum for diversion of services	300,000.00
	Contingency	200,000.00
	<i>SUB-TOTAL (CARRIED TO BID SUBMISSION FORM)</i>	
	Add Value Added Tax (15%)	
	TOTAL (Including VAT)	
Amount in Words		

Proposed Construction of RC Drains and Absorption Pits at SSR International Airport

Item	Description	Unit	Qty	Rate	Amount
	BILL 1.0				
1.0	Preliminaries and general				
	<i>All provisional items will be re-measured.</i>				
1.1	Cost of performance security	Sum			
1.2	Cost of insurances for the works and third party.	Sum			
1.3	Allow for site installations, mobilisation, demobilisation including temporary water, electricity, lighting, fuel, power, telecommunication facilities, area demarcations and barricading, etc Allowance also to be made for setting out of works including equipment, survey personnel and superintendence of the works.	Sum			
1.4	Contractor to allow for compliance with all airport regulations in terms of safety, security, access permit and interfacing with Authorities, etc.	Sum			
1.5	Allow for submission of all documents such as progress report, as made drawings, etc.	Sum			
1.6	The Contractor shall include in this bill for all costs he considers attributable to P&G items and for all other costs he considers necessary for the proper completion of the works which have not been included in the unit rates.	Sum			
	<i>Total for Bill 1.0: c/f to summary sheet</i>				

Proposed Construction of RC Drains and Absorption Pits at SSR International Airport

Item	Description	Unit	Qty	Rate	Amount
	BILL 2.0				
	LOT A				
2.1	RC Drains				
2.1.1	Construction of RC cross drain Type A. Rate to include excavation in all type of soils and rocks, formwork, reinforcement, concrete, heavy duty metallic grill, temporary diversion of road, etc. All complete as per drg. No. AML/PDFD/02A and AML/PDFD/05	m	12		
2.1.2	Construction of RC cross drain Type B. Rate to include excavation in all type of soils and rocks, formworks, reinforcements, concrete, metallic grill, temporary diversion of road, etc. All complete as per drg. No: AML/PDFD/02A and AML/PDFD/05	m	20		
2.1.3	Construction of Open drain Type C. Rate to include excavation in all type of soils and rocks, formworks, reinforcements, concrete, heavy duty metallic grill, etc. All complete as per drg. No AML/PDFD/02A and AML/PDFD/06	m	25		
2.2	Absorption pits				
2.2.1	Construction of absorption pit 20x15x4m deep. Rate to include for excavation in all type of soils and rocks, geotextile, boulders,spalls, Rc drain connection, etc. All complete as per drg. AML/PDFD/06.	No	1		
2.2.2	Ditto but for absorption pit 15x10x4m	No	1		
	<i>c/f to page 4 of 8</i>				

Proposed Construction of RC Drains and Absorption Pits at SSR International Airport

[illegible]

Proposed Construction of RC Drains and Absorption Pits at SSR International Airport

Item	Description	Unit	Qty	Rate	Amount
	BILL 3.0				
	LOT B				
3.1	RC Drains and Catch pits				
3.1.1	Construction of RC cross drain Type A. Rate to include excavation in all type of soils and rocks, formwork, reinforcement, concrete, heavy duty metallic grill, temporary diversion of road, etc. All complete as per drg. No. AML/PDFD/02A and AML/PDFD/05	m	6		
3.1.2	Construction of covered drain Type D. Rate to include excavation in all type of soils and rocks, formworks, reinforcements, concrete, metallic grill, temporary diversion of road, etc All complete as per drg. No: AML/PDFD/06	m	13		
3.1.3	Construction of Catch pit. Rate to include excavation in all type of soils and rocks, formworks, reinforcements, concrete, metallic grill, temporary diversion of road, etc All complete as per drg. No: AML/PDFD/07	No	2		
3.1.4	Allow for connection of Upvc pipes 110mm dia. from existing RWPs to Catch pits. Rate to include Upvc elbows, tees, clips, etc. All complete as per drg. No: AML/PDFD/03 and to engineer's approval. (Approximate 100m)	Sum			
3.1.5	Supply and Lay Upvc pipe dia. 160mm. Rate to include excavation from natural ground level up to formation level in all type of soils and rocks. All complete as per drg. No: AML/PDFD/03	m	15		
	<i>c/f to page 6 of 8</i>				

Proposed Construction of RC Drains and Absorption Pits at SSR International Airport

[illegible]

Proposed Construction of RC Drains and Absorption Pits at SSR International Airport

Item	Description	Unit	Qty	Rate	Amount
	BILL 4.0				
	LOT C				
4.1	Demolition works				
4.1.1	Dismantle existing chainlink fence and submit to client. Refer to Drg No. AML/PDFD/04	m	35		
4.1.2	Demolish existing upstand beam and cart away debris from site. Refer to Drg No. AML/PDFD/04	m	35		
4.2	Absorption pits				
4.2.1	Construction of absorption pit 10x20x4m deep. Rate to include for excavation in all type of soils and rocks, geotextile type Kaymat U 14 or equivalent, Blue basalt boulders & spalls, Rc drain connection, etc. All complete as per drg. AML/PDFD/04 & AML/PDFD/06	No	1		
4.3	Fencing works				
4.3.1	Supply and place galvanised chainlink fence. Rate to include for heavy duty chainlink fence, galvanised poles and "Y" shape supports, intermediate and corner posts, heavy duty chainlink fence, stainless steel barbed wires (Razor type or equivalent), straining wires, concrete bases & concrete Kerbs, concrete 20 & 25 Mpa, etc. all complete as per drg. No. AML/PDFP/04 and AML/PDFP/08	m	85		
4.3.2	Allow for levelling of the natural ground around absorption pit.	m ²	4000		
	Total for Bill 4.0: c/f to summary sheet				

Proposed Construction of RC Drains and Absorption Pits at SSR International Airport

Item	Description	Unit	Qty	Rate	Amount
	BILL 5.0				
	SCHEDULE OF RATES				
	<u>Man Power</u>				
5.1	Project Manager	hr	1		
5.2	Site Engineer	hr	1		
5.3	Site Agent	hr	1		
5.4	Supervisor	hr	1		
5.5	Foreman	hr	1		
5.6	Skilled labour	hr	1		
5.7	Non skilled labour	hr	1		
	<u>Plant and Equipment</u>				
5.8	JCB	hr	1		
5.9	Excavator	hr	1		
5.1	Bob Cat	hr	1		
5.11	Generator	hr	1		
5.12	Lorry (15 ton)	hr	1		
5.13	Saw cutting machine	hr	1		
5.14	Lighting equipment	hr	1		

ANNEX 2

SPECIFICATIONS

TABLE OF CONTENTS

SECTION 1 - GENERAL	1-1
Article 1.1 Location Of Site.....	1-1
Article 1.2 Works To Be Executed	1-1
Article 1.3 Extent Of Contract	1-2
Article 1.4 Works Executed By Employer Or Other Contractors	1-2
Article 1.5 Liaison With Authorities	1-3
Article 1.6 First Aid, Welfare And Safety Precautions	1-3
Article 1.7 Alterations To And Preservation Of Services.....	1-5
Article 1.8 Programme To Be Furnished.....	1-6
Article 1.9 Setting Out	1-7
Article 1.10 Notice Of Operations	1-7
Article 1.11 Progress Report.....	1-8
Article 1.12 Temporary Works	1-8
Article 1.13 Water And Electricity Supplies	1-9
Article 1.14 Nature Of Ground And Conditions Of Work	1-9
Article 1.15 Faulty Work	1-9
Article 1.16 Particulars Of Existing Works	1-9
Article 1.17 Protection Of Works	1-9
Article 1.18 Protection From Water.....	1-10
Article 1.19 Unauthorised Persons	1-10
Article 1.20 Filling In Holes And Trenches	1-10
Article 1.21 Joint Measurement Of Extras	1-10
Article 1.22 Advertising	1-10
Article 1.23 Transport For Engineer	1-11
Article 1.24 Provisional Acceptance.....	1-11
Article 1.25 Progress Photographs.....	1-11
Article 1.26 Responsibility Of The Contractor.....	1-11
Article 1.27 Units Of Measurement.....	1-11
Article 1.28 Standard Specification	1-12
Article 1.29 Site Diary	1-12
Article 1.30 Environment Management And Monitoring	1-12
Article 1.31 Access Restrictions	1-15
Article 1.32 Particular Health And Safety Requirements At SSR International Airport	1-15
SECTION 2 – MATERIALS	2-1
Article 2.1 Quality Of Materials	2-1
Article 2.2 Approval Of Source Of Supply	2-1
Article 2.3 Defective Materials.....	2-2
Article 2.4 Handling And Storage Of Materials	2-2
Article 2.5 Borrow Pits And Spoil Tips.....	2-3
Article 2.6 Boulders Of Basalt.....	2-3
Article 2.8 Material For Drainage Layer	2-4
Article 2.9 Stone Aggregate Generally	2-4
Article 2.10 Material For Concrete	2-4
Article 2.11 Manholes/ Catch pit	2-6
Article 2.12 Filter Material	2-6
Article 2.13 Water.....	2-6
Article 2.14 Stone Work	2-7

Article 2.15 Cement	2-7
Article 2.16 Steel Reinforcement.....	2-8
Article 2.17 Mould Oil.....	2-8
Article 2.18 Material For Forms, Falsework And Centering.....	2-8
Article 2.19 Concrete Porous Pipes	2-9
Article 2.20 Precast Concrete	2-9
Article 2.21 Admixtures	2-9
Article 2.22 Precast Concrete Slabs.....	2-9
Article 2.23 Geotextiles	2-10
Article 2.24 Polystyrene	2-11
SECTION 3 - TESTING	3-1
Article 3.1 General.....	3-1
Article 3.2 Provision And Operation Of Laboratory	3-1
Article 3.3 Additional Tests.....	3-2
Article 3.4 Inspection And Testing Of Manufactured Materials	3-2
Article 3.5 Tests On Suspect Materials And Workmanship.....	3-3
Article 3.6 Testing Of Aggregates	3-3
Article 3.7 Tests For Water Purity.....	3-4
Article 3.8 Tests For Manufactured Materials.....	3-4
Article 3.9 General Control And Tests During Construction	3-5
Article 3.10 Frequency Of Tests.....	3-7
Article 3.11 Frequency For Other Manufactured Materials	3-7
Article 3.12 Alteration In Frequency Of Tests	3-7
Article 3.13 Apparatus Of The Laboratory.....	3-8
Article 3.14 Control Of Surfaces	3-8
SECTION 4 - SITE CLEARANCE AND EARTHWORKS	4-1
Article 4.1 Mass Diagram.....	4-1
Article 4.2 Existing Structures And Services	4-1
Article 4.3 Demolition And Dismantling.....	4-1
Article 4.4 Demolition Of Masonry, Concrete, And Reinforced Concrete Structures	4-1
Article 4.5 Site Clearance	4-2
Article 4.6 Cutting Of Trees	4-2
Article 4.7 Ownership Of Materials	4-2
Article 4.8 Classification Of Excavated Materials	4-3
Article 4.9 Removal Of Top Soil.....	4-3
Article 4.10 Dewatering.....	4-4
Article 4.11 Excavation	4-4
Article 4.12 Compaction Of Earthworks	4-5
SECTION 5 – DRAINAGE.....	5-1
Article 5.1 General.....	5-1
Article 5.2 Drainage Programme	5-1
Article 5.3 Drainage Excavation.....	5-1
Article 5.4 Timbering And Shoring Of Excavations	5-1
Article 5.5 Trenches And Holes Excavation And Backfilling.....	5-2
SECTION 6 – CONCRETE	6-3
CONCRETING MATERIALS AND THEIR HANDLING	6-3
Article 6.1 General Requirements.....	6-3
Article 6.2 Water for Concreting	6-3

Article 6.3 Cement	6-5
Article 6.4 Aggregate	6-8
Article 6.5 Properties of Aggregates	6-11
Article 6.6 Storage and Handling of Aggregates	6-13
Article 6.7 Steel Reinforcement	6-14
Article 6.8 Concrete Admixtures	6-17
Article 6.9 Curing Membrane	6-18
Article 6.10 Definition	6-19
Article 6.11 General	6-20
Article 6.12 Ready-Mixed Concrete	6-20
Article 6.13 Alkali-Silica Reactivity	6-22
Article 6.14 Designed Concrete Mixes	6-23
Article 6.15 Requirements for Designed Mixes	6-27
Article 6.16 Requirements of Nominal Volumetric Mix	6-29
Article 6.17 Concrete Quality Control	6-29
Article 6.18 Characteristic Strength	6-30
Article 6.19 Workability	6-31
Article 6.20 Density	6-31
Article 6.21 Temperature	6-31
Article 6.22 Climatic Conditions	6-31
Article 6.23 Cement Content	6-32
Article 6.24 Free-Water/Cement Ratio	6-32
Article 6.25 Aggregate Grading	6-32
Article 6.26 Air Content	6-32
Article 6.27 Non-Compliance	6-32
Article 6.28 Ready Mixed Concrete	6-33
Article 6.29 Waterproof Concrete	6-33
Article 6.30 Quality Control of Concrete Production	6-34
Article 6.31 Failure to comply with requirements	6-35
Article 6.32 Mixing Concrete	6-36
Article 6.33 Conveying	6-37
Article 6.34 Depositing	6-37
Article 6.35 Placing Concrete under water	6-38
Article 6.36 Curing and Protection	6-38
Article 6.37 Waterbars	6-39
Article 6.38 Concrete Sealing Coat	6-39
Article 6.39 Formwork	6-39
Article 6.40 Tolerances	6-40
Article 6.41 Formation of Holes for Fixing	6-41
Article 6.42 Batching, Transporting and Placing Concrete	6-41
Article 6.43 High Temperature Concreting	6-44
Article 6.44 Low Temperature Concreting	6-46
Article 6.45 Curing and Protection of Concrete	6-46
Article 6.46 Damaged Concrete	6-47
Article 6.47 Striking Formwork	6-48
Article 6.48 Re-use of Formwork	6-49
Article 6.49 Cambers	6-49
Article 6.50 Mortices, Holes Chases in Concrete	6-49
Article 6.51 Final Preparations	6-50
Article 6.52 Falsework	6-50

Article 6.53 Heavy Duty Concrete (Granolithic) Screeds to Benchings and Channels	6-51
Article 6.54 Cracks in Concrete Structures	6-51
Article 6.55 Movement Joints.....	6-51
Article 6.56 Construction Joints	6-52
Article 6.57 Movement Joints.....	6-53
Article 6.58 Expansion Joints	6-53
Article 6.59 Size and Sequence of Concrete Pours.....	6-54
Article 6.60 Water Bars	6-54
Article 6.61 Bond Breakers	6-55
Article 6.62 Joint Fillers for Expansion Joints	6-55
Article 6.63 Joint Sealing.....	6-56
Article 6.64 Joint Bond Breaking for Contraction Joints and Sliding Joint	6-56
Article 6.65 Precast Concrete Production.....	6-57
Article 6.66 Bedding Precast Concrete Units	6-57
Article 6.67 Post-Tensioned Wall Panels, Jointing and Post-Tensioning	6-58
Article 6.68 Chamber Rings and Cover Slabs	6-58
Article 6.69 Segmental Tunnels and Shafts.....	6-58

SECTION 1 - GENERAL

Article 1.1 Location Of Site

The site of works is located at SSR International Airports Co Ltd. as indicated in the location plan.

Article 1.2 Works To Be Executed

The works to be executed involve, amongst others, the following:

Construction of RC drain and Absorption pits at Lot A

1. Site clearance and setting out of the works.
2. Construction of RC cross drain.
3. Construction of open RC drain.
4. Bulk excavation for absorption pits, supply and place geotextile and backfill with Blue Basalt boulders and spalls.
5. Remove existing clogged materials from existing absorption pit and cart away debris.
6. Supply and place geotextile and Backfill existing pit with Blue Basalt boulders and spalls.

Construction of RC drain and Absorption pits at Lot B

1. Site clearance and setting out of the works.
2. Construction of RC cross drain.
3. Construction of covered RC drain.
4. Construction of Catch pits.
5. Supply and place Upvc pipes and connect to catch pits and absorption pits.
6. Bulk excavation for absorption pits, supply and place geotextile and backfill with Blue Basalt boulders and spalls.
7. Remove existing clogged materials from existing absorption pit and cart away debris.
8. Supply and place geotextile and Backfill existing pit with Blue Basalt boulders and spalls.

Construction of RC drain and Absorption pits at Lot C

1. Site clearance and setting out of the works.
2. Dismantle existing fence and hand over to the Client.
3. Break to remove existing concrete upstand beam and cart away debris from AML compound.
4. Bulk excavation for absorption pits, supply and place geotextile and backfill with Blue Basalt boulders and spalls.
5. Supply and erect galvanised post and fence including construction of concrete upstand beam and installation of barbered and straining wires.

Note:

The contractor will be working in a live airport environment. Service providers deliver goods 24 hrs, 7 days per week to the airport. Therefore, interruption of traffic movement will not be authorised during the construction phase. The contractor shall organise and plan his works in such a way that no congestion or traffic jam is caused during the execution of the entire works.

However, the contractor may opt to work on one side of the road and then after completion, change to other side.

Article 1.3 Extent Of Contract

The work specified shall include all general work preparatory to execution, all matters, things, requisites and work of any kind necessary for the due and satisfactory construction, completion and maintenance of the Works to the true intent and meaning of the Drawings and this Specification and further drawings and orders that may be issued by the Engineer from time to time; compliance by the Contractor with all Conditions of Contract whether specifically mentioned or not in the clauses of this Specification; all materials; apparatus, plant, machinery, tools, fuel, water, temporary works and roads, strutting, timbering moulds and tackle of every description, transport, offices, stores, workshops, staff and labour; the provision of proper and sufficient protective works, temporary fencing, lighting and watching required for safety of the public and protection of the Works and adjoining lands and waterways; all measures necessary to ensure the safety of shipping, and sanitary accommodation for staff and workmen; taking and maintenance of all insurances, the payment of all wages, salaries, fees, royalties, duties or other charges arising out of the execution of the Works; the regular clearance of rubbish, reinstatement and clearing up and leaving perfect on completion.

Any error in description or in quantity or omission of items from the contract bills shall not vitiate this contract but shall be corrected accordingly.

Article 1.4 Works Executed By Employer Or Other Contractors

The Contractor is advised that other contractors employed by the Employer and his employees will be working concurrently in connection with other projects within the airport premises.

The Contractor will be informed of areas which will be reserved for use by other contractors. The Contractor shall not enter or use these areas without the prior written permission of the Engineer, unless such entry is permitted elsewhere in the Contract, and shall not obstruct access to such areas without having provided an acceptable alternative access.

The Contractor shall not interfere in any way with any works, whether the property of the Employer or of a third party and whether the position of such works is indicated to the Contractor by the Engineer or not. The Contractor shall respect the construction and finishing of works are articles supplied or installed by others and will be held responsible for any loss or damage thereto if caused by him, his employees or his sub-contractors.

Throughout the period of execution of the Works, the Contractor shall attend coordination meetings to be convened by AML with other contractors and stakeholders. The Contractor shall abide, within the provisions of the Conditions of Contract, to decisions taken during these meetings.

Article 1.5 Liaison With Authorities

The Contractor shall keep in close contact with Airports of Mauritius Co Ltd, the Police, the Ministry of Environment and Sustainable Development and other institutions who have regulatory or statutory oversight and/or control of the Works and its immediate environment. The Contractor shall comply with the requirements of these authorities in the execution of the works under the purview of the respective institution or authority, control of workmen, movement of traffic, passage through inhabited zones or other matters, and shall provide all assistance or facilities, which may be required by such officials, in the execution of their duties.

The Contractor shall keep all necessary contacts and liaison to secure the approvals required from the respective authorities. All required notifications, documentation and approvals required shall be properly maintained and recorded to that effect. The costs associated for the liaison with authorities and securing all necessary approvals shall be included in Bill of Quantities Item 101.

Article 1.6 First Aid, Welfare And Safety Precautions

The Contractor shall provide, equip and maintain an adequate First Aid Station on the Site of the Works and provide all necessary transport and shall have experienced First Aid men available for attending minor accidents.

The Contractor shall allow in his prices and be responsible for the cost of all site welfare arrangements and health requirements.

Work is to be executed in a safe and responsible manner and the Contractor is to proceed in accordance with the provisions of the appropriate legislation. Particular attention is drawn to the need for adequate hand railing and fencing off dangerous areas, e.g., excavations on roads.

1.6.1 Safety & Security Regulations in Airport Environment

All Contractors working on the landside & airside zones have to comply with the safety & security regulations/requirement, in force at the SSR International Airport, namely;

- (i) The Contractor shall comply with the requirements and regulations of AML and the Department of Civil Aviation (DCA) with regards to the entry of personnel & vehicles into the Landside and airside areas of the airport. Person or vehicle not in possession of a valid access permit will not be allowed on the landside and airside areas. The Contractor shall submit a list of all its personnel & vehicles to be deployed on the project. The access permit is

delivered by the DCA upon recommendation of AML and against payment. Contractor to verify the cost of access permit for personnel & vehicle prior to submitting its bid.

Personnel & vehicle will be denied access in case of non-compliance. Drawing ref AML/PDFD/01 shows the Contractor's access to the sites of works, the security control points and the landside and airside demarcation.

- (ii) All Contractor's personnel shall attend a Safety & Security Briefing prior to having access to the sites of works.

All Contractor's vehicles shall be adequately insured and will be verified for airside worthiness before operating within the airside.

- (iii) There are 2 levels of Security Control at SSR International Airport. For access into the landside zone, the Contractor's personnel and vehicle will have to go through the Primary Security Control For access into landside zone.,

- (iv) All Contractor's personnel shall wear reflectorised jackets.

- (v) Smoking on the airport premises is strictly prohibited.

- (vi) All vehicles operating on the airport compound will be equipped with fire extinguisher. Contractor will not be allowed to store any tools outside the site of works.

- (vii) All the Contractor's personnel, vehicles and equipment shall be confined within the delineated working zone. There shall be no overspill of construction work or material over AML's premises.

- (viii) The Contractor must take all precautions to prevent any spillage or dropping of materials or any other debris in transit. Any spillage, dropping of materials or any other debris will have to be immediately removed.

- (ix) Welding activities is not carried out without the prior permission of AML.

- (x) All debris/excavated material shall be safely stacked in a container to prevent them from being blown away by wind and shall be carted away from the airport premises at the end of each working day.

- (xi) Water bowers shall be provided for watering in case of excessive dust.

- (xii) The Contractor's personnel shall comply with any direction or verbal instruction given by AML's Safety Officer or the DCA.

1.6.2 Dust Control Measures

As the site of works is located near the aircraft movement areas, dust emanating from the works will have to be controlled at all times.

It will be required that the Contractor keeps enough water bowsers permanently on site during execution of the works, to control dust emanating from the works.

Article 1.7 Alterations To And Preservation Of Services

1.7.1 Contractor's Responsibilities

The Contractor shall acquaint himself with the position of all existing works and services such as water pipelines, sewer pipelines, fuel pipelines, irrigation canals, power cables surface water drains, water mains, electricity, telephone cables and telephone lines, optical fibre and poles, etc. before any excavation or other work likely to affect them is commenced.

Where work is being carried out in the vicinity of overhead power lines, the Contractor is responsible for ensuring that all persons working in such areas are aware of the relatively large distance that high voltage electricity can short to earth when cranes, or other large masses of steel, are in the vicinity. The Contractor's attention is drawn to BS 162:1990, which states safe clearance for various voltages.

In all cases where such works are exposed, they shall be properly shored or hung up. Special care must be exercised in refilling to compact the ground under mains, cables, etc., and not to cover up exposed water meters and stopcock boxes, etc.....

Poles supporting cables, adjacent to the Works, shall be kept securely in place until the work is completed, and then shall be made safe and permanent.

1.7.2 Survey Of Existing Services

The Contractor shall carry out a survey of any existing services which may interfere with or be damaged by the construction and shall submit this to the Engineer who will instruct the Contractor as to what measures are required to remove, alter, change or re-direct existing services. Precautions shall be taken to maintain the flow of water in streams, rivers, conduits and pipelines. The work required to protect services will be notified to the Contractor after approval by the relevant services authorities.

Notwithstanding the foregoing requirements, and without lessening the Contractor's responsibility, the Contractor shall inform the Engineer immediately if any existing works are exposed.

The foregoing requirements will apply equally to any work on services or roads completed by the Contractor in an earlier stage of the Contract.

The price for investigation of all services, its protection, temporary diversion and maintenance of such services shall be deemed to be included in the tendered rates and price.

1.7.3 Removal and Diversion Of Services

The Contractor shall be responsible for arranging, for the moving of services where necessitated by the works, subject to the approval of the Engineer.

Immediately after the issue of the Engineer's instructions to commence work, the Contractor shall carry out a survey of all the existing services likely to be affected by the permanent works.

He shall then liaise with the relevant authority for the removal, modification or diversion of the services.

In the case of existing irrigation or water pipes the Contractor shall work, in conjunction with the C.W.A and Irrigation Authority, and the Engineer for finalisation of all instructions regarding the works on CWA and Irrigation network. Permanent supply using existing services shall be maintained throughout the construction period, and any costs shall be included in the contractor's tendered rates for any temporary diversions required by the contractor.

1.7.4 Damage to Services

Any damage to, or interference with existing services, occasioned during the progress of the Works, shall be deemed to be the responsibility of the Contractor, who shall undertake to make good at his own expense any damage so caused to the existing services or other features and shall be liable in respect of all claims arising from such damage or interference however occasioned.

Article 1.8 Programme To Be Furnished

Within fourteen days (14) days after the date of Letter of Acceptance, the Contractor shall submit to the Engineer for his approval: -

- A general programme (Programme of Works) showing the timing, order of procedure and general methods for carrying out the Works, with timing for mobilisation of equipment and plant and for purchase of important materials (Milestones).
- The organization (Organigram), staff (Staff List), labour (Labour List), equipment and plant (Plant List) proposed for the execution of the Contract. The planning shall be updated every two weeks.
- The layout and general arrangement of all temporary Works including site installation, he proposes to construct for the purposes of the Contract.

The Engineer after examining and if necessary discussing with the Contractor such document shall give his final approval before the commencement of the Works.

Article 1.9 Setting Out

- 1.9.1 The Contractor shall be responsible for the full and proper setting out of the Works. The principal setting out points and benchmarks shall be referenced out during construction and the Contractor shall maintain these throughout the Contract Period.
- 1.9.2 The dimensions and levels shown on the Drawings are believed to be correct, but the Contractor shall verify the same on Site and is no way absolved from responsibility from any consequence arising from the inaccuracy of such dimensions or levels.
- 1.9.3 The Contractor may be required to prepare and submit additional drawings to complete the tender drawings. He shall give the Engineer not less than 24 hours notice, of his intention to set out or give levels for any part of the work in order that arrangements can be made for checking. The Contractor shall provide all the necessary instruments, appliances, labour and any material or staging that the Engineer may require for checking the setting out or levels as specified in the Article hereof.
- 1.9.4 Any marks made by the Engineer shall be carefully preserved Work shall be suspended for such time as it is necessary for checking the lines and levels on any part of the Works.

Throughout the Contract, both the general and detailed methods of the complete setting out of the Works shall be submitted by the Contractor for the prior approval of the Engineer.

The Contractor shall ensure that all plant operator, gangers and key men working on the Site are made aware both of the positions of all important line and level marks and of the importance of reporting the least disturbance of the same. In the event of any reference marks being damaged or misplaced during the Works, the contractor shall replace or reinstate such marks to the satisfaction of the Engineer.

Article 1.10 Notice Of Operations

The Contractor shall submit for the approval of the Engineer, a detailed notice of operations by sections of two hundred metres at least (15) days before starting the works on the section under consideration. These documents will consist of (but not limited to) the following:-

- The results of the geotechnical survey for materials, the laboratory test results and the quantities.
- The proposals for protecting and/or rerouting the network after research and discussions with the competent authorities as required by Article 1.8.
- The detailed planning of the works

It is clearly pointed out that the Contractor will not be allowed to start work unless and until the above documents are submitted to and approved by the Engineer. The Engineer shall give his approval or make any remarks within a period of fifteen days. The Contractor is allowed to start the works, if no answer is received from the Engineer within the prescribed delays. The Contractor shall carry out the modifications required within 48 hours of receipt of the Engineer's reply, failing which he shall not be allowed to start the works on the sections concerned.

It is pointed out that the approval (or absence of reply) of the Engineer shall not in any way absolve the Contractor of his contractual obligations under the terms of the Contract.

No separate payment will be made in respect of providing the notice of operations and preparation and the costs thereof shall be deemed to be included in the other rates and prices.

Article 1.11 Progress Report

The Contractor shall submit to the Engineer every fortnight a Progress Report for the preceding period, showing up to date progress during the previous period on all important items in each section of the Work in the manner prescribed by the Engineer including the plant and personnel schedule. The progress report shall be related to the programme such as defined in Article 1.10 of these Technical Specifications.

Article 1.12 Temporary Works

1.12.1 The Contractor shall be wholly responsible for obtaining a site for his camps, offices, stockpiles of aggregates, constructional plant.

All temporary buildings or stores and plant shall be located only on sites approved by the Engineer.

1.12.2 The Contractor shall maintain all offices required by his Site Staff, workshops, storage sheds, etc., and clear away on completion of the Contract and leave the Site in clean and tidy condition.

1.12.3 The Contractor shall provide latrines and ablutions for his employees, maintain them in a sanitary condition throughout the Contract and clear away on completion and leave the Site in a clean and tidy condition. The Contractor shall be solely responsible for any living accommodation required by his employees.

1.12.4 When no longer required for the Contract, all such provisions shall be left or dismantled and disposed of as directed by the Engineer and their Sites shall immediately be cleaned and left as far as practicable in the same condition as that obtained immediately prior to occupation.

Article 1.13 Water And Electricity Supplies

It is the Contractor's responsibility to provide water and electricity for both construction purposes and also for the camps and offices. The Contractor's attention is drawn to the fact that no separate payment will be made for the provision of water and electricity and the Contractor shall be deemed to have included for these in his rates and prices. The Engineer may reject any water, which in his opinion is contaminated and not sufficiently clean for the purpose intended.

Article 1.14 Nature Of Ground And Conditions Of Work

The Contractor must satisfy himself as to the general circumstances at the site of the Works and the construction thereon, the surface of the ground and nature of the materials to be excavated, the possibility of subsidence from soft ground and bad and broken materials, and falls of rock in or arising out of the Works and the rates and prices in the Bills of Quantities will be held to cover all such contingencies.

Article 1.15 Faulty Work

Any work, which fails to comply with this Specification, shall be rejected and the Contractor shall, at his own expense, make good any defects, as directed by and to the satisfaction of the Engineer.

Article 1.16 Particulars Of Existing Works

Such information as may be given on the Drawings, as to the present condition and character of the existing structures, roadways and other services, and as to the form and dimensions of various parts of the existing structures and positions and particulars of pipes, cables and other mains and information arising as a result of trial pits and boreholes is given without guarantee of accuracy and neither the Employer nor the Engineer will be liable for any discrepancy therein.

Article 1.17 Protection Of Works

The Contractor shall take all steps necessary to protect the permanent Works and all stores and materials from the effects of weather, including floods and cyclones, theft and shall be entirely responsible for any delay, damage or loss arising therefrom. The Contractor shall take account in his rates for the mitigation of noise and dust pollution generated in the execution of the contract.

Article 1.18 Protection From Water

The Contractor shall keep the whole of the Works free from water and allow in his prices for all dams, cofferdams, pumping, piling, shoring, temporary drains, sumps etc., necessary for the purpose and shall clear away and make good at his own cost and to the satisfaction of the Engineer all damage caused thereby. The drainage of the natural ground in the vicinity of the earthworks and drainage work generally shall be carried out in advance of the rest of the Works.

Article 1.19 Unauthorised Persons

No unauthorised persons are to be allowed on to any part of the Site and the Contractor shall take steps to prevent this and instruct his Foremen and Watchmen accordingly.

Article 1.20 Filling In Holes And Trenches

The Contractor immediately upon completion and approval of any work shall fill up all holes and trenches which may have been made or dug, level mounds or heaps of earth that may have been raised or made, and clear away all rubbish which may have become superfluous or have been occasioned or made by the execution of such work; and the Contractor shall bear and pay all costs, charges, damages and expenses which may be incurred or sustained on account or in consequence of any accident which may happen by reason of holes and trenches connected with the work being dug and left unfenced or material being left or placed in improper situations.

Article 1.21 Joint Measurement Of Extras

In such case as the Contractor shall find it necessary to execute any works, or provide any materials which he feels entitled to claim as extras to the Bill of Quantities he shall obtain written permission from the AML before commencing such work and shall make arrangements for the Works, or materials to be measured jointly with AML, and the quantities agreed. Neglect to obtain authority to commence any such work, shall entitle AML to disallow any claim for extras arising there from. The fact that joint measurement took place in no way commits AML to recognise the validity of such claim, if it is considered unjustified. AML, shall at all times, have full access to the Contractor's time books and may daily check the item of any extra works with the Contractor's timekeeper or otherwise, but the fact of his agreeing upon any time, shall in no way bind AML to value the work, other than by measurement if he thinks fit to do so.

Article 1.22 Advertising

The Contractor shall not erect any advertisement in any form within the Site or on adjoining ground.

Not Applicable.

Article 1.23 Transport For Engineer

Not applicable

Article 1.24 Provisional Acceptance

After completion of the Works and at least eight (8) working days before the date of substantial completion, the Contractor is to submit to the Engineer the as-built drawings.

The drawings shall be supplied at the Contractor's expenses in two (2) of which shall be in the form of printouts and one (1) copy on CD roms.

The failure to supply the as-built drawings in time shall automatically prevent the substantial completion.

Article 1.25 Progress Photographs

The Contractor shall arrange with a professional photographer approved by the Engineer for the taking of progress photographs including electronic copies for the different stages of construction of the Works, upon the direction of the Engineer. The photographs will be taken at intervals of 15 days minimum and the Contractor shall arrange to supply four unmounted enlargements in A4 size on hard paper (Bristol Type) and electronic copies of each print chosen by the Engineer for enlargement.

The number of exposures and enlargements will be as directed/ordered by the Engineer.

Article 1.26 Responsibility Of The Contractor

Where the approval of the Engineer is required under these Technical Specifications, such approval shall not relieve the Contractor of his duties or responsibilities under the Contract.

Article 1.27 Units Of Measurement

The units of measurement to be used throughout this Contract are in general metric units of metres (m), kilogrammes (kg), Newton (N) degrees Celsius (C) and litres (l).

Article 1.28 Standard Specification

In order to establish standards of quality, reference has been made in this Specification to certain British Standards (BS) and to certain other National or International Standards.

The British or other Standards referred to shall be the latest edition published at the date of issue of tender documents.

All the conditions and particulars as to standard of materials, workmanship and tests contained in such British or other Standards shall be compiled for the various items. Other equivalent National or International Standard Specifications, which will ensure equal or higher qualities of materials or workmanship, may be substituted at the sole discretion of the Engineer if requested by the Contractor.

Article 1.29 Site Diary

A diary shall be held on site by the Engineer or his representative.

The following entries shall be made every day: -

- 1 Administrative procedures relative to the execution and running of the contract, such as notifications, visas etc.....
- 2 Climatic conditions (rainfall, winds, temperature, water levels etc.)
- 3 The results of control tests
- 4 Incidents and details likely to have an effect on the future functioning of the works, calculation of cost prices and the actual duration of the Works.
- 5 List of resources for proper execution of the works.
- 6 Any observation and instruction imposed on the Contractor

Everyday there shall be annexed to this journal, a detailed statement prepared by a representative of the Contractor and which shall indicate for each item of work the working hours, the number and qualification of the personnel, the equipment present on site and their running time, the duration and causes of any stoppages, the daily evaluation of the amount of work executed.

Article 1.30 Environment Management And Monitoring

The Employer has the statutory obligation to comply with the requirements of the Environment Protection Act, 2002 as well as conditions as part of the EIA License to be issued for the project. Accordingly, a list of environmental impact mitigating measures is described in this section which the Contractor shall comply to. The Obligation of the Contractor shall also consist of submission of a method statement to demonstrate compliance prior to start of construction works as well as submission of a monthly report in a format to be approved by the Engineer describing the environmental protection

measures and monitoring of compliance of such measures. The cost of compliance to these conditions and measures including costs of submission of related reports and method statements shall be included in BOQ Item 101; no separate payment shall be made for due compliance with these conditions.

Within 14 days of the Commencement Date, The Contractor shall submit a method statement detailing;

1. Contractor's Work Camp:

- proposed location and layout of the site; measures proposed to mitigate potential adverse environmental impacts resulting from its installation. The plan shall be consistent with the provisions of construction norms.
- sewage management plan for the operation of the work camp (if any) indicating proposed arrangements for the collection and disposal of sewage consistent with applicable national regulations (e.g. provision of sanitary latrines, installation of proper sewage collection and disposal systems designed to prevent pollution of watercourses;
- waste management plan indicating proposed arrangements for the collection and disposal of domestic waste.

2. Contractor's Yard:

- waste management plan indicating proposed arrangements for the collection and disposal of various types of wastes (e.g., used oil, used tires, etc.) consistent with the applicable national regulations;
- equipment maintenance areas and lubricant and fuel storage facilities: Plan / description of site and layout. Storage facilities for fuels and chemicals shall be located away from natural watercourses, drinking water supply and irrigation facilities. Such facilities shall be bounded and provided with impermeable lining to contain spillage and prevent soil and water contamination;
- Dust management plan describing the proposed approach for dust abatement in sensitive sections on access or haul routes. Information on type and numbers of equipment should also be provided;
- Solid wastes and non-compostable wastes shall be collected and disposed of to the satisfaction of the Local Authority.
- Soil Management Plan detailing measures to be undertaken to minimize effects of wind and water erosion on topsoil stockpiles, measures to minimize loss of fertility of top soil; Temporary storage of excess materials: timeframes, haul routes and disposal sites. Disposal sites must be officially approved by the competent authorities;
- Traffic safety: a method statement on the approach proposed for the effective management of traffic safety throughout the construction process.
- Necessary precautions shall be taken during site preparation and infrastructural works so as not to cause any nuisance by way of noise and dust pollution to the public and surrounding environment

Issue	Mitigation Measures
Temporary storage of materials has potential to cause siltation and obstruction of watercourses	Locate material stockpiles away from watercourses
Disposal of excavated materials may cause unwanted environmental impacts	The contractor must ensure that maximum reuse is made of excavated materials in the permanent works, such as construction of embankments, for landscaping measures or noise berms. All costs associated with disposal of excess materials shall be included in the tendered rates and prices
Soil / water pollution	<p>Submit to Engineer a plan of the location and layout of equipment maintenance areas and lubricant and fuel storage facilities including indications on the distance from water sources and irrigation facilities.</p> <p>Locate storage facilities for fuels and chemicals away from watercourses. Such facilities will be bounded and provided with impermeable lining to contain spillage and prevent soil and water contamination.</p> <p>Store and dispose waste/used oil consistent with MoE requirements.</p>
Loss of topsoil	Topsoil shall be stripped and reused to cover areas where excess materials will be dumped and along road sections where roadside vegetation will be provided. Long-term stockpiles of topsoil will be immediately protected against wind or water erosion.
Disposal of surplus materials may cause unintended environmental impact or disfigure the landscape	<p>Submit to Engineer a <u>soil management plan</u> detailing measures to be undertaken to minimize effects of wind and water erosion on stockpiles, including timeframes, haul routes and location of disposal sites.</p> <p>Conduct consultation with local authorities and landowners on the selection of disposal sites and secure MoE's approval.</p>
Siltation and obstruction of watercourses and drainage due to improper disposal of excess materials	<p>Transport excess materials to the final disposal sites as extraction proceeds to minimize erosion risks.</p> <p>Provide settlement basins as required.</p> <p>Prevent earthworks and stone works related to road construction from impeding the flow of rivers / streams and canals or existing irrigation and drainage systems.</p>
Dust emission along temporary roads and tracks	Regularly spray water on haul roads to suppress dust, especially along sections that will pass close to settlements.
Air pollution due to exhaust emission from the operation of construction machinery	<p>Maintain construction equipment to good standards and avoid, as much as possible, idling of engines.</p> <p>Banning of the use of machinery or equipment that cause excessive pollution (e.g., visible smoke).</p>

Issue	Mitigation Measures
Soil compaction due to operation of heavy equipment	Confine operation of heavy equipment within the ROW, as much as possible, to avoid soil compaction and damage to agricultural land.
Traffic impairment	<p>Submit <u>traffic management plan</u> to AML prior to mobilization.</p> <p>Provide adequate signalisation, appropriate lighting, well-designed traffic safety signs, barriers and flag persons for traffic control.</p> <p>Allow for adequate traffic flow around construction areas</p>

Article 1.31 Access Restrictions

Restrictions shall apply with regards to access inside the premises of the airport.

The Contractor shall forthwith comply with the Department of Civil Aviation requirements pursuant to section 11 of the Civil Aviation (Security) Regulations 2002, guidance to applications for permanent passes. Permanent passes will be issued to the Contractor's Personnel & Vehicles after completion & signature of Department of Civil Aviation (DCA) and confirmation from 2 referees that the intended pass holder is known to them and of good character and production of a certificate from the Director of Public Prosecution confirming that the applicant has never been convicted of any crime or misdemeanour in the Republic of Mauritius. The Department of Civil Aviation may reject the application of any applicant or revoke the permit of any pass holder at any time, without giving prior notice & without the need to substantiate the grounds of such rejection or revocation. The Employer will not be liable for any costs incurred by the contractor due to refusal of access to the site of any of the Contractor's Personnel, Plant or vehicle. A yearly fee of MUR300 per person and MUR300 per vehicle will be applicable for the issue & renewal of airport passes. Costs & time associated with obtention of airport passes shall be deemed to be included in the tendered rates and prices.

Contractor's personnel shall be fully vaccinated prior to access the Airport premises. The pass holder shall keep his/her vaccination card in their custody at all time and provide upon request by DCA and AML officers.

The rate is subject to increase following policy of DCA.

Article 1.32 Particular Health And Safety Requirements At SSR International Airport

The Contractor shall make adequate arrangements with regards to the requirements of the Employer concerning special precautions and safety measures concerning works inside the premises of the airport. A copy of AML's safety requirements inside the airport is enclosed in appendix A of these specifications and the Contractor shall forthwith comply with same and the cost associated with complying to these requirements shall be deemed to be included in the tendered rates and prices.

SECTION 2 – MATERIALS

Article 2.1 Quality Of Materials

All materials used in the Works shall be of the qualities and kinds specified and shall be approved by the Engineer. They shall comply with the requirements of the current amended editions, at the date of invitation to tender, of the British Standards (hereinafter abbreviated to B.S) published by the British Standards Institution, or AASHTO and ASTM Specifications as specified in the Technical Specifications. All materials may be checked both at the source and on Site and approval of any material at its source does not necessarily imply that it will be approved on site.

All materials shall be delivered on to the site in sufficient period before they are required for use in the Works, so that such samples as the Engineer may wish are taken for testing and approval, and the Contractor shall furnish any information required by the Engineer on the materials. Each supplier must be willing to admit the engineer or his representative to his premises for the purpose of obtaining the samples.

No materials of any description shall be used and no approved source of supply may be changed without prior sanction by the Engineer.

Samples of the approved materials will be retained by the Engineer until the completion of the Contract. The Contractor shall provide suitable labelled boxes or bags for the storage of these samples.

Materials used in the Works shall conform to the samples approved by the Engineer.

Article 2.2 Approval Of Source Of Supply

Before ordering any materials, the Contractor shall submit, for the approval of the Engineer, the name of the Manufacturer of all items to be used in the Works and the source of supply of all materials to be used and the relevant Agreement Certificate. The Contractor shall ensure that the materials proposed conform to the Specification and Drawings prior to submission for approval of Engineer.

The approval in writing of the Engineer shall be obtained before relevant items are obtained. The information regarding the names of suppliers may be submitted at different times, as may be convenient, but no source of supply shall be changed without the Engineer's prior approval.

Two copies of each order for materials are to be delivered to the Engineer and if any variation from the Standard or type of materials is subsequently found necessary, it shall be approved in writing by the Engineer.

Article 2.3 Defective Materials

All materials which do not comply with the requirements of the Specification will be rejected and all such materials, whether in place or not, shall be immediately removed from the site by the Contractor at his own expense.

Article 2.4 Handling And Storage Of Materials

2.4.1 The Contractor shall make his own arrangements for the storage space and yards.

2.4.2 All materials for use in the Works shall be handled with due care and whenever not in immediate use, stored or stockpiled as follows or as directed by the Engineer.

2.4.3 Stockpiling of Aggregates

Approved aggregates shall be stockpiled at approved locations; prior to stockpiling, the site shall be cleaned, levelled and well drained by the Contractor, who shall if required by the Engineer, also lay suitable hard surfacing.

Special care shall be taken to avoid segregation, contamination and mixing of different classes of aggregates. Stockpiles shall be built by layers of about 80 cm high. Material to be loaded shall be taken from the upper layer and never from the toe of the stockpile.

Coral sand for concrete shall be washed as necessary and as required by the Engineer.

2.4.4 Buildings for Storage

The siting of the buildings for storage shall be approved before construction commences. All buildings shall be adequate for the complete protection of the materials to be kept therein and precautions shall be taken against fire particularly with regard to the storage of inflammable materials.

2.4.5 Storage of Cement

Cement shall be stored in well ventilated, watertight buildings with floors raised 50 cm above ground level and cement shall be within 15cm of the sides of the buildings to ensure circulation of air. Each consignment shall be kept separately and the contractor shall use the consignments in the order in which they are delivered on site. When being conveyed to the site in lorries or other vehicles, they shall be properly covered with tarpaulins or other effective waterproof coverings. Cement, which has become unsuitable through absorption of moisture shall be rejected and removed from the site by the Contractor at his own expense.

2.4.6 Storage of Steel Reinforcement

Steel reinforcement shall be stored, sheltered and supported by wooden blocks so as to prevent sagging. Bars shall be stored in separate lots according to diameter and quality.

2.4.7 Bulk Storage for Bitumen and Cement

The Contractor may use bulk storage for bitumen and cement provided he can satisfy the Engineer that the capacities are adequate.

2.4.8 Top Soil

Topsoil to be used later for verges or to cover embankment slopes and borrow pits shall be stockpiled on well-drained ground to be approved by the Engineer.

Article 2.5 Borrow Pits And Spoil Tips

- 2.5.1 The Contractor will be required to obtain naturally occurring materials for the works from sources outside the area occupied by the permanent works.

The Contractor will also be required to locate, prove and propose for the Engineer's approval sources of fill materials and spoil tips. The approved sources for fill materials shall be designated "Borrow Pits". The fill materials proposed shall satisfy the requirements of Article 2.7.1 and 2.7.2. In case naturally occurring stones such as 'Grabbeaux' or similar materials are proposed as borrow pit material, such material shall be clean, free from dust and organic matter, besides satisfying the requirements of Articles 2.7.1 and 2.7.2 as regards maximum size and shall be subject to the approval of the Engineer. Any material which is rejected by the Engineer shall be immediately removed from the site and replaced at the Contractor's expense.

No additional cost shall be paid for substituted material such as 'Grabbeaux' or other in place of borrow pit material.

- 2.5.2 The Contractor is required to make all arrangements for land and access thereof in compliance with Clause 1.10 of the Specification.

Article 2.6 Boulders Of Basalt

Only clean, dense and not altered boulders of basalt shall be used for production of aggregates.

The Contractor shall submit for the approval of the Engineer and before crushing is started the method he intends to follow for the selection of boulders of basalt conforming to these requirements.

Article 2.8 Material For Drainage Layer

Quality and source of supply of materials to be used for drainage layer shall be submitted to the agreement for the Engineer:-

Coarsely crushed basalt materials or spalls can be used.

- The materials shall be clean and free from impurities and vegetable matter (not more than 1%)
- Maximum Size: not more than 100 mm
- Proportion of particles less than 2 mm: not more than 10%

Article 2.9 Stone Aggregate Generally

The stone for use in the works shall be obtained from approved quarries or stockpiles of basalt boulders operated by the Contractor or by an approved Sub-Contractor and consisting of hard, tough, heavy, compact basalt, or other approved rock washed before crushing if necessary, broken, screened and graded as specified hereafter, to the satisfaction of the Engineer and free from flat, flaky, elongated, soft or decomposed pieces, excess dust and any dirt or acids or other deleterious substances.

Aggregates for different purposes are classified hereafter.

Article 2.10 Material For Concrete**2.10.1 Coarse Aggregate**

Coarse aggregate shall consist of crushed basalt, complying with BS 882. The aggregate shall be clean, hard, free from soft, friable, porous, elongated pieces, free from impurities which may adversely affect the strength or durability of the concrete or attack the reinforcement. Aggregate shall be washed if so directed.

The aggregate shall comply with the following requirements.

Sub Class 1 : The combined grading of aggregates for use in reinforced concrete, where shown on the Drawings or where directed by the Engineer, shall be uniformly graded from 20 mm down to 5 mm according to BS 882. The Flakiness index shall not exceed 35. The Los Angeles value shall not exceed 30.

Sub-Class 2 : The combined grading of aggregate for mass concrete, where shown on the Drawings or where directed by the Engineer, shall be uniformly graded from 40 mm down to 5 mm according to BS 882. The flakiness index shall not exceed 35. The Los Angeles value shall not exceed 35.

2.10.2 Fine Aggregate

Fine aggregate complying with the grading zones of BS 882 shall consist of approved sand clean from clay, organic matter, and other impurities; and it shall be washed if so directed.

The sand equivalent values shall be as follows:-

For class 20/25 and above concrete the sand equivalent value shall exceed 75.

For class 16/20 concrete the sand equivalent value shall exceed 70.

Coral sand shall not be used.

Crushed basaltic sand shall be washed.

Article 2.11 Manholes/ Catch pit

Unless otherwise particularly specified or directed, manholes shall be constructed in Grade C25/30 concrete. Roof slabs shall be reinforced as detailed on the drawings.

Benching and channels of manholes shall be in grade C16/20 concrete finished with 20mm thick cement mortar on top of the channels and benchings.

Where applicable, half round pipe shall be set in the floor of the manhole to form the channel.

Where precast concrete manholes/ Catch pits are permitted to be used they shall comply with BS 1917 and be constructed in accordance with the manufacturer's instructions. Individual rings and cover slabs shall have an approved watertight joint. Under roads and paved areas precast concrete manholes shall be surrounded with 150mm of Concrete Grade C16/20.

The maximum allowable lift of concrete in the construction of walls shall be 1.2m.

The cost of forming key joints as directed by the Engineer shall be deemed to be included in the rates for concrete in manholes.

The ends of all pipes are to be properly built in and neatly finished off, and pipe sockets are to be cut off.

The tops of the chambers and shaft walls are to be level all round to give a proper bearing to the cover slabs which shall be securely bedded and pointed in cement mortar.

Manhole chambers shall be subjected to water test as directed by the Engineer. The chambers to be tested shall be filled with water and allowed to stand full for 48 hours. They shall then be tested and deemed to be watertight if the drop in water level is not more than 12mm in a further 24 hours. Any chambers, which fail the test, shall be repaired and made watertight at the Contractor's expense and retested to the satisfaction of the Engineer.

Article 2.12 Filter Material

Filter material for under drains shall consist of sand or granular material to be approved by the Engineer.

Article 2.13 Water

Water shall be free from oil, acid, alkali, earth, vegetable or organic matter, or other deleterious substances in suspension or solution which may have a harmful effect on the Works. Water used for concrete, mortar shall comply with the requirements of B.S. 3148 and shall be tested if there is any doubt as to its suitability. If water is not available from a public supply, the Engineer's approval shall be obtained regarding the source of supply and manner of its use. Contaminated water shall not be used.

Article 2.14 Stone Work**(a) Generally**

Stone for use in masonry work shall consist of sound undecomposed basalt obtained from approved boulders and be of even texture and colour.

(b) Stone for Pitching and Stone Facing

Stone for pitching to drains, inlets and outlets, embankments and around structures shall consist of sound, undecomposed basalt with thickness not less than 15 cm and facing dimensions not less than 22 cm.

(c) Stone For Rip Rap

Stone for use as riprap shall consist of reasonably well-shaped, hard, dense, and durable rock. Separate lumps of stone shall weigh generally between 10 and 80 kg of which 80% shall be 20 kg or larger and not more than 10% less than 10 kg.

(d) Hardcore

Hardcore filling where required shall be clean hard quarry chips, clean basalt, hard broken stone or other approved material broken to 75mm gauge. All fillings shall be laid in layers not exceeding 150mm thick well packed, rammed and blinded on top with fine stone or other approved fine material and watered to receive concrete.

MANUFACTURED MATERIALS**Article 2.15 Cement****General**

The cement shall be of approved manufacture and shall be delivered in bags with seals unbroken, or if delivered in bulk, it shall be delivered in approved containers.

Test Certificates from the manufacturers or supplier shall be submitted for each consignment and shall indicate the results of the tests for compressive strength, setting time, soundness and fineness carried out in accordance with the requirements of the relevant British Standard, but the Engineer may require further tests to be made after the cement is delivered to the site.

If such certificates are not available, samples shall be taken from different bags or containers of the consignment, suitably packed, and sent for testing in accordance with B. S. to an approved laboratory, or where directed by the Engineer.

The Engineer may require further tests to be made if any cement is stored on site for a longer period than three months.

The failure of any sample to satisfy the requirement of the relevant British or other approved Standard shall entitle the Engineer to reject the entire consignment from which it was taken.

Cement Received Through Importing Agents

Each consignment of cement received through importing agents shall be accompanied by a further certificate stating that no cement has been rebagged or the percentage of rebagging (which shall not exceed 10 %) as the case may be.

The Contractor shall state the name of the local supplier or importing agent and the approval of the Engineer, in writing, shall be obtained before the order of any consignment.

Ordinary Portland Cement

Cement shall be manufactured by an approved firm and comply in all respects with the requirements of the B.S. 12

Article 2.16 Steel Reinforcement

Steel reinforcement shall comply with the requirements of B.S. 4449 and B.S. 4461. The steel shall be free from oil, grease, dirt and paint and any loose rust shall be removed before use.

No heating except for fishtailing and no welds except in reinforcing fabric shall be made in any bar without permission in writing from the Engineer. All bending shall be done in an approved machine with the steel cold and in accordance with B.S. 4466.

The Contractor shall supply the Engineer with a certificate stating the origin and process of manufacture and test sheets, signed by the maker, giving the results of each of the tests applied. If and when required he shall also grant all necessary facilities to the Engineer for the selection of test pieces and shall cause these to be prepared and submitted where directed for test. The Engineer shall have the option of testing and approving at the works of the suppliers of all or any of the steel required under the Contract, and the Contractor shall advise the Engineer when the whole or any of the steel is ready for test at the Works, in order to conform with the provisions of the B.S. as regards Test and Inspection.

Article 2.17 Mould Oil

Mould oil shall be of an approved proprietary brand and shall be used in accordance with the Manufacturer's recommendation or as directed by the Engineer.

Article 2.18 Material For Forms, Falsework And Centering

All timber used for forms, falsework and centering shall be sound wood, well seasoned and free from loose knots, shakes, large cracks, warping and other defects. Before use on the work, it shall be properly stacked and protected from injury from any source. Any timber, which becomes badly warped or cracked, prior to the placing of concrete shall be rejected. Forms, which are unsatisfactory in any respect, shall not be used. All shuttering for all outside surfaces above final ground level shall be either tongued and grooved or provided with a suitable lining to produce a smooth surface finish and shall be termed thin facing shuttering. Other shuttering shall be termed normal shuttering.

Irrespective of nature or position, all joints in shutterings shall be sufficiently tight to prevent leakage of liquids from concrete.

If the Contractor proposes to use steel shuttering, he shall submit to the Engineer, dimensioned drawings of all the component parts, and give details of the manner in which it is proposed to assemble or use them. Steel shuttering will only be permitted if it is sturdy in construction and if the manner of its use is approved by the Engineer.

Struts and props shall, where required by the Engineer, be fitted with double hardwood wedges or other approved devices so that the moulds may be adjusted as required and eased gradually when required. Wedges shall be spiked into position and any adjusting device locked before the concrete is cast.

Article 2.19 Concrete Porous Pipes

Concrete porous pipes for French drain shall comply with the requirements of B.S. 1194.

Article 2.20 Precast Concrete

Precast kerbs, slabs, channel edging and quadrants shall comply with the requirements of B.S. 340 and with the Drawings.

Where the Contractor is permitted to carry out precasting on site, the precast units shall in addition to complying with the relevant B.S., be manufactured in steel moulds on a vibrating table or as directed by the Engineer.

Article 2.21 Admixtures

Unless agreed by the Engineer, neither admixtures nor cement containing additives shall be used.

Article 2.22 Precast Concrete Slabs

Precast concrete slabs shall be "Trief" interlocking concrete blocks, type Super Trief Blocks (125 mm - (5 in)- thick with a finish) or similar.

Article 2.23 Geotextiles

General Characteristics

Geotextile shall be of the non-woven type having the following characteristics:

Table 2.8 – Geotextile Membrane

	Subgrades	French Drains
Mass per unit area	$\geq 250 \text{ g/m}^2$	$\geq 200 \text{ g/m}^2$
Tensile strength	$\geq 20 \text{ KN/m}$	$\geq 15 \text{ KN/m}$
Penetration load (CBR) at rupture	3 KN	2.5 KN
Elongation	$\geq 60\%$	$\geq 60\%$
Pore size O_{90} (dry)	$\leq 100 \text{ Mm}$	$\leq 100 \text{ Mm}$
Permeability (10 cm head)	130 l/s/m^2	160 l/s/m^2

Geotextiles shall be delivered in rolls wrapped in a protective layer of plastic to avoid degradation from direct sunlight, ingress of dust, mud and water during storage.

Laying at subgrade level

- Prior to laying of geotextiles, the site will be well graded and sharp objects such as rocks, stumps of trees or bushes which might puncture or tear the fabric shall be removed. Any significant hollows or unevenness in the site should be filled.

During the rolling out into position of the geotextile, sufficient allowance shall be made in order to provide an overlap at least 500 mm between adjacent sheets. The edges of the geotextiles shall be properly weighted to maintain the position of the geotextile before covering with sub base materials or other fill. Once the geotextile is laid it shall not be trafficked until an adequate layer of fill is placed over it. Blades or buckets of construction plant must not be allowed to come in to contact with the fabric during filling operations.

For drainage applications, all sharp stones and projections shall be removed from the bottom and walls of trenches before lining of trenches with geotextiles.

The edges of the fabric shall be laid on the ground at the edges of the trench and held by small piles of aggregates.

During the filling process, no attempt shall be made to restrain the top of the fabric.

Upon completion of filling of the trenches, the free lengths of fabric shall be wrapped over the drainage layer. The overlaps shall be at least 500 mm.

Jointing / cutting

The minimum overlap shall be 500 mm. In applications where the geotextile is subject to tensile stress, the overlap shall be increased by 100 mm. Overlaps shall be sown or stapled as

per the manufacturer's recommendations. Stitching should be at least 50 mm back from the free edges of the fabric.

Article 2.24 Polystyrene

The board shall be formed of polystyrene base resin in an extrusion process and shall be homogeneous and essentially unicellular. It shall conform to the requirements of ASTM 11230

SECTION 3 - TESTING

Article 3.1 General

The Contractor shall carry out on the Site tests for selection and control of materials and workmanship in accordance with the Technical Specifications and as instructed by the Engineer. Such instructions shall in no way affect the responsibility of the Contractor to ensure that all materials and workmanship are in accordance with the Contract.

Article 3.2 Provision And Operation Of Laboratory

3.2.1 General

Not Applicable

3.2.2 Laboratory

The Contractor shall provide, equipment and apparatus to carry out all tests required for the selection of materials, design of mixes, control of materials and workmanship, in compliance with the requirements of these Technical Specifications. The Contractor shall ensure that at all times during the currency of the Contract, he has sufficient quantity of apparatus, equipment, chemicals and other materials, and is adequately staffed to carry out any and all of the tests by the methods described hereunder, and at the speed and in volume required by the progress of the works, and the Engineer's instructions.

All tests shall be carried out by an approved Laboratory and testing facilities. The Laboratory shall certify all test results.

The Contractor shall provide and maintain all labour, tools and equipment that may be required for the digging of trial pits and collection of samples in connection with all tests.

All tests to be performed shall be in accordance with Standard Specifications of the B.S., LCPC, AASHTO and ASTM as specified in these Technical Specifications.

All tests including crushing of concrete cubes shall be carried out in an approved laboratory.

The Contractor shall provide and maintain all essential services including lighting, clean water and sinks with adequate drainage facilities. The Contractor shall provide such work benches, tables and chairs as required by the Engineer.

The Contractor shall maintain the building in a clean and tidy condition and shall be responsible for the security of the building and its contents at all times.

3.2.3 Design of Mixes

The Contractor shall carry out tests to establish proper proportions and characteristics of mixes as described in Parts VI and VII of these Technical Specifications.

3.2.4 Tests On Materials

The Contractor shall carry out tests to ensure that all materials to be used in the Works are in accordance with the Technical Specifications.

3.2.5 Tests on Workmanship

The Contractor shall carry out tests at the frequencies specified herein, or as directed by the Engineer to ensure that all workmanship is in accordance with the Technical Specifications.

3.2.6 Tests Carried Out by A Nominated Testing Authority

Whenever the facilities of the Contractor's laboratory are determined to be inadequate by the Engineer to carry out control tests on materials or workmanship, such tests shall be carried out at the Contractor's expense by any other testing laboratory which shall be nominated by the Engineer, and the Contractor shall be fully responsible for any delays in the testing or work which may ensue.

3.2.7 Test Results

All samples and records shall be preserved for as long as the Engineer may direct and they shall be kept and labelled in an orderly fashion to his satisfaction. The results of all tests shall be entered on standard forms, samples of which will be provided by the Engineer and two legible copies of each completed form shall be delivered to him with the minimum of delay. No material shall be incorporated in or rejected from the Works until the results of all relevant tests have been approved.

Article 3.3 Additional Tests

In addition to the tests required under other articles hereof, the Engineer shall have power to order independent tests of all materials to be carried out by some person appointed by him at such place as he may determine and from the result of such tests there shall be no appeal. No payment shall be made for these additional tests and the costs thereof shall be deemed to be included in other rates and prices.

Article 3.4 Inspection And Testing Of Manufactured Materials

Whenever considered desirable by the Engineer, inspectors may be sent to the factory to test the materials or to supervise their manufacture. Materials shall be tested before leaving the factory as well as after delivery to the site and the Engineer shall be at liberty

to reject materials notwithstanding the preliminary test at the factory. Should the Engineer not decide to send an inspector to the manufacturer's works, the Contractor shall obtain from the manufacturer certificate of test, proof sheets, mill sheets etc. showing that the materials have been tested in accordance with the requirements of these Specifications relating thereto and shall provide adequate means of identifying the materials on site with the corresponding certificates etc..., but neither the omission of the Engineer to send an inspector nor the production of the manufacturer's certificate of test shall affect the liberty of the Engineer to order further tests on samples selected from the materials delivered to the site and to reject after delivery materials found to be unsuitable or not in accordance with these Technical Specifications.

Article 3.5 Tests On Suspect Materials And Workmanship

Where so directed, tests other than the tests specified herein, shall be carried out on the completed works or portions thereof at any time until the final handing over certificate has been issued. Where there is any doubt that the work has not been carried out in accordance with the provisions of the contract or the Engineer's instructions, such tests shall be carried out jointly by the Engineer and the Contractor, or at the request of either party, by an independent Testing Authority which shall be nominated by the Engineer.

Article 3.6 Testing Of Aggregates

3.6.1 Sampling of Aggregates

The sampling of aggregates shall be carried out in accordance with the procedure given in B. S. 812 Section 1.

3.6.2 Tests on Aggregates

Sieve Analysis	:	B. S. 812
Amount passing No. 200 B.S. Sieve	:	B. S. 812
Flakiness Index Test	:	B. S. 812
Specific Gravity	:	B. S. 812
Bulk Density	:	B. S. 812
Los Angeles Abrasion Test	:	AASHTO Designation T 96-49
Sand Equivalent Test	:	AASHO T 176
Moisture Content	:	B. S. 812
Speedy Moisture Content	:	as directed by the Engineer

Article 3.7 Tests For Water Purity

The tests shown below shall be conducted in accordance with the relevant British Standard 3148.

Article 3.8 Tests For Manufactured Materials

Each batch of cement delivered to site must be accompanied by a Manufacturer's Certificate giving results of tests proving its compliance with the requirements of BS 12 or BS 4027 as appropriate. The tests shall be carried out in accordance with BS 12 together with the tests for determining the percentage of alkali in the Cement expressed as Na₂O.

In addition to the above the Engineer may order that any cement which has been stored on site for more than one month shall be tested in accordance with BS 12, and used only when it meets the design requirement.

Further, the Engineer may require the Contractor to take samples from cement bins or bagged cement and to carry out the following tests:

3.8.1 Ordinary and Rapid Hardening Portland Cement

<u>TEST</u>	<u>BRITISH STANDARD</u>
Compressive Strength Test	: B.S.4550 Part 3 Section 3.4
Consistency of Standard Cement Paste	: B.S. 4550 Part 3 Section 3.5
Initial and Final Setting	: B.S. 4550 Part 3 Section 3.6
Soundness Test	: B.S. 4550 Part 3 Section 3.7
Fineness Test	B.S. 4550 Part 3 Section 3.3

3.8.2 Bituminous Materials

Sampling Bituminous Materials	: AASHTO T 40
Penetration Test	: AASHTO T 49
Softening Point	: AASHTO T 53
Ductility Test	: AASHTO T 51
Viscosity	: AASHTO T 201/T 59
Solubility Test	: AASHTO T 44

Distillation	: AASHTO T 78
Residue from Distillation	: AASHTO T 59
Flash Point	: AASHTO T 48/T 79

3.8.3 Tests on Steel Bars and Wire

All reinforcement shall be supplied with a manufacturer's test certificate showing that it has been tested and found to comply with the relevant standards BS 4449, 4482, 4461, 4483, 2691, and 4360. If required by the Engineer, the Contractor shall provide samples free of charge for testing at an approved laboratory. No payment shall be made for these tests and the costs thereof shall be deemed to be included in other rates and prices.

Article 3.9 General Control And Tests During Construction

3.9.1 Description

The Contractor shall be responsible for the quality of all materials to be included in the permanent works.

The Engineer or his representative shall inspect the materials and works from time to time during and after construction and get the quality of the materials and Works tested by himself, by his Testing and Quality Control Units or by any other agency deemed fit by him generally as per the requirements stipulated in the Specifications. Additional tests may also be conducted where, in the opinion of the Engineer, need for such tests exists, in the absence of clear indications and frequency of tests for any item procedures and tests as directed by the Engineer shall be followed.

The Contractor shall provide necessary co-operation and assistance in obtaining the samples for tests and carrying out the field tests as required by the Engineer from time to time. This shall include provision of labour, attendant and assistance necessary in connection with the tests.

For the work of embankment, subgrade and pavement, construction of subsequent layer of same or other layer over the finished layer shall be done after obtaining permission from the Engineer.

Similar permission from the Engineer shall be obtained in respect of other items of work prior to proceeding with the next stage of construction.

For cement, bitumen, mild steel deformed bars, high tensile steel, prestressing materials, bearings, and similar other materials essential tests are to be carried out at the manufacturers' plants or at laboratories other than the site laboratory. The Contractor shall also furnish the test certificates to the Engineer. For testing of cement concrete at site during construction, arrangement for supply of samples, sampling, testing and supply of test results shall be made by the Contractor as per the frequency and number of tests as stipulated in these Specifications or as approved by the Engineer.

The method of sampling and testing of materials shall be as required under relevant clauses stipulated in these Specifications or as approved by the Engineer.

Where the Engineer consider that for the interest of the quality on materials or workmanship, modifications, if any, are necessary, such shall be carried out as per direction of the Engineer by the Contractor at his own expenses.

3.9.2 Field Moisture Content Test

This test shall be carried out in accordance with B. S. 1377, Part 2, Test 1 or by using a Speedy Moisture Tester as directed by the Engineer. When using the latter method it must be noted that the instrument requires calibration for each type of material being tested.

To improve the accuracy of the instrument, at least six small ball bearings should be placed in the Speedy Tester and these will assist in breaking up the soil, so allowing the calcium carbide to react with the moisture more readily.

3.9.3 In-Situ Dry Density Control

The test shall be carried out using the sand-cone method or the rubber-balloon method or nuclear density and/or moisture method as directed by the Engineer. In case the nuclear densiometer is used, at each test location the average of four readings taken at positions rotated by 90° will be used. A check/comparison test using the sand replacement method (sand cone or the rubber balloon test methods) will be carried out at a 50 test interval. Initial calibration of the instrument will be done by carrying out at least fifty tests in parallel with the sand replacement method for each different material encountered. The check tests will be used to update the initial calibration of the instrument. The instrument shall have a valid calibration certificate before the initial site calibration mentioned above is carried out.

3.9.4 Surface Treatment

As directed by the Engineer

3.9.5 Concrete

Sampling	: B. S. 1881
Slump Test	: B. S. 1881
Compressive Strength Test	: B.S. 1881
Indirect Tensile Strength	: B. S. 1881
Compressive Strength of Concrete Pipes	: B. S. 556

Article 3.10 Frequency Of Tests

The frequency of tests for soils and aggregates, steel, water, reinforcement, cement, and of quality control test outside shall be as shown in the tables on pages “Specification Section - 3-11”, Specification Section - 3-12, Specification Section - 3-13 and Specification Section - 3-14

Article 3.11 Frequency For Other Manufactured Materials

For all other manufactured materials, the frequency of testing shall be as indicated in the relevant British or other approved Standards, or as directed by the Engineer.

Article 3.12 Alteration In Frequency Of Tests

Notwithstanding any provision in these Technical Specifications as to the frequency of tests, the Engineer shall be empowered to alter the number, type or nature of such tests, as may in his opinion, be necessary for the proper execution of the works. The Engineer shall be at liberty to increase the frequency of testing, and repeat tests which, in his opinion, are unsatisfactory and vary the nature and type of test.

Article 3.13 Apparatus Of The Laboratory

The laboratory shall be equipped to carry out at least the following tests:-

1. Sieve Analysis
2. Atterberg Limits
3. Proctor
4. Specific Gravity
5. Moisture Content
6. Bulk Density
7. Sand Equivalent
8. Field Moisture Content
9. In-Situ Dry Density (Rubber balloon or sand-cone method or nucleo gammadensometer method)
10. Slump for fresh concrete
11. Measures of Deflections using a Benkelman Beam
12. Measure of Temperature (0 – 400 °C)
13. All other necessary tests may be carried out by Nominated Testing Authority.

Article 3.14 Control Of Surfaces

The Contractor shall provide straight edges, templates for checking the finish of the surfaces. They shall be maintained in good condition during all the works.

SECTION 4 - SITE CLEARANCE AND EARTHWORKS

Article 4.1 Mass Diagram

Not Applicable

Article 4.2 Existing Structures And Services

The existing structures and services on the Site include:-

- (a) Services such as channel, water-mains, sewer lines ,optical fibre,telephone, electricity cables, overhead lines, street lighting ,etc.....
- (b) Masonry, concrete, reinforced concrete
- (c) Structures
- (d) Existing Roads

Article 4.3 Demolition And Dismantling

The Engineer must be given 7 days' notice of any proposal to demolish or dismantle all or any part of the existing structure on the Site, which is necessary for the completion of the Works.

The Contractor shall give the Engineer an explanation of the method and order of demolition and the steps taken to ensure the safety and stability of any remaining structure affected thereby.

The approval of the Engineer shall not relieve the Contractor from his responsibility for injury, loss, inconvenience and annoyance to persons, damage to animals, property and Works consequent on the demolition and dismantling.

Article 4.4 Demolition Of Masonry, Concrete, And Reinforced Concrete Structures

Demolition of existing masonry, concrete, reinforced concrete structure if any shall be carried out in accordance with the Drawings or as directed by the Engineer.

The Works as directed by the Engineer shall include: -

- Demolition (reinforcement shall be cut off close to concrete)
- Removal of material

- Loading, carting away & disposal of material as directed by the Engineer
- Filling under embankment of all inspection pits and openings made in connection with the removal of these structures to the original ground or to the lines and levels as directed by the Engineer, to be levelled with an approved material compacted to a density at least equal to that of the surrounding ground or as directed by the Engineer.

Article 4.5 Site Clearance

Clearing site shall consist of clearing the ground of trees, bush, hedges, fences, shrubs, stumps, rubbish, loose boulders, piles of boulders and other objectionable material excluding soil and rock, including disposal from areas shown on the Drawings or as directed by the Engineer, and shall include the grubbing up of all root and backfilling with approved materials of all cavities caused by the clearing to a density at least equal to that of the surrounding ground.

The Works include the loading, carriage and disposal of all materials to tip as directed by the Engineer.

Article 4.6 Cutting Of Trees

Trees defined as having a girth of 1,000 mm, measured 1,000 mm from the ground shall be cut by the Forestry Service or by owners, at the request of Engineers. Otherwise, this work shall be carried out by the Contractor and paid under day work schedule. The Contractor must seek the approval of the Forestry Service prior to the removal of any trees.

The removal of stumps and roots of such trees as defined above, is included in the works. Holes left by the removal of stumps and roots shall be backfilled and compacted to 90% B.S. Heavy Compaction with approved materials up to the top of the sub-grade level or as directed by the Engineer.

Article 4.7 Ownership Of Materials

Materials, components and other items which the Contractor has demolished, dismantled or otherwise removed in compliance with the Contract shall remain the property of Employer unless and until the Contractor is informed in writing by the Engineer that ownership of all or any of the materials, components and other items belong to a third party.

Article 4.8 Classification Of Excavated Materials

4.8.1 Topsoil

Topsoil shall consist of a material containing vegetable root system existing in a thin layer on the natural ground surface complying with the Technical Specifications.

4.8.2 Approved Material

Approved material shall consist of all material complying with section 2 of the Technical Specifications or which, in the opinion of the Engineer, is suitable for incorporation in the construction.

4.8.3 " Rock"

Rock is defined as all materials, which in the opinion of the Engineer, require blasting or the use of metal wedges and sledgehammers, or the use of compressed air drilling for their removal and which cannot be extracted by ripping with a tractor of at least 300 brake hp with a single, rear mounted, heavy duty ripper. Tractor shall be in good order, operating weight forty (40) tones, operated by qualified operator.

4.8.4 Power Of The Engineer

Should any difference of opinion arise between the Contractor and the Engineer, as to the classification of the material, the Engineer's decision shall be final.

Article 4.9 Removal Of Top Soil

Where embankment/subgrade will be constructed on natural ground, removal of topsoil depth shall be directed by the Engineer, shall be stripped after clearing and grubbing. In the fill areas containing humus or other deleterious materials harmful to the stability of road, the Engineer may order for a depth greater than 300 mm within the area designated. The stripped area shall be compacted as per the specification. The stripped materials shall be stockpiled for use on the surfaces before turfing and surplus material shall be disposed off as directed by the Engineer to a site identified by the Contractor and approved by the Engineer at any distance from the work site.

Where the removal of topsoil has not been specifically directed, any top soil excavated shall be deemed to be part of the general excavation.

Article 4.10 Dewatering

During construction of the RC drain, the excavated trench shall be maintained in such a condition that it is well drained at all times. In order that the trench, formation level or sub base may not be subject to wetting, during or after construction, the Contractor shall at all times, and especially at an early stage of the work be required to provide adequate drainage by scheduling ditch work and outlet construction so as to prevent such wetting. The Contractor shall clean and trim all such drainage ditches from time to time during the work or when directed by the Engineer, so that there may be a free water flow throughout the whole period of work. The Contractor shall immediately repair damage attributable to wetting through failure to provide such measures.

No separate payment shall be made for this work as these are deemed to be included in the relevant items of the Bill of Quantities.

Article 4.11 Excavation

- 4.11.1 "Excavation" shall consist in the loosening, digging, loading, hauling and disposal of normal, soft, rippable, loose, unsuitable and boulders materials to the lines, levels, slopes and widths shown on the Drawings or as directed by the Engineer. It shall include compaction, finishing and shaping of all surfaces formed by such excavations in accordance with these Technical Specifications.

The Contractor shall take special care for the saving of all suitable excavated materials for embankment or subgrade construction.

- 4.11.2 Removal of existing structures, site clearance, removal of topsoil and removal of unsatisfactory material shall be carried out in proper sequence so that one operation does not interfere with another. Sufficient time shall be allowed between each operation for any measurement required by the Engineer to be carried out and the Contractor shall not proceed with any other operation until such time as any measurement has been agreed and approved.
- 4.11.3 where a firm foundation is not encountered at the bottom of the excavation due to presence of soft, spongy or other unstable material, the Contractor shall, at his own expense, remove such unstable material and replace with approved material thoroughly compacted to a density not less than 95% B. S. Heavy Maximum Dry Density.
- 4.11.4 All excavations shall be carried out in such a manner that the back slopes are neatly trimmed to the lines shown on the Drawings or as directed by the Engineer.
- 4.11.5 Where excavation reveals a combination of suitable and unsuitable materials, the Contractor shall, wherever the Engineer considers it practicable and so directs, carry out the excavation in such manner that the suitable materials are excavated separately for use in the works without contamination by the unsuitable material.
- 4.11.6 In wet weather clay cuttings shall not be excavated and shall not be taken down to less than 25 cm above final level of the subgrade.

- 4.11.7 The Contractor shall take all necessary precautions to prevent slips and falls to the sides of the excavation, but if any should occur, the Contractor shall remove, at his own expense, all such fallen or displaced materials and replace if required with suitable material compacted to a density not less than that of the adjoining ground at his own expense.

Article 4.12 Compaction Of Earthworks

- 4.12.1 The moisture content of fill material of natural ground during compaction shall never exceed B. S. Heavy Optimum Moisture Content (OMC) for the densities specified in Article 4.26.2 hereof of more than 2%.

- 4.12.2 The compaction requirements are as follows:-

(Heavy Maximum Dry Density: H.M.D.D.)

- (a) Compaction of the top 30 cm of natural ground under the embankment: not less than 90% B.S.H.M.D.D.
- (b) Compaction of the top 30 cm of cuts under the pavement structure: not less than 95% B.S.H.M.D.D.
- (c) Compaction of embankment except for the top 30 cm: not less than 90% B.S.H.M.D.D.
- (d) Compaction of the top 30 cm of the embankment other than rock or boulder embankment: not less than 95% B.S.H.M.D.D.

SECTION 5 – DRAINAGE

Article 5.1 General

The present section includes the construction of:

- RC Drains
- RC Open Drain
- Absorption pits
- Rehabilitation of existing Absorption pits

Article 5.2 Drainage Programme

The Contractor shall submit to the Engineer for his approval immediately after the signature of the Contract a carefully prepared programme for the drainage works which shall allow for completion of all drainage systems necessary for drainage during construction, before works are started.

Article 5.3 Drainage Excavation

The Contractor shall excavate all drainage systems to the lines, levels, gradients and dimensions shown on the Drawings or as directed by the Engineer.

Excavation for drainage systems shall be carried out in accordance with the requirements of the section “earthworks” of these Technical Specifications.

Should excavations be executed to greater depth or dimensions than necessary through the incidence of boulders or through other causes, the Contractor shall backfill and make good, with approved materials thoroughly compacted, to the correct level and dimensions and to the approval of the Engineer.

The material excavated for drainage systems shall be, if suitable, set aside for use as backfill and if unsuitable or in excess, run to spoil tips.

Article 5.4 Timbering And Shoring Of Excavations

The sides of excavations such as trenches, holes shall, where required, be timbered and shored to the satisfaction of the Engineer. The Contractor shall remain liable for any damage or injury consequent upon removal of timbering or shoring.

Where directed by the Engineer the timbering and shoring shall be left in excavations and measured and paid for except if, in the Engineer's opinion, the necessity for leaving the timber in has arisen from carelessness or neglect on the part of the Contractor.

Article 5.5 Trenches And Holes Excavation And Backfilling

- 5.5.1 The trenches and holes excavations shall be of sizes sufficient to enable the bottom to be compacted as required, the bed to be laid, the pipes and concrete to be placed accurately and proper backfilling and ramming to be carried out.
- 5.5.2 Where required the bottom of such excavations shall be compacted to 95% B.S.H.M.D.D.
- 5.5.3 Where rock is met at level of the intended bottom of the trench or hole, it shall be cut to a depth of 20 cm below this level and replaced with sand, granular material or other material to the approval of the Engineer.
- 5.5.4 Trenches and holes shall be kept free from water until any works such as concrete or joints therein are sufficiently set; the Contractor shall construct any temporary drains that the Engineer may deem necessary.
- 5.5.5 Where seepage of water occurs in trenches or holes, bedding and backfilling shall be carried out using sand, granular material or crushed stones or other material as directed by the Engineer.
- 5.5.6 Material for backfilling shall be to the approval of the Engineer and shall be deposited in layers not exceeding 15 cm of loose material, compacted with power rammers, the moisture content of the material being adjusted to facilitate thorough compaction. The density of each compacted layer shall not be less than 95% of B.S.H.M.D.D.

Backfilling shall be brought up evenly on both sides of the pipe. Special care shall be taken to compact thoroughly the material under the haunches of the pipe and to ensure that backfilling material is in intimate contact with the pipe.

Jointed pipes shall be tested as directed by the Engineer.

Masonry works shall comply with the requirements of Article 6.11 and the end of all pipes shall be neatly built into the walls and finished with cement mortar.

No separate payment shall be made for excavation of pipe culverts and the cost thereof shall be deemed to be included in the rate for provision and laying of the pipe.

SECTION 6 – CONCRETE**CONCRETING MATERIALS AND THEIR HANDLING****Article 6.1 General Requirements**

This section covers in reference to internationally valid specifications definition in regard to structures made from concrete and stipulates the required quality standards.

For the case that amendments of the Specification becomes necessary the contractor should support his proposed amendments with appropriate documentation using as far as possible actual applications with the respective approval process.

All workmanship, materials, tests and performance in connection with the concrete work shall be in conformity with the British Standard Code of Practice BS 8110 for the Design, Materials and Workmanship for “The Structural Use of Concrete” and BS 8007 1987 “Code of Practice of Concrete Structures for Retaining Aqueous Liquids” where not inconsistent with these Preambles.

Materials for concreting shall contain no harmful substances that will affect the strength or durability of the concrete.

Article 6.2 Water for Concreting

Water for use in concrete shall conform to the requirement of section 4.2, 4.3.1, 4.3.2 and 4.3.3 of BS EN 1008:2002. The water shall also conform to either the chemical requirement in section 4.3.4 of BS EN 1008:2002, or the requirement for setting time and compressive strength in section 4.4 of BS EN 1008:2002. Water supplied as potable water is deemed to conform to the requirements of BS EN 1008:2002.

The water used for making and curing concrete and mortar shall be free from objectionable quantities of silt, organic matter, alkali, salt or other impurities. In particular, inorganic matter in solution shall not exceed 500 parts per million by weight and in suspension shall not exceed 30 parts per million by weight and the total alkali bicarbonate/carbonate content of the water shall be less than 1000 parts per million by weight.

The Chloride content of the waster expressed as Cl, shall not exceed the level given in Table 23.1 unless it can be shown that the chloride content of the concrete will not exceed the maximum value for the specified class selected from Section 5.2.7 of EN 206-1:2000.

Table 23.1- Maximum chloride content of mixing water

End use	Max. Chloride content mg/l	Test procedure
Prestressed concrete or grout	500	Section 6.1.3 of BS EN 1008:2002
Concrete with reinforcement or embedded metal	1000	
Concrete without reinforcement or embedded metal	4500	

The sulphate content of the water expressed as SO_4^{2-} shall not exceed 2000 mg/l.

The water shall be from an approved source and shall contain no deleterious matter which significantly affects the setting time or strength or durability of the concrete or which has any effect on the appearance of the hardened concrete by discoloration or efflorescence or prevents the achievement of the approved test cube strengths at 28 days for the appropriate grade of concrete.

The initial setting time obtained on specimens made with the water shall be not less than 1 hour and not differ by more than 25% from the initial setting time obtained on specimens made with distilled or de-ionised water. The final setting time shall not exceed 12 hours and not differ by more than 25% from the final setting time obtained on specimens made with distilled or de-ionised water. The mean compressive strength at 7 days of the concrete or mortar specimens, prepared with the water, shall be at least 90% of the mean compressive strength of corresponding specimens prepared with distilled or de-ionised water. The Contractor shall test the water which he proposed to use and shall submit the records of such tests to the Engineer before placing any concrete in the permanent works.

The Contractor shall make regular tests of the water during concrete construction works. The water shall be sampled at the point of discharge into the mix and the frequency of sampling shall be as approved by the Engineer. The sample of water of not less than 5 litres shall be taken. The sample shall be correctly identified and representative of the water to be used, due regard being given to the possible effects of seasonal fluctuations. The sample shall be stored in a clean and sealed container. The container shall be rinsed out with water from the source prior to filling the capacity with the water sample.

Tests shall include:

- (1) Chemical analysis to determine the alkalinity, pH and concentrations of calcium, magnesium, potassium, sodium, sulphate and chloride.
- (2) Physical analysis to determine electrical conductivity, suspended solids, colour and smell.
- (3) Comparative tests for initial setting times and compressive strengths of cement pastes prepared with water from the proposed source and with distilled water.

Any one of the following conditions may make the source of water unsuitable for concreting:

- i. Total dissolved solids in excess of 2000mg/l.
- ii. Chloride ion content in excess of 500mg/l.
- iii. Sulphate measured as sulphur trioxide in excess of 1000mg/l.
- iv. Alkali carbonates and bicarbonates in excess of 1000mg/l.
- v. Presence of organic substances indicated by colour or odour
- vi. In comparative tests with distilled water, variations in initial setting times in excess of 30 minutes or reductions of compressive strength in excess of 10 per cent.

In addition to the above water for concrete shall be included in an assessment of total chloride and sulphate contents in a proposed concrete mix.

Article 6.3 Cement

6.3.1 Cement Requirements, Acceptance, Sampling and Testing.

Cement unless otherwise specified shall be Portland Cement of strength class 42.5 N complying with the requirements of BS EN 197-1:2000 and a manufacturer's certificate of Test in accordance with BS EN 197-1:2000 shall be supplied for each consignment delivered to the site.

The Portland cement shall not contain less than 8% and not more than 13% by weight of tricalcium aluminate.

Cement may be delivered to the site either in bags or in bulk.

If delivered in bags, each bag shall be properly sealed and marked with the manufacturer's name and shall be stored in a weatherproof shed of adequate dimensions with a raised floor. Each consignment shall be kept separate and marked so that; it may be used in the sequence in which it is received. Any bag found to contain cement which has set or partly set shall be completely discarded and not used in the works. Such bag/bags shall be removed from site within 24 hours. Bags shall not be stacked more than 1.5 m in height.

All bagged cement shall be stored in a weatherproof building having dense impervious bituminous (or concrete) floors, sufficiently elevated to prevent absorption of moisture, which shall be kept clean at all times.

Bags shall be stacked close together to reduce circulation of air but shall not be stacked against outside walls.

If delivered in bulk, the cement shall be stored in waterproof silo either provided by the cement supplier or by the Contractor but in either case the silo shall be to the approval of the Engineer.

Cement shall be delivered to site in consignments of sufficient quantity to ensure that there is no suspension or interruption to the work of concreting at any time. Samples of cement shall be taken in the presence of the Engineer, on request, for testing in an approved independent laboratory and the Engineer shall have access to the cement store at all reasonable hours.

Cement for use in the Works are designed as below:

- Ordinary Portland Cement (OPC):

Cement containing not less than 8% and not more than 13% by weight of tricalcium aluminate.

- Moderately Sulphate Resisting Portland Cement (MSRPC):

Cement containing not less than 4% and not more than 8% by weight of tricalcium aluminate.

- Sulphate Resisting Portland Cement (SRPC):

Cement containing not more than 4% by weight of tricalcium aluminate.

Unless otherwise specified or approved, all cement shall comply with the following requirements:

- i. The heat of hydration shall not exceed 320kJ/kg at 7 days.
- ii. The specific surface shall not be greater than 325m²/kg when measured by the air permeability method.
- iii. The temperature of cement shall not exceed 75°C at the time of incorporation into a concrete mix.
- iv. When required, low alkali cements shall have an equivalent acid soluble alkali content (computed from Na₂O + 0.658 K₂O) of less than 0.60 per cent by weight.
- v. The performance characteristics of cement shall not be such as to necessitate excessive cement contents or be likely to cause or accentuate any undesirable properties in the fresh or hardened concrete, notwithstanding apparent compliance with this specification.

Primary and secondary sources of the required cements shall be proposed and only cement from an approved source shall be brought onto the site. No other cement shall be used on any part of the temporary or permanent works.

If requested by the Engineer, a typical recent sample of cement from each proposed manufacturer and works shall be fully tested (including potential compound composition based on anion and cation analyses) in an approved independent

laboratory in accordance with the approved Standard and the results shall be included with the relevant proposal.

No cement shall be brought onto site until the above acceptance procedures have been completed and source approval obtained.

Cement shall be delivered to site in consignments of sufficient quantity to ensure that there is no suspension or interruption to the work of concreting at any time.

Unless approval is given in writing for the handling of cement in bulk, cement shall be packaged by the manufacturer in bags which are so designed as to prevent any contamination and to minimise the adverse effects of moisture and high humidities during transportation and storage. Two unused sample bags shall be provided for approval and retention by the Engineer.

The bags shall be marked with the manufacturer's name, the brand name (if appropriate), the name of the producing works, the cement type, the Standard to which it was made, and the date of manufacture, or date code.

Where bulk cement deliveries are proposed, details of off-site storage and loading arrangements shall be approved and reasonable facilities provided for the Engineer to inspect these arrangements for approval purposes.

Consignments shall be used in the order in which they were delivered.

Differing types or brands shall not be mixed together for use in the Works.

A certificate must be provided for each consignment of cement which shall include the following information:

The manufacturer's bulk average test results for the manufacturing batch including chemical composition and physical properties determined in accordance with the approved specification for cement testing.

The date of manufacture, the date of original loading and the date of intended delivery to site.

Cement shall not be used after 6 months from its manufacture date or after it has been held in store for more than 3 months, unless it is retested and satisfies the relevant standard. A re-test certificate will only be valid for a further period of 6 months.

All cement shall be used within 12 months of date of manufacture.

Cement which the Engineer considers to have deteriorated in any way shall not be used and shall be removed from site without delay.

Samples of cement shall be taken in the presence of the Engineer, on request, for testing in an approved independent laboratory and the Engineer shall have access to the cement store at all reasonable hours.

6.3.2 Storage of Cements

Cement shall be stored immediately upon receipt at site.

All bagged cement shall be stored in a weatherproof building having dense impervious bituminous (or concrete) floors, sufficiently elevated to prevent absorption of moisture, which shall be kept clean at all times.

Bags shall be stacked close together to reduce circulation of air but shall not be stacked against outside walls.

Each consignment and type of cement shall be stored separately for ease of access, identification, inspection and sampling.

If bagged cement is stored in silos it shall be charged into the silos through a 6mm mesh screen which is welded or bolted to and covers the entire feed area of the silo charging hopper.

Cement stored in silos shall be adequately protected against rain, humidity and dewfall, and all silo charging and discharging points shall be properly sealed. Silo aeration equipment shall, if dictated by climatic conditions, incorporate de-humidifiers.

Article 6.4 Aggregate

Aggregates shall conform with the requirements of BS EN 12620:2002+A1:2008 and the sources and types of all aggregates are to be approved in all respects by the Engineer before work commences.

The grading of aggregates shall be one within the limits set out in BS EN 12620:2002+A1:2008 and as later specified and the grading, once approved, shall be adhered to throughout the works and not varied without the approval of the Engineer. Fine aggregate shall be clean, crushed rock sand and coral sand, of hard quality and shall be free from lumps of stone, earth, loam, dust, salt, organic matter and any other deleterious substances. The maximum quantities of material passing the 63 um sieve shall not exceed the values given in Table 4 of BS EN 12620:2002+A1:2008.

Coarse aggregate for concrete shall be crushed blue basalt stones to the approval of the Engineer. It shall be hard, clean and roughly cubical in shape, non porous, free from dust, decomposed stone, clay, earthy matter, foreign substances or friable, thin, elongated or laminated pieces. It shall be graded within limits of Table 2 of BS EN 12620:2002+A1:2008 for graded aggregate. The flakiness index shall not exceed 40. if in the opinion of the Engineer, the aggregate meets with the above requirements but is dirty or adulterated in any manner it shall be screened and/or washed with clean water, if he so instructs, at the Contractor's expense.

Aggregates shall be delivered to the site in their prescribed sizes or grading and shall be stock-piled separately on paved areas or boarded platforms in separate units to avoid intermixing, excessive segregation and contamination with other materials.

On no account shall aggregates be stock-piled on the ground. Fine aggregate shall be allowed to drain until it has reached uniform moisture content before it is used.

6.4.1 General Requirements for Aggregates

Aggregates shall be obtained by processing natural material obtained from sources approved by the Engineer.

Aggregates shall be free from deleterious impurities including organic matter, earth, loam, clay; clayey, shaley or decomposed rock. They shall be hard, strong and durable and contain no harmful material that will adversely affect the strength and durability of the concrete or induce corrosion of any embedded steel.

Aggregates shall not be composed of or contain any inclusion of materials likely to cause staining or otherwise disfigure concrete surfaces.

The aggregates shall not contain any material that is deleteriously reactive with alkalis contained in the cement, the aggregate itself, mixing water, or water in contact with the finished work in amounts that are sufficient to cause excessive local or general expansion of the concrete.

6.4.2 Fine Aggregates

Fine aggregate shall be aggregate mainly passing the 5.0mm sieve.

Fine aggregates shall be natural sand, manufactured crushed rock sand, or a combination of both. The term "manufactured crushed rock sand" does not include crushed rock fines which are by-products of coarse aggregate production.

A combination of natural sand and manufactured crushed rock sand will only be permitted where the two materials are separately batched and where each material separately complies with the requirements of this specification. In addition the evidence of full scale comparative site trials shall clearly demonstrate that a combined fine aggregate provides improved concretes in relation to the use of either material as a sole fine aggregate.

The organic content of fine aggregate shall be determined in accordance with an approved standard test procedure. The Engineer will decide on the basis of trial mixes whether a failure to meet the limits of the approved standard are sufficient grounds to reject the batch.

6.4.3 Coarse Aggregate

Coarse aggregate shall be aggregate mainly retained on the 5.0mm sieve.

Coarse aggregates shall be either natural gravel, crushed gravel or crushed rock which shall be prepared as single sized aggregates and blended to produce the required nominal gradings.

Where an aggregate comprises a mixture of natural and crushed material the proportion of natural (uncrushed) particles shall not vary by more than 10% from

the proportion contained in the aggregates used in those full scale site trial mixes which are subsequently approved.

6.4.4 Grading of Aggregates

Except where otherwise approved on the basis of evidence of acceptable performance in concrete, the grading of aggregates shall comply with Tables 23.2, 23.3 and 23.4 as appropriate.

Coarse aggregate shall be produced, stockpiled and batched in single sizes, except that if approved, graded coarse aggregate may be used for concrete in small works or for small batches of concrete.

For concrete having a nominal maximum aggregate size of 40mm, not less than three single sized coarse aggregates from Table 23.3 shall be combined. Similarly for 20mm nominal maximum sized coarse aggregate, not less than two single sized gradings of Table 23.3 shall be combined.

Unless otherwise specified, all-in aggregate will not be permitted for structural concrete.

Table 23.2 - Gradings for Fine Aggregate (Percentage by mass passing sieves)

Sieve Size	Overall Limits	Additional Limits for Grading		
		C	M	F
10.00mm	100	-	-	-
5.00mm	89-100	-	-	-
2.36mm	60-100	60-100	65-100	80-100
1.18mm	30-100	30-90	45-100	70-100
600 micron	15-100	15-54	25-80	55-100
300 micron	5-70	5-40	5-48	5-70
150 micron	0-15*	-	-	-

Notes for Table 23.2 : Fine aggregate shall comply with the overall limits in the table. Additionally, not more than one in ten consecutive samples shall have a grading outside the limits for any one of the gradings C, M or F.

Table 23.3 - Gradings for Coarse Aggregate (Percentage by mass passing sieves)

Sieve Size (mm)	Graded Aggregate			Single-sized Aggregate				
	40mm to 5mm	20mm to 5mm	14mm to 5mm	40mm	20mm	14mm	10mm	5mm
50	100	-	-	100	-	-	-	-
37.5	90-100	100	-	85-100	100	-	-	-
20	35-70	90-100	100	0-25	85-100	100	-	-
14	-	-	90-100	-	-	85-100	100	-

10	Oct-40	30-60	50-85	0-5	0-25	0-50	85-100	100
5	0-5	0-10	0-10	-	0-5	0-10	0-25	50-100
2.36	-	-	-	-	-	-	0-5	0-30

Table 23.4 - Gradings for All-in Aggregate (Percentage by mass passing sieves)

Sieve Size	Aggregate Size			
	40mm	20mm	10mm	5mm
50.0mm	100	-	-	-
37.5mm	95-100	100	-	-
20.0mm	45-80	95-100	-	-
14.0mm	-	-	100	-
10.0mm	-	-	95-100	-
5.00mm	25-50	35-55	30-65	70-100
2.36mm	-	-	20-50	25-70
1.18mm	-	-	15-40	15-45
600 micron	8-30	10-35	10-30	5-25
300 micron	-	-	5-15	3-30
150 micron	0-8*	0-8*	0-8*	0-15
* May be increased to 10% for crushed rock fines				

Article 6.5 Properties of Aggregates

The permissible limits on the physical, mechanical and chemical properties of fine and coarse aggregates are shown in the Table 23.5.

Table 23.5 - Properties of Aggregates

Property		Aggregate		
		Fine	Coarse	Unit
Elongation Index		-	25(a)	% w/w max
Flakiness Index		-	25(a)	% w/w max
Material finer than 75 micron (wet sieving):	Crushed rock	3	1(b)	% w/w max
	Natural or crushed gravel	7(c)	3(b)	
Clay Lumps and Friable Particles		3	2	% w/w max
Shell content as hollow shells retained on 5.0mm sieve likely to form voids or remain partially unfilled (by visual examination)		-	5	% w/w max
Water Absorption		2.5	2.5	% w/w max
Soundness (5 cycles magnesium sulphate)		15	15	% loss max
Ten per cent Fines Value	Heavy duty concrete floor finishes	150		kN min
	Concrete pavements	100		
	Other concrete	75		
Shrinkage		0.05		% max
Total acid soluble sulphate (as sulphur trioxide) measured in 10% hydrochloric acid solution)		0.4 (d)	0.4 (d)	% w/w max
Total acid soluble chloride (as chloride ion) measured in 10% nitric acid solution		0.6 (d)	0.03 (d)	% w/w max

Notes on Table 23.5 :

- This figure is for the predominant size fraction of each single-sized aggregate.
- This figure is for each of the single sized aggregate.
- Not Used
- These maximum limits must not be individually exceeded and must be reduced if any of the following overriding limitations for the total concrete mix are exceeded:
 - the total sulphate content, as sulphur trioxide, of any mix, including any present in the other constituent materials, shall not exceed 4.0% by weight of cement in the mix;
 - the total chloride ion content of any mix, including any chloride present in the other constituent materials, shall not exceed the values in Table 23.6 below:

Table 23.6- Limits of Chloride Content of Concrete

Type or use of concrete	Maximum total chloride content expressed as a percentage of chloride ion by mass of cement (inclusive of pfa or ggbfs when used)
Prestressed concrete	0.1
Heat-cured concrete containing embedded metal	
Any concrete made with cement in which the tricalcium aluminate content is 4% or less	0.15
Concrete containing embedded metal and made with cement in which the tricalcium aluminate content is greater than 4% and combinations with ggbfs or pfa	0.3
Unreinforced concrete made with cement in which the tricalcium aluminate content is greater than 4% and combinations with ggbfs or pfa	0.6

Notes on Table 23.6 :

pfa : Pulverised Fuel Ash

ggbfs : Ground Granulated Blast Furnace Slag

Article 6.6 Storage and Handling of Aggregates

All aggregates shall be processed, transported, stockpiled, handled and batched such that they are not contaminated or otherwise affected adversely in either physical or chemical respects.

Dense concrete or bituminous slabs shall be laid to cover all aggregate stockpile areas and shall extend to cover all surrounding areas where aggregates are likely to be discharged or handled. These areas shall be kept swept clean to ensure that the aggregates are not contaminated by the adjacent ground through trafficking or otherwise and shall be sufficiently strong to withstand all trafficking for the duration of use.

In those situations where aggregates might suffer excessive contamination by windblown materials, wind breaks and/or stockpile covers shall be provided.

Adequate stocks of tested and approved aggregates shall be maintained on site or at the source of supply to maintain continuity of work.

The general or localised build-up of fines in aggregate stockpiles shall not be allowed and any material which, in the opinion of the Engineer, is so affected will be rejected.

Any aggregates which have suffered segregation or contamination, or which otherwise do not comply with the requirements of this specification, shall be rejected and removed from site. Reprocessed aggregates may be submitted for approval.

Supplementary processing and/or effective washing of aggregate on site may be required if:

- (a) The aggregate producer's methods do not satisfy the Engineer that the end products will consistently comply with the requirements of this specification, or
- (b) The aggregate suffers unacceptable changes either during handling, transportation or storage.

Article 6.7 Steel Reinforcement

Steel reinforcement shall be plain mild steel bars or high yield deformed bars complying with MS 10:1999, or cold worked deformed bars complying with MS 10:1999. Steel reinforcement shall be cut from straight bars free from kinks and bends or other damage and cold bent by experienced competent workmen. At the time of incorporation in the works, the reinforcement shall be clean and free from loose mill scale and loose rust.

Bars of diameter 20 mm or greater shall be bent in a bending machine designed for the purpose and approved by the Engineer. Bending and cutting shall be in accordance with BS 4466:1989 unless otherwise specified or ordered by the Engineer.

The Contractor shall supply the Engineer with the certificates of the manufacturer issued in compliance with MS 10:1999 for all the required tests, including the rebend test, in respect of each consignment delivered to site.

Steel fabric reinforcement shall comply with MS 34:2002 & MS 35:2006. Fabric reinforcement shall be delivered to site in flat sheets unless otherwise required by the Contract. The steel manufacturer's routine batch test certificate for each consignment of bar and fabric reinforcement delivered to the site shall be provided. This certificate shall state: the cast analysis of the steel supplied, the carbon equivalent value, results of tensile, bend and rebend tests and deformed bars, the rolled-on mill mark.

Additionally, independent sampling and testing of reinforcement delivered to the site may be required.

Tying wire for steel reinforcement shall be 1.6mm diameter annealed mild steel wire.

All reinforcement storage shall be on wooden supports on a dense, impervious concrete or bituminous slab specially placed for the purpose. The slab or slabs shall be free from dust, sand, soil or other materials which may encroach on the area by reason of wind, vehicular or foot traffic or otherwise. These requirements shall apply equally to reinforcement bending and cleaning areas and to any

prefabricated reinforcement storage areas. The concrete or bituminous slabs shall be constructed and fully completed before any reinforcement is delivered to the site.

At the time of fixing, reinforcement shall be free from loose mill scale or rust scale, and shall not be contaminated by grease, dirt, oil, paint, soil, sulphates, chlorides or any other agency which may impair the bond or initiate or accentuate any reinforcement corrosion.

Before concreting, reinforcement shall be subject to a final inspection and if considered to be in any way unsatisfactory same shall be rectified in accordance with an approved method.

In those environments where the concentration of atmospheric salts is likely to lead to unacceptable contamination of reinforcement by corrosive wind-blown dust and dew fall, all of the following additional measures shall be carried out:

- a) Prior to use all rusting shall be removed from the reinforcement by blast cleaning. About one day after this cleaning, the reinforcement shall be inspected. If new rusting is occurring the cleaning process shall be repeated.
- b) After blast cleaning, prior to fixing and when not being handled all reinforcement shall be protected by close wrapping with impervious sheeting.
- c) Fixed reinforcement shall be covered by impervious sheeting whenever it is not being worked upon and, unless otherwise approved, concreted within three days of commencement of fixing.
- d) Reinforcement bars protruding from previously placed concrete, e.g. starter bars, shall be close wrapped with impervious sheeting.
- e) Strict supervision shall be exercised to prevent contamination of reinforcement resulting from operatives walking on it.
- f) Prior to concreting any rusting of reinforcement shall be cleaned off by wire brushing or blast cleaning. Steel reinforcement shall be stored sheltered and supported by wooden blocks so as to prevent sagging. Bars shall be stored in separate lots according to diameter and quality.

No claim on account of non-availability of bars up to 12 metre lengths will be allowed.

6.7.1 Fixing Reinforcement

Reinforcement shall be accurately bent to the shapes and dimensions shown on the drawing and in accordance with BS 4466:1989. Reinforcement must be cut and bent cold and no welded joints will be permitted unless so detailed.

Reinforcement shall be accurately placed in position as shown on the drawings and shall be secured against displacement by using No 18 S.W.G. annealed binding wire or suitable clips at intersections and laps and shall be supported by approved concrete plastic or metal supports, steel chairs, spacers or metal hangers to ensure the correct position and cover before concreting and shall be kept in the same position during concreting. However, metal supports, chairs,

etc shall have minimum 12 mm cover made of concrete blocks, or shall have approved plastic shoes.

6.7.2 Position and Correctness of reinforcement

No concreting shall be commenced until the Engineer has inspected the reinforcement in position and until he has approved the same. The Contractor **shall give two clear days notice** of his intention to concrete. The minimum period between two inspections shall be 24 hours.

Irrespective of whether any inspection and/or approval of the fixing of the reinforcement has been carried out as above, it shall be Contractor's sole responsibility to ensure that the reinforcement complies with the details on the drawings and is fixed exactly in positions shown therein and in the position to give the prescribed cover.

The Contractor will be held entirely responsible for any failing or defect in any portion of the reinforced concrete structure and including any consequent delay, claims, third party claims, etc... where it is shown that the reinforcement, has been incorrectly positioned or it is incorrect in size or quantity with respect to the detailed drawings.

Unless otherwise permitted by the Engineer, reinforcement shall not bent after being embedded in hardened concrete

Unless otherwise instructed concrete cover to reinforcement bars in any face shall be as per Table 23.7.

Table 23.7: Concrete cover to reinforcement.

	A For all members of structures more than 300 m away from the sea and at altitude less than 350 m, and internal members in other areas (mm)	B For external members exposed to weather for structures located in proximity of sea within 300 m from sea and for structures at altitude greater than 350 m (mm)
(a) Foundations against earth face	75	75
(b) Foundations against blinding	50	50
(c) Walls below ground or against water face	40	40
(d) Columns:		
>200 mm	35	35
200 mm or less	30	30
(e) Ground beams	30	35
(f) Beams and walls	30	35
(g) Slab on hardcore	30	35
(h) Suspended slabs	30	30

Article 6.8 Concrete Admixtures

Concrete admixtures complying with BS EN 480 shall be allowed with the prior approval of the Engineer. "Plasticiser" where used will be added to the mixing water in proportion recommended by the manufacturer and strictly in accordance with their written instructions, to achieve better workability. Where approved or specified admixtures shall be used as a means of:

- a) Increasing workability of the concrete without increasing water/cement ratio;
- b) Controlled and limited retardation of setting;
- c) Increasing concrete durability;
- d) Reducing bleeding and associated settlement and cracking.

Where not specified, approval will not be given unless a clear technical advantage resulting from their use which cannot be obtained by reasonable variation of the constituents of the concrete mix is demonstrated.

Only liquid admixtures will be permitted. They shall comply with the approved standard, shall be "chloride free" and shall not contain other substances which adversely affect the durability or performance of the concrete. Admixtures that excessively retard or accelerate the setting time of concrete will not be permitted. Admixtures used to produce flowing concrete and those classes of admixture added at the concrete placing point will only be permitted in exceptional circumstances where clear technical benefit in their use has been established.

Water reducing admixtures shall normally be limited to those based on ligno-sulphonates.

Air entraining agents shall be based on neutralised vinsol or other resin. The density of air entrained concrete shall not be more than 5% less than the density of non-air entrained concrete manufactured with the same aggregates at the same water content.

Admixtures shall be stored and used strictly in accordance with the manufacturer's instructions.

The following information must be submitted to the Engineer for approval purposes.

- i. Dosage rate.
- ii. The typical damage and detrimental effects, if any, of under-dosage and over-dosage.
- iii. The chemical name(s) of the main active ingredients in the admixture.
- iv. Confirmation that the admixture is "chloride free".
- v. The manufacturer's declared acid soluble alkali content expressed as equivalent sodium oxide by mass.
- vi. Whether or not the admixture leads to the entrainment of air when used at the manufacturer's recommended dosage.
- vii. The length of time and the conditions under which the admixtures should be stored.

In addition the suitability and effectiveness of any admixture shall be verified by trial mixes with the cements, aggregates and other materials to be used in the works.

If two or more admixtures are to be used simultaneously in the same concrete mix, data shall be provided to assess their interaction and to ensure their compatibility.

No additional cost will be paid for the use of the plasticizer.

Article 6.9 Curing Membrane

Liquid curing membranes for use on concrete shall be applied strictly in accordance with the manufacturer's instructions and shall comply with the following:

Only products which have been proved to be effective through extensive use shall be proposed and manufacturers' literature shall include recent test certificates illustrating effective quality control and high curing efficiencies. The curing efficiency of the membrane shall be not less than 90% when tested in accordance with the approved standard.

All materials shall be supplied in the containers marked by the manufacturer with his name, date of manufacture, shelf life, pot life and instructions for handling and application.

The liquid shall contain a white or silver colour pigment in sufficient quantity to give a uniform colour when applied to the concrete surface.

The liquid shall be of such chemical composition and consistency that it can be applied by an approved mechanical sprayer in fine spray to produce an even, uniform, impervious, continuous touch dry film within one hour of application which will not crack, peel or disintegrate within three weeks of application.

The membrane shall not be poisonous, odorous or explosive and shall not react chemically with cement.

Curing membrane shall not be applied to surfaces to which further concrete is to be bonded or at stop ends where joints are to be formed.

Curing membranes shall not be used where they will cause unacceptable surface discolouration or are incompatible with subsequent surface treatment.

Where potable water will be in contact with the concrete surface, curing membranes shall not be used unless certified by a recognised authority for such use and approved.

CONCRETE TYPES, MIX DESIGN AND QUALITY CONTROL

Article 6.10 Definition

Certain terms used in this section of the specification are defined below:

<i>Aggregate/Cement Ratio :</i>	The ratio of the mass of total aggregate to the mass of cement in a concrete mix.
<i>Batch :</i>	The quantity of concrete mixed in one cycle of operations of a batch mixer, or the quantity of concrete conveyed ready-mixed in a vehicle or the quantity discharged during 1 minute from a continuous mixer.
<i>Cement Content :</i>	The mass in kilograms of cement contained in a cubic metric of fresh, fully-compacted concrete.
<i>Cementitious materials :</i>	OPC Ordinary Portland cement MSRPC Moderately sulphate resisting Portland cement SRP Sulphate resisting Portland cement GGBFS Ground granulated blast furnace slag PFA Pulverised fuel ash
<i>Characteristic strength :</i>	That value of strength below which 5% of the population of all possible strength measurements of the specified concrete are expected to fall.
<i>Designed Mix :</i>	A concrete mix in which the required performance is specified and the Contractor is responsible for selecting mix proportions, within the constraints of the Contract, to produce the required performance.
<i>Free Water Content :</i>	Water in the mix which is free to combine with the cement in the mix including free water in the aggregates, but not water absorbed by the aggregates.
<i>Grade (of concrete) :</i>	The means of describing a particular quality of concrete. In the case of designed mixes the grade of concrete is in terms of a number which is its 28 day characteristic cube strength in N/mm^2 at $20^\circ\text{C} \pm 1^\circ\text{C}$. In the case of prescribed mixes the grade is in terms of a number which will normally (but not contractually) be its 28 day characteristic strength in N/mm^2 .
<i>Margin :</i>	The amount by which the mean strength exceeds the characteristic strength.
<i>Maximum Free-Water / to be Cement Ratio :</i>	The highest mean free-water/cement ratio permitted used in the concrete mix.
<i>Minimum Cement used in Content :</i>	The lowest mean cement content permitted to be the concrete mix.
<i>Prescribed Mix :</i>	A concrete mix in which the mix proportions are specified.
<i>Ready-Mixed Concrete :</i>	Concrete mixed in a stationary mixer or in a truck mixer and supplied in the fresh condition either at the site or into vehicles for transport to the site.

Article 6.11 General

Method statements shall be prepared for each grade and type of concrete in the contract and shall include:

- Definition of the method of design of the mix, by reference to a recognised documented design method. Designed aggregated proportions shall be based on measured and not assumed relative densities.
- Proposed mix proportions including any proposed admixtures and, for new batching installations, results of preliminary batch testing.
- Results of testing of trial mixes to demonstrate that the proposed mix complies with the strength and workability requirements of this specification.

Method statements shall be approved before any concrete is placed and any alteration in the source or quality or proportioning of any of the materials in the mix will necessitate a new method statement.

Article 6.12 Ready-Mixed Concrete

Ready-mixed concrete shall be used only with Engineer's approval in writing and shall comply with the requirements of this specification and BS 5328 and the following special requirements.

The concrete shall be brought to the Site from an off site central batching plant using truck mixers. Truck mixer units and their mixing and discharge performance shall conform to the requirements of BS 4251.

The discharge of the concrete shall be completed within one (1) hour after the admixture of the water to the mix (aggregate and cement) unless otherwise agreed by the Engineer. The time of such admixture shall be recorded on the Delivery Note together with at least the following additional information:

- Concrete designation
- Nominal maximum size of coarse aggregate, slump and cement content.
- Chemical admixtures.

Water shall be added under supervision either at the Site or at the central batching plant as agreed by the Engineer, but in no circumstances shall water be added in transit. The ready-mixed concrete plant shall be capable of consistently producing concrete to the requirements of the specification and have the ability to meet the daily concrete demand placed on it by the Contract.

The plant shall be operated under formal quality control and quality assurance procedures which shall be made available for inspection when requested. The Engineer shall have the right of entry to the plant during all normal working hours.

Ready-mixed concrete shall unless otherwise approved, be transported in truck type concrete mixers complying with the approved standard.

No water shall be added to the mix after departure from the ready-mix plant unless authorised by the Engineer.

Approval will not be given for the supply of ready-mixed concrete from more than one plant at any one time.

Before discharging the concrete at the point of delivery, a delivery ticket shall be provided for each batch of concrete on which is printed, stamped or written the following minimum information :

- i. Name or number of ready-mixed concrete depot
- ii. Serial number of ticket
- iii. Date
- iv. Truck number
- v. Name of purchaser
- vi. Name and location of site
- vii. Grade or mix description of concrete including minimum cement content, if specified
- viii. Specified workability
- ix. Type of cement
- x. Nominal maximum size of aggregate
- xi. Type or name of admixture, if included
- xii. Quantity of concrete in cubic metres
- xiii. Time of loading
- xiv. Space shall be provided for any additional items which have been specified and for the following to be completed on site:
- xv. Arrival and departure times of the truck
- xvi. Time of completion of discharge
- xvii. Extra water added at the site and the signature of the authorising site personnel

Article 6.13 Alkali-Silica Reactivity

All concrete used in the permanent works shall be designed to minimise the risk of alkali-silica reaction by complying with one of the following requirements (where examination of the aggregates suggest the potential for other forms of alkali reactivity, then the aggregate shall not be used):

either

(i) The aggregate is approved as being non-reactive.

or

(ii) The Portland cement shall have a guaranteed equivalent acid soluble alkali content ($\text{Na}_2\text{O} + 0.658 \text{ K}_2\text{O}$) not exceeding 0.6%.

If requested, weekly certificates which name the source of cement and confirm compliance with alkali content requirement shall be provided.

If the contribution of alkalis to the concrete from sources other than the cement (see (iii) below) exceeds 0.2kg/m^3 , then this option shall not apply.

or

(iii) The total mass of alkali in the concrete shall not exceed 3.0kg/m^3 , less any alkali contributed to the concrete from sources other than the cementitious materials (Portland cement and any blast furnace slag (ggbfs) or pulverised fuel ash (pfa) with which Portland Cement is combined).

The **equivalent alkali content** of the concrete contributed by the Portland cement to the concrete shall be calculated from :

either

$$A = \frac{(C + 10) \times (a + 0.1)}{100}$$

where

A = equivalent alkali content contributed by Portland cement (kg/m^3)

C = target mean Portland cement content of the concrete excluding any ggbfs or pfa (kg/m^3)

a = monthly mean equivalent acid soluble alkali content of the Portland cement (%) determined as ($\text{Na}_2\text{O} + 0.658 \text{ K}_2\text{O}$)

OR

$$B = \frac{(C + 10) \times (b - 0.15)}{100}$$

where

B = equivalent alkali content contributed by Portland cement (kg/m^3)

b = guaranteed maximum equivalent alkali content of the Portland cement as guaranteed by the manufacturers for the particular works for all consignments (%)

The **equivalent alkali content** of the concrete contributed by any **pfa or ggbfs** shall be calculated from :

$$D = \frac{E \times d}{100}$$

where

D = equivalent alkali content contributed by pfa or ggbfs (kg/m^3)

E = target mean pfa or ggbfs content of the concrete (kg/m^3)
d = water soluble alkali content of pfa or ggbfs (%)

Where alkalis are contributed to the concrete from sources other than the cementitious material the limit of 3.0kg/m^3 from the cementitious material shall

be reduced by this amount. Such sources include, mix water, admixtures and chloride contamination of aggregates.

The **equivalent alkali** contributed by **sodium chloride contamination** of aggregates shall be calculated from:

$$E = \frac{0.76}{100} \times (CF \times MF + CC \times MC)$$

where

E = equivalent alkali contribution made to the concrete by the sodium chloride (kg/m^3)

CF = chloride ion content of the fine aggregate as a percentage by mass of dry aggregates

CC = chloride ion content of the coarse aggregate as a percentage by mass of dry aggregate

MF = fine aggregate content (kg/m^3)

MC = coarse aggregate content (kg/m^3)

The chloride ion content of aggregates containing significant amounts of chloride shall be determined in accordance with the approved standard and shall be undertaken weekly.

Certificates shall be provided on request confirming compliance with the Specification and stating:

- (a) The target mean cementitious material content of the concrete.
- (b) The names of the works manufacturing the cement and pfa or ggbfs.
- (c) The proportion of pfa or ggbfs expressed as a percentage by mass of the total cementitious material.
- (d) A weekly report of the cement alkali determinations.
- (e) The monthly mean alkali content of the Portland cement.
- (f) A weekly report of the water soluble alkali determinations on pfa and ggbfs.

Article 6.14 Designed Concrete Mixes

6.14.1 Designed Concrete Mixes – Requirements

The Contractor shall design all the concrete mixes called for on the drawings, and bills of quantities making use of the ingredients which have been approved by the Engineer for use in the permanent works and in compliance with this Specification.

- (i) The aggregate portion shall be well graded from the nominal maximum size to small sizes downwards.
- (ii) The cement content shall be such as to achieve the strengths but in any case not less than the minimum necessary for impermeability and durability.
- (iii) The workability shall be consistent with ease of placing and proper compaction having regard to the presence of reinforcement and other obstructions.
- (iv) The water-cement ration shall be the minimum consistent with adequate workability but in any case not greater than that allowable for impermeability and durability taking due account of any water contained in the aggregates.
- (v) The drying shrinkage determined in accordance with BS 1881 shall not be greater than 0.05%

- (vi) The ratio of fine aggregates to total aggregates based on mass shall be within the following limits:

Coarse Aggregate Size	Minimum Ratio	Maximum Ratio
10mm	0.45	0.55
14mm	0.40	0.50
20mm	0.35	0.45
40mm	0.30	0.40

- (vii) The mix proportions shall be selected from Table 23.8.

Table 23.8: Guidance on mix design limits for durability of concrete made with normal weight (Aggregates of 20 mm nominal maximum size¹⁾)

Condition of exposure	Type of concrete	Maximum free w/c ratio	Minimum cement content	Minimum grade
<u>Mild</u>	<u>Unreinforced non-structural</u> <u>Unreinforced structural²⁾</u> <u>Reinforced</u> <u>Prestressed</u>	<u>–</u> <u>0.80</u> <u>0.65</u> <u>0.60</u>	<u>–</u> <u>220</u> <u>275</u> <u>300</u>	<u>–</u> <u>C16/20</u> <u>C25/30</u> <u>C30/37</u>
<u>Moderate</u>	<u>Unreinforced non-structural</u> <u>Unreinforced structural²⁾</u> <u>Reinforced and Prestressed</u>	<u>–</u> <u>0.65</u> <u>0.60</u>	<u>–</u> <u>275</u> <u>300</u>	<u>–</u> <u>C25/30</u> <u>C30/37</u>
<u>Severe</u>	<u>Unreinforced</u> <u>Reinforced and prestressed</u>	<u>0.60</u> <u>0.55</u>	<u>300</u> <u>325</u>	<u>C30/37</u> <u>C35/45</u>
<u>Very severe</u>	<u>All⁵⁾</u>	<u>0.55</u>	<u>325</u>	<u>C35/45</u>
<u>Most severe</u>	<u>Unreinforced⁵⁾</u> <u>Reinforced and prestressed⁵⁾</u>	<u>0.50</u> <u>0.45</u>	<u>350</u> <u>400</u>	<u>C35/45</u> <u>C40/50</u>
<u>Abrasive</u>	<u>All⁵⁾</u>	<u>0.50</u>	<u>350</u>	<u>C35/45</u>

1) Adjustments to minimum cement content should be made for aggregates of nominal maximum size other than 20 mm in accordance with BS EN 206-1:2000

2) For concrete in design chemical class DC-1 made with normal-weight aggregate and used in foundations and slabs to low rise structures, a minimum grade of C10 may be used provided the minimum cement content is not less than 175 kg/m³ for designated mixes and 210 kg/m³ for other types of concrete.

3) Where concrete is subject to freezing whilst wet, air entrainment should be used. In the case of air entrained concrete the grade may be reduced by 5.

Table 23.9: Mix proportions of concrete

Standard mix	Constituent	Nominal maximum size of aggregate			
		40mm		20mm	
		Slump 75mm	Slump 125mm	Slump 75mm	Slump 125mm
ST1	Cement (kg)	180	200	210	230
	Total aggregate (kg)	2010	1950	1940	1880
ST2	Cement (kg)	210	230	240	260
	Total aggregate (kg)	1980	1920	1920	1860
ST3	Cement (kg)	240	260	270	300
	Total aggregate (kg)	1950	1900	1890	1820
ST4	Cement (kg)	280	300	300	330
	Total aggregate (kg)	1920	1860	1830	1800
ST5	Cement (kg)	320	340	340	370
	Total aggregate (kg)	1860	1830	1830	1770
ST1 ST2 ST3	Fine aggregate (percentage by mass of total aggregate)	30 to 45	30 to 45	35 to 50	35 to 50
ST 4 ST5	Fine aggregate (percentage by mass of total aggregate)				
	Grading limits C	30 to 40		35 to 45	
	Grading limits M	25 to 35		30 to 40	
	Grading limits F	25 to 30		25 to 35	

NOTE 1 The mix proportions for standard mixes are based on the use of cements of standard classes 42.5 or higher. The mass of concrete shall be increased by 10% when cements of standard strength classes 32.5 and 37.5 are used.

NOTE 2 The cement content together with the total masses of saturated surface dry aggregates and added water will produce approximately one cubic metre of concrete. The values given are based on typical values of the relative densities of cement and aggregates. For some aggregates having higher or lower relative densities, adjustments may be required to the quantity of aggregates to produce this volume of concrete having the required workability and cement content.

NOTE 3 The values given for aggregate content shall be adjusted to allow also for the characteristics of the aggregate as described 4.3.2 of BS 5328-3:1990.

NOTE 4 The aggregates for mixes ST1, ST2 and ST3 may be batched by volume.

NOTE 5 When standard mixes are specified with workabilities less than 75mm slump, the mix proportions are to be taken from the appropriate 75 mm slump column.

Grades of Concrete

- (i) Where concrete is classified with respect to its compressive strength, Table 3.2 for normal-weight and heavy-weight concrete applies. The characteristic compressive strength at 28 days of 150 mm diameter by 300 mm cylinders ($f_{ck,cyl}$) or the characteristic compressive strength at 28 days of 150 mm cubes ($f_{ck,cube}$) may be used for classification.

Table 23.10: Concrete Grades and Strengths

GRADE OF CONCRETE	MINIMUM CHARACTERISTIC CYLINDER STRENGTH (N/mm ²)	MINIMUM CHARACTERISTIC CUBE STRENGTH (N/mm ²)
C8/10	8	10
C12/15	12	15
C16/20	16	20
C20/25	20	25
C25/30	25	30
C30/37	30	37
C35/45	35	45
C40/50	40	50
C45/55	45	55
C50/60	50	60
C55/67	55	67
C60/75	60	75
C70/85	70	85
C80/95	80	95
C90/105	90	105
C100/115	100	115

Note: The strength requirements given above shall apply irrespective of the maximum size of aggregates used.

Conformity of concrete compressive strength is assessed on specimens tested at 28 days¹⁾ in accordance with BS EN 206 – 1: 2000 for:

— groups of n non-overlapping or overlapping consecutive test results f_{cm} (Criterion 1);

— each individual test result f_{ci} (Criterion 2).

NOTE The conformity criteria are developed on the basis of non-overlapping test results. Application of the criteria to overlapping test results increases the risk of rejection.

Table 23.11 — Conformity criteria for compressive strength

Production	Number n of test results for compressive strength in the group	Criterion 1	Criterion 2
		Mean of n results (f_{cm}) N/mm ²	Any individual test result (f_{ci}) N/mm ²
Initial	3	$\geq f_{ck} + 4$	$\geq f_{ck} - 4$
Continuous	Not less than 15	$\geq f_{ck} + 1.48\alpha$	$\geq f_{ck} - 4$

Table 23.12 — Conformity criteria for family members

Number n of test results for compressive strength for a single concrete	Criterion 3
	Mean of n results (f_{cm}) for a single family member (N/mm ²)
2	$\geq f_{ck} - 1.0$
3	$\geq f_{ck} + 1.0$
4	$\geq f_{ck} + 2.0$
5	$\geq f_{ck} + 2.5$
6	$\geq f_{ck} + 3.0$

Notes:

- (a) The minimum cement contents given above are per cubic metre of compacted concrete made with 20 mm nominal size of aggregates.
For maximum aggregate size of 12 mm, the minimum cement content should be increased by 40 kg/m³. For maximum aggregate size of 40 mm, the minimum cement content may be reduced by 30 kg/m³.
- (b) Under the heading ‘Maximum water/cement ratio’, column A applies to sheltered and average conditions and column B applies to severe conditions and water retaining structures. Use of ‘An Approved Concrete Admixture’ to BS EN 480 to achieve the strength with the maximum water/cement ratio as tabulated above is allowed.
- (c) Use of more than 40 kg over and above the minimum cement content specified and tabulated above is not allowed.

Article 6.15 Requirements for Designed Mixes

(1) Evidence of Suitability of Proposed Mix Proportions

Evidence should be submitted to the Engineer for each grade of concrete showing that at the intended workability, the proposed mix proportions and manufacturing method will produce concrete of the required quality.

The following information should be provided before any designed mix is supplied. Subsequently the Contractor should declare any change in sources of materials and any change in cement content which results in a difference greater than 20 kg/m³ from the cement content last declared:

- (a) Nature and source of each material
- (b) The proposed proportions or quantity of each constituent per cubic metre of fully compacted concrete.
- (c) Either
 - (i) Data from previous production of concrete using the materials and plant which will be used to produce the concrete, confirming that the proposed mix proportions satisfy the criteria given in 3.10 (2), or.
 - (ii) Where no satisfactory data exist under item (a) data from mixes confirming that the proposed mix proportions satisfy the requirements of 3.10 (3).

Sampling and testing shall be carried out by the methods described in the relevant Parts of BS 1881.

(2) Proposals based on previous production data

When based on previous production data, the mean 28 days compressive strength calculated from n cube results, from separate batches of concrete shall exceed the specified characteristic strength by

$$k_s [0.86 + (2/n)]$$

where

k_s is a statistical constant, not less than 1.64,
3.0 N/mm²

n is the number of consecutive test results, not less than 10 and not greater than 100. A test result may be a single result or the mean of two or four results from cubes of the same sample provided the difference between the strengths of two cubes divided by their mean is less than 30%.

When n exceeds 100, the mean strength shall exceed the specified characteristic strength by k_s , in which k shall not be less than 1.64 and s shall not be less than 3.0 N/mm².

Previous production data for use in calculating these criteria shall be 28 days compressive strength results from separate batches of concrete sampled at random over an immediately prior period exceeding one month and not exceeding one year, using the materials and plant which are proposed for the work.

(3) Proposal based on Trial Mixes

Where trial mixes are required three separate batches of concrete should be made using materials likely to be typical of the proposed supply and preferably under full scale production conditions. If circumstances make this inconvenient, with a written permission of the Engineer the batches may be mixed in a laboratory. The workability of each of the trial batches shall be the same as the proposed supply. Three cubes shall be made from each batch for test at 28 days. The average compressive strength of the three cubes tested at 28 days shall exceed the specified characteristic strength by at least 10 N/mm².

(4) Additional Trial Mixes

During production before any change is made to an approved design mix, Contractor shall seek an approval for the Engineer giving reasons for the change and substantiating the proposal. This approval may only be obtained if the proposal is submitted with test results of the proposed design mix.

Article 6.16 Requirements of Nominal Volumetric Mix

If the Contractor fails to achieve the requirements of the strength of concrete and/or prefers nominal volumetric mix, he may use the following with a written approval from the Engineer:

Description	Mix 30/37 1:1.8:2.8	Mix 25/30 1:2.4:3.8	Mix 20/25 1:2.7:4.2	Mix 12/15 1:4:6
Cement	1 bag of 50 kg	1 bag of 50 kg	1 bag of 50 kg	1 bag of 50 kg
Crushed rock sand	1¼ cu ft	1¾ cu ft	1 ^{7/8} cu ft	1 ^{7/8} cu ft
Coral sand	1 cu ft	1¼ cu ft	1½ cu ft	1½ cu ft
10 mm to 5 mm graded aggregate	1 cu ft	1¼ cu ft	1¼ cu ft	1¼ cu ft
20 mm to 10 mm graded aggregate	2½ cu ft	3½ cu ft	4 cu ft	4 cu ft
Maximum water/cement ratio	0.55	0.6	0.65	0.65
Maximum slump	50 mm	50 mm	50 mm	50 mm

Article 6.17 Concrete Quality Control**6.17.1 General Requirements**

A method statement shall be submitted for the proposed methods of controlling and recording the quality of concrete and shall include the following:

- i. Cube strengths
- ii. Workability (slump)
- iii. Density of fresh concrete
- iv. Density of hardened concrete
- v. Cement content
- vi. Water content
- vii. Aggregates proportions
- viii. Air content (when required)
- ix. Temperature of mix during placing
- x. Climatic conditions during placing

All sampling and testing shall be carried out in accordance with the approved standards.

This information shall be recorded on a standard form, which must be submitted for approval.

The Engineer will record the ease of placement, and the subsequent condition of the concrete after stripping of formwork. If the quality is unsatisfactory the concrete shall be repaired or replaced and the mix design or method of placing altered to prevent any recurrence of the problem.

On site cube crushing equipment shall be calibrated immediately after delivery and calibration verified at 4 monthly intervals or as required.

Article 6.18 Characteristic Strength

Compliance with characteristic strength requirements shall be based on the 28 day compressive strength of cubes sampled, cured and crushed in accordance with the approved standard.

Where the range of individual cube strengths made from the same sample exceeds 15% of their mean strength, the method of making, curing and testing cubes shall be reviewed. If the range of individual cube strengths exceeds 20% of their mean, then the results shall be considered unacceptable.

Additional tests to determine sampling and testing errors may be ordered at any time.

For the assessment of strength of designed mixes the sampling regime and compliance requirements shall be in accordance with either Testing Plan A or B below. Testing Plan A shall be the method used except where the Engineer directs the use of Testing Plan B.

Testing Plan A:

- (i) A single sample shall be obtained from one randomly selected batch of concrete representing an average volume of not more than 20m³ except that at least one sample shall be taken on each day for each grade of concrete used.
- (ii) Two test cubes shall be prepared from each sample for testing at 28 days.
- (iii) The mean strength of each pair of test cubes shall be called a "test result".

Compliance with the specified characteristic strength shall be judged in accordance with the table below:

Table 23.13 - Concrete Strength Compliance Requirements

Test Result	The average test result shall exceed the specified characteristic strength by at least:	Any individual test result shall not be less than the specified characteristic strength minus:
First 2	1N/mm ²	3N/mm ²
First 3	2N/mm ²	3N/mm ²
Any consecutive 4	3N/mm ²	3N/mm ²

If agreed with or required by the Engineer additional pairs of cubes shall be prepared for testing at an early age or subjected to a nonstandard regime of curing. If requested by the Contractor and approved by the Engineer, accelerated curing techniques may be used to give an early indication of 28 day strength. Accelerated curing shall be carried out in accordance with the approved standard and a statistically significant correlation shall be established between the 28 day

strengths determined by normal curing and accelerated curing before the method is adopted on site.

Testing Plan B :

Testing Plan B shall be used when directed and is for testing single batches of concrete and for those occasions where the Engineer requires assurance that concrete placed in a particular part of the Works is of adequate quality.

- (i) One test cube shall be made from each of two independent samples obtained from each batch of concrete selected for testing in accordance with this plan.
- (ii) Compliance with the specified characteristic strength shall occur provided the average 28 day strength of the two test cubes exceeds the specified characteristic strength by not less than 2N/mm² or one tenth of the specified strength, whichever is the smaller.
- (iii) If agreed with or required by the Engineer, cubes shall be prepared for testing at an early age or subjected to a non-standard regime of curing.

Article 6.19 Workability

Unless otherwise approved, workability shall be measured by means of the slump test.

Slump of concrete shall be calculated from the mean of two tests carried out at the time and point of placing and shall be within $\pm 25\text{mm}$ or one third of the target value, whichever is the greater and shall be determined for each batch of concrete.

Article 6.20 Density

The density of fully compacted fresh concrete shall not be less than 98% of the target value and shall be reported for all prepared cubes.

The density of hardened concrete shall be recorded for all cubes and shall be reported as the mean saturated surface dry density of each pair of cubes prepared for strength testing.

Article 6.21 Temperature

The temperature of fresh concrete at the time of placing shall be not less than the specified minimum temperature less 2°C or more than the specified maximum temperature plus 2°C.

Article 6.22 Climatic Conditions

Maximum, minimum and wet bulb temperatures shall be recorded at the point of concrete placing whenever concrete is being placed.

In addition wind speed shall be measured if required by the Engineer.

Article 6.23 Cement Content

Where compliance is assessed by observation of the batching or from autographic records, the cement content should not be less than 95% of the specified minimum or more than 105% of the specified maximum or it shall be within $\pm 5\%$ of the target value as appropriate.

Where compliance is assessed from the results of analysis tests on fresh concrete, the cement content should not be less than 90% of the specified minimum or more than 110% of the specified maximum or it shall be within $\pm 10\%$ of the target value.

Article 6.24 Free-Water/Cement Ratio

Where compliance is assessed by observation of the batching or from autographic records (corrected for moisture content of the aggregates), the free water/ cement ratio shall not exceed 105% of the specified maximum value or target value as appropriate.

Where compliance is assessed from the results of analysis tests on the fresh concrete, the free-water/cement ratio should be not more than 110% of the specified value or target value as appropriate.

Article 6.25 Aggregate Grading

The combined grading of the aggregates shall not vary by more than $\pm 4\%$ from the target grading.

Article 6.26 Air Content

The percentage air content determined from individual samples taken at the point of placing the concrete and representative of any given batch of concrete should be within ± 1.5 of the required value. The average percentage air content from any four consecutive determinations from separate batches should be within ± 1.0 of the required value.

Air content shall be determined for each batch of air entrained concrete.

Article 6.27 Non-Compliance

In the event of non-compliance with the specified requirements or if test results suggest an inconsistency in batching or quality of materials, the Engineer may:

Accept defective concrete after considering the amount of concrete at risk, the validity of test results, and implications of incorporating defective concrete in the works.

Instruct the Contractor to remove defective concrete as represented by the test results.

Instruct the Contractor to carry out field and/or laboratory tests on the hardened concrete.

Withdraw his approval of the concrete mix design(s) or concrete batching/mixing facilities.

Article 6.28 Ready Mixed Concrete

Ready mixed concrete may be used subject to the approval of the Engineer.

When it is used the Contractor shall ensure that all the requirements of these specifications are complied with.

Further to above requirements, the Contractor shall ensure that transport and delivery of ready mixed concrete comply with the recommendations of Clause 4.10.4 of BS 5328: Part 3:1990.

The concrete shall be transported to the site in truck mixers and shall be continuously agitated until it is delivered on site. The Contractor shall ensure that no water is added after it is delivered.

For plant mixed concrete the Contractor shall check that the delivery note for each truck shows the time when water is first added to the concrete materials, and the maximum allowable time interval between the completion of discharge and the mixing of water. This time interval should be 30 minutes less than the initial setting time of the cement. Any concrete which is not placed in its final position within this time interval should not be used.

Sample of works cube shall be taken by the Main Contractor at the place where concrete is finally placed in the structural members.

Article 6.29 Waterproof Concrete

Where 'waterproof concrete' is specified, 'sealocrete', 'sika', or other approved waterproofing material and plasticizing agent complying to concrete admixtures to British Standard shall be added to the mixing water in the proportion recommended by the manufacturers and strictly in accordance with their written instructions. Waterproof concrete shall be grade 30/37 and shall meet all the strength requirements of the specified class, except that the fine aggregate shall consist solely of rock sand.

Article 6.30 Quality Control of Concrete Production

6.30.1 Sampling

For each class of concrete in production at each plant for use in the permanent works, samples of concrete shall be taken at the point of mixing and/or of deposition as instructed by the Engineer, and in the presence of a representative of the Engineer, all in accordance with the sampling procedures described in BS 1881 and with further requirements set out below.

Six 150 mm cubes shall be made from each sample and shall be cured and tested all in accordance with BS 1881, two at seven days and two others at 28 days.

Each sample shall be taken from one batch selected at random and at intervals such that the rate of sampling is not less than the minimum rates of sampling given in Table 14.14. At least one sample should be taken of each grade of concrete on each day that concrete is placed. The actual rate of sampling shall be increased for critical elements if instructed by the Engineer.

Table 23.14: Minimum Rate of Sampling

Minimum Rate of Sampling	
Average Rate of Sampling on Sample Per	Example where Applicable
10 m ³ or 10 batches	Columns, cantilever
20 m ³ or 20 batches	Beams, slabs
50 m ³ or 50 batches	Solid rafts, breakwaters, floors

6.30.2 Testing

- (a) The consistency of all concrete shall be determined by means of the slump test in accordance with British Standards Specification No 1881-102:1983 'Methods for determination of slump'. The Contractor shall provide the necessary number of slump.

Slump tests shall be made at frequent intervals when concreting is in progress and as ordered by the Engineer. It shall, nonetheless be determined for each batch from which samples are taken for other tests. The first consistency tests shall be made immediately concreting is commenced on any section. For the purposes of any test two slump tests shall be taken at a time and the average adopted for compliance to this specifications.

The slump required shall be determined by the Engineer and shall be varied to suit the purpose for which the concrete is required. The slump of the concrete in any batch shall however, not differ from the value established by trial mixed by more than 25 mm or one third of the value, whichever is the greater. No concrete shall be used with a slump exceeding 75 mm without the approval of the Engineer.

The cost of providing slump apparatus and labour and materials required for taking slump tests shall be included in the rates for concrete in the Bill of Quantities.

- (b) The water cement ratio as estimated from the results of (a) above, or when required by the Engineer, determined by samples from any batch shall not vary by more than 5% from the specified maximum value or the value established during the trial mixes, whichever is the lower.
- (c) The compressive strength of the concrete at 28 days shall be such that any individual test result as well as the means of the first 2, first 3 or any consecutive 4 test results comply with the strength requirements given under the appropriate headings in Table 3.2. in this context, a result is defined as the average strength of the two cubes taken from one batch and tested at 28 days.
- (d) When the difference between the strengths of the two cubes divided by their mean exceeds 30%, the test result shall be deemed invalid.

Article 6.31 Failure to comply with requirements

- (1) Quantity of concrete represented by strength test results
The quantity of concrete represented by a group of four consecutive test results shall include the batches from which the first and last samples were taken together with all intervening batches. Similarly, the first two or three results shall be taken as representing all the intervening batches. For the individual test result requirements given in Table 3.2 only the particular batch from which the sample was taken shall be at risk.
- (2) The Contractor shall take any action instructed by the Engineer to remedy concrete which does not comply with the specification. The results of such actions do not nullify the previous establishment of non-compliance with the specification based on requirements for cube test results. The Contractor shall be responsible for all costs and delays for such actions. Such action may include but is not necessarily confined to the following:
 - i. Increasing the frequency of sampling until control is again established.
 - ii. Cutting test cores from the concrete and testing in accordance with Bs 1881
 - iii. Carrying out strengthening or other remedial work to the concrete where possible or appropriate
 - iv. Carrying out non-destructive testing such as load tests on beams
 - v. Removing the failed concrete

Article 6.32 Mixing Concrete

The mixer shall comply with the requirements of BS 1305 or BS 4251 where applicable. The mixing time shall be not less than that recommended by the manufacturer, subject to the Engineer's approval of the trial mixes.

Mixers that have been out of use for more than 30 minutes shall be thoroughly cleaned before any fresh concrete is mixed. Unless otherwise agreed by the Engineer, the first batch of concrete through the mixer shall then contain only two-thirds of the normal quantity of coarse aggregate. Mixing plant shall be thoroughly cleaned before changing from one type of cement to another.

The mixing shall continue until there is a uniform distribution of the materials and the mass is uniform in colour and consistency, but in no case shall the mixing time be less than 1 minute for batches of up to 0.5 m³ and 1.5 minutes for larger batches after all the ingredients, including the full amount of water, are in the mixer.

The Engineer may permit, subject to preliminary tests, to reduce the above mixing times for high-spread pan type mixers by half of a minute.

The Engineer shall have the right to increase the above minimum mixing time when the charging and mixing operations fail to produce a concrete batch throughout which the ingredients are uniformly distributed and the consistency is uniform. The concrete shall also be uniform from batch to batch, except where changes in composition and consistency are required.

Water shall be added prior to, during and following the mixer-charging operations. Excessive over-mixing requiring the addition of water to preserve the required concrete consistency will not be permitted.

No dry materials shall be introduced into the mixer until all material from the previous batch has been removed.

Incrustations of concrete or mortar shall not be allowed to accumulate on the interior surface of the mixing drum. Re-mixing of concrete, or addition of water in an attempt to improve the consistency of a mixture which has already begun to set or which is otherwise unsuitable for casting, shall not be permitted and such concrete shall be spoiled.

Where small quantities (not exceeding 3 m³) are involved, the Engineer may in exceptional cases permit hand mixing of lean and other non-reinforced concrete. No hand mixing shall be done unless authorised in writing by the Engineer. The batches in hand mixing shall not exceed 0.5 m³. Hand mixed concrete shall not be used until the mixing of the whole batch has been completed and the concrete is of uniform colour and consistency. Hand mixing shall be done twice on dry aggregate, and at least twice wet, on a clean and even surface, which will prevent the loss of water during mixing. The water added shall be measured in order to prevent the use of an excessive quantity of water.

When mixing by hand, the minimum quantity of cement shall be increased by 10 %, above that specified in Table 3 of BS 5400 Part 8.

Article 6.33 Conveying

- (1) The concrete shall be mixed as near to the place where it is required as is practicable to avoid re-handling and only as much as is required for a specified section of the work shall be mixed at one time, such section being commenced and finished in one operation without delay. All concrete must be efficiently handled and used in the works within twenty (20) minutes of mixing. It shall be discharged from the mixer direct either into receptacles or barrows and shall be distributed by approved means which do not cause segregation or loss of ingredients or otherwise impair the quality of the concrete. Approved mechanical means of handling will be encouraged, but the use of chutes for placing concrete is permitted provided they are not longer than 6 m and their slope do not exceed one vertical to two horizontal and is not less than one vertical to three horizontal. Conveying of concreting by hand-buckets or similar shall not be allowed. Similarly conveying of concrete by belt conveyor shall not be allowed.
- (3) Pumped Concrete – Coarse aggregate size shall be limited to 20 mm for pumped concrete mixes. The slump of concrete discharged into the pump may exceed the specified slump by the amount of slump loss in the pumping system up to a maximum of 25 mm. the slump loss shall be the difference between slump tests made at both ends of the pumping system. If tests indicate a loss greater than 25 mm, the Contractor shall modify the pumping system as required to reduce the slump loss to 25 mm or less.
- (3) A superplasticiser should preferably be used in pumped concrete. The slump of the concrete mix shall not exceed 75 mm before addition of superplasticiser.

Article 6.34 Depositing

Placing of concrete in supported elements, e.g. slab, beam shall not be started until the concrete previously placed in top parts of columns is not longer plastic and has been in place at least for two hours.

Concrete shall be placed from height not exceeding 1.5 m directly into its permanent position and shall not be worked along the shutters to that position unless otherwise approved, concrete shall be placed in a single operation to the full thickness of slabs with beams and similar members. The Engineer shall allow concrete to be placed for walls exceeding 150 mm thickness from a height up to 3 m and in layers not exceeding 750 mm if FORM-SCAFF or other approved system of formwork is used.

In addition, Contractor will ensure that the concrete shall be deposited continuously such that no concrete shall be deposited on concrete which has hardened sufficiently to cause the formation of seams or places of weakness within the section. Placing shall be carried out at such a rate that the concrete which is being integrated with fresh concrete is still plastic.

Concrete in columns may be placed to a height of 3 m with careful placing and vibration to achieve satisfactory results. Where the height of the column exceeds 3 m suitable openings must be left in the shutters so that this maximum lift is not exceeded.

Concrete shall be placed continuously until completion of the part of the work between construction joints as specified hereinafter or of a part of approved extent. At the completion of a specified or approved part construction joint of the form and in the positions hereinafter specified shall be made. A record of all such joints must be made by the Contractor and a copy supplied to the Engineer.

Article 6.35 Placing Concrete under water

When required concrete shall be deposited under water by an approved method in such a way that the fresh concrete enters the mass of previously placed concrete from within causing water to be displaced with minimum disturbance at the surface of the concrete.

Article 6.36 Curing and Protection

Care must be taken that no concrete becomes prematurely dry and fresh concrete must be carefully protected within two hours of placing from rain, sun and wind by means of Hessian sacking, polythene sheeting or other approved means. This protective layer and the concrete itself must be kept continuously wet for at least three days after the concrete has been placed. The Contractor must allow for the complete covering of all fresh concrete for a period of three days.

Hessian or polythene sheeting shall be in the maximum widths obtainable and shall be secured against wind. The Contractor will not be permitted to use old cement bags, Hessian or other material in small pieces. When temperature exceeds 30°C the new concrete shall be covered with a layer of drip dry Hessian.

Curing compound to Engineer's approval may be used.

Traffic or loading shall not be allowed on the concrete except with the written permission of the Engineer.

Contractor should allow in his price the adequate supply and storage of water, if not available from the water main, for curing of the concrete as specified above.

If the Contractor intends to use curing compound or membrane, he should submit full details of the same with manufacturer's literature and test certificate from independent laboratory and seek the Engineer's approval before use. The curing compound should have an efficiency index of not less than 90% when tested in accordance with BS 7542:1992.

The curing compound shall be applied strictly in accordance with the manufacturer's recommendations. The method of monitoring the application rate and the area to which curing compound has been applied shall be submitted by the Contractor for Engineer's approval and the approved method shall be strictly

followed by the Contractor. The Engineer may, at his discretion, require the Contractor to adopt an effective alternative means of curing any area of the structure where membrane curing is unsatisfactory in the opinion of the Engineer.

Article 6.37 Waterbars

Not Applicable

Article 6.38 Concrete Sealing Coat

Not Applicable

Article 6.39 Formwork

Formwork is defined as the casing into which concrete is poured, and its supporting falsework.

It shall be designed and constructed so that the concrete can be efficiently placed and compacted without displacing or deforming the reinforcement. It shall be firmly supported, braced, guyed or tied back so that it is stable against vertical and horizontal forces. It shall be capable of adjustment and sufficiently strong not to distort significantly by the pressure of the concrete or by other loads and influences. Internal spacers and ties shall be of types that do not produce holes completely through the concrete and any permanently embedded parts shall not be nearer the finished surface than the cover to the reinforcement. Joints in the formwork shall be close fitting to prevent leakage. Temporary openings shall be provided, if necessary, for cleaning and inspection. The arrangement shall allow for removal of formwork from the sides of members without disturbing soffit formwork.

Rough-faced formwork may be used only for surfaces which are normally never exposed to view. Where such surfaces are to be tanked, by covering with paint or sheeting, the formwork shall be capable of achieving a finish suitable for the proposed tanking.

Exposed formwork shall be used for surfaces of concrete which will be exposed to view or to liquids. It shall be constructed from material of sufficiently high quality to produce a smooth concrete surface of uniform texture and appearance without visible imprint of grain or steppings or ridges. Where lined, the same type of lining shall be used throughout any one structure.

All formwork shall have joints close enough to prevent leakage of liquid from the concrete and formwork shall be jacked or wedged and clamped or bolted to permit adjustments before concreting and to permit easing and removal of formwork without jarring the concrete. Formwork shall be securely braced and strutted against lateral deflections and vertical movements. Where formwork is supported on previously constructed portions of the reinforced concrete structural frame, the Contractor shall by consultation with the Engineer ensure that the supporting concrete structure is capable of carrying the load and / or is sufficiently propped from lower floors or portions of the frame to permit the load to be temporarily carried during construction.

Formwork shall be cambered by the Contractor to the amount approved by the Engineer to compensate for anticipated deflections prior to hardening of the concrete.

Separate specification clauses cover the requirements for formwork for special surface finishes.

Formwork, or an approved alternative, shall be used for upper inclined surfaces of concrete where the slope is greater than 30° to the horizontal.

Formwork shall be designed so that splays, fillets, chamfers and projections are cast as the work proceeds. Unless specifically deleted all external angles on exposed concrete shall have a 25mm by 25mm chamfer.

Before placing the concrete, all extraneous matter shall be removed from the interior of formwork and the faces to be in contact with the concrete shall be wetted or treated with a non-staining composition to prevent adhesion. The composition shall be applied in such a manner as not to reduce the bond between reinforcement and concrete.

Facilities for examination of the formwork after its erection and before concrete is placed shall be provided and 24 hours' notice shall be given to enable the Engineer to examine the formwork if he so wishes. Approval of formwork must be obtained before any concrete is placed.

Tolerances and Finishes of Concrete Surfaces

Article 6.40 Tolerances

Concrete surfaces in the final work shall not vary from those shown in the Contract to an extent discernible by eye and, subject to the requirements of cover to reinforcement, shall not exceed the following, unless tolerances for particular surfaces are specifically shown on the drawings:

Tolerances for Unexposed Surfaces:

Deviations from line level or verticality as shown on the drawings shall not exceed 15mm.

Article 6.41 Formation of Holes for Fixing

The Contract includes the formation of holes and pockets for the later building in of holding down bolts, other fixing devices, services and structural steelwork. Boxes for the formation of such holes shall be adequately supported and preferably fixed rigidly to the main formwork.

All holes shall be formed in positions to be detailed for the various items of machinery.

Except where specifically allowed fixing holes should be cast as individual pockets and not as one hole for a group of fixings.

Where a group of holes has to be formed for a number of bolts for fixing one item, the formers shall be securely fixed together before the concrete is poured around them. The boxes shall be suitably protected to avoid extraneous matter falling onto them.

Article 6.42 Batching, Transporting and Placing Concrete

Aggregates and cement shall be batched by accurate and efficient weigh-batching devices. Cement shall be weighed by a separate device.

The devices shall be properly maintained and kept clean.

A simple means of varying the water supply to the mixer shall be provided. This shall incorporate a metering device to ensure that the amount of water fed to the mixer can be accurately controlled, ascertained and recorded.

Unless otherwise recommended by the manufacturer or approved, admixtures shall be dosed into the added mix water within the time allocated for that operation.

Dispensing equipment for admixtures shall be of an approved type. They shall be capable of controlling the measurement of varying quantities of admixture by amounts not exceeding $\pm 5\%$ of the required quantity. The equipment shall contain a fail safe device and a calibrated sight glass for visual checking of the measured quantity. Ability to draw-off liquid from the sight glass shall be provided. The equipment shall be regularly serviced and cleaned and to assist in this, the equipment shall be fitted with a flushing device. The range over which the equipment will operate within the required accuracy shall be clearly marked on the equipment.

The display of weight on the weighing devices shall be readily discernible and shall directly display weights down to at least 0.5% of the nominal capacity of the weighing hopper.

At any time during operation, the indicated weight shall not vary from the true weight by more than 1.5% of the actual scale reading, except that in the range up

to quarter scale capacity the variation shall not be greater than 1.5% of the quarter scale reading.

Sufficient test weights shall be kept on site for checking the accuracy of all weighing devices. Checks shall be carried out immediately prior to the first use of the plant at the Site and thereafter at two week intervals during production.

The results of these checks shall be recorded and submitted to the Engineer.

Prior to use at the site and thereafter at six month intervals, all weighing devices shall be inspected and tested over their full range by a specialist firm who shall prepare a report and calibration certificates, copies of which shall be submitted to the Engineer.

The following tolerances on batched materials as discharged into the mixer shall apply:

Table 23.15 – Batched Material Tolerances

Material	Tolerance
Cement	$\pm 2\%$ of the weight of cement in the batch
Aggregate	$\pm 2\%$ of the weight of each aggregate in the batch
Water	$\pm 2\%$ of the weight of water added to the batch
Admixture	$\pm 5\%$ of the amount added to the batch

All plant and equipment used for mixing concrete shall be maintained in good working order and shall be kept clean and free of hard or partially set concrete.

Concrete shall be mixed in batches in machines of an approved type complying with the approved standard and capable of discharging their contents whilst running.

All materials, including water, shall be thoroughly mixed before they are discharged. The mixing time shall not be less than that recommended by the manufacturer.

Mixers shall be used within 80 to 100% of the manufacturer's rated capacity which shall be clearly displayed on the mixer in terms of the volume of mixed concrete.

The quantity of water added to the mix shall not exceed the target value determined from the trial mixes adjusted to take account of the moisture content and absorption value of the aggregates as they reach the mixer.

No additional water shall be added after concrete has been discharged from the mixing plant.

The moisture content of the aggregate shall be monitored so that the necessary adjustments can be made to amount of water fed into the mixer.

For this purpose the moisture content of aggregates shall be determined at least twice daily during continuous concrete production using an approved method of rapid moisture content determination.

Each certificate must be countersigned by the Engineer or a member of his staff and one copy retained on site, prior to incorporation of the concrete into the Works. Such signature shall not constitute acceptance of the concrete.

The following additional information shall be recorded and shall be supplied to the Engineer within 24 hours:

- (i) Position in the structure where the concrete was placed.
- (ii) Time of placing.
- (iii) Whether test cubes were taken on delivery.
- (iv) Slump on delivery.
- (v) Mix and ambient temperatures.

Concrete shall be conveyed to the place of final deposit as rapidly as possible after mixing, by methods which will prevent the segregation, loss or contamination of any of the ingredients. No additional water shall be added after the concrete has been discharged from the mixing plant, and the concrete shall be placed and compacted not more than two hours after mixing.

Detailed method statements shall be supplied for the batching of concrete and for the methods of placement for each structure or type of structure including any proposals for the use of spouts, chutes or pumps as a means of transporting concrete.

The concreting of a section of the work shall be continuous until it is completed and shall be carried out as quickly as possible.

The concrete shall be deposited in regular courses and spread out in layers of not more than 500mm thickness and compacted with immersion vibrators used by properly trained and supervised operators. Concrete shall not be dropped into place from a height exceeding 2 metres. Vibrators shall penetrate the full depth of the layer of concrete and where the underlying layer is of fresh concrete shall enter and re-vibrate that layer to achieve effective knitting together. Vibrators shall not be allowed to remain in contact with the reinforcement or formwork. Over and under vibration shall be avoided and vibrators shall be withdrawn slowly to prevent void formation. Care shall be taken to compact the concrete fully around reinforcement but without causing displacement of the bars. Hand compaction will not be permitted.

Sufficient vibrators shall be provided at each pour location to ensure that the concrete is fully compacted without delay.

At least one reserve vibrator and power source shall be provided on site and not less than one reserve for every two in use at one time. Immediately before the mixing and pouring of concrete each day the necessary vibrators shall be started and tested. Undue difficulty in starting a vibrator shall be sufficient grounds for rejection.

External vibrators shall not be used without written approval.

Concrete floors and inverts shall be cast in one layer except where specified otherwise or when written approval has been obtained to an alternative construction method.

Care shall be taken to prevent men engaged in placing concrete from introducing foreign matter into the concrete from their footwear or in any other way and where concrete is placed directly against the surfaces of excavations any softened material shall first be removed.

Article 6.43 High Temperature Concreting

High temperature concreting is defined as any combination of high air temperature, low relative humidity and wind velocity which may tend to impair the quality of fresh or hardened concrete or otherwise result in abnormal properties.

Concrete shall not be placed when the shade temperature exceeds 40°C.

The temperature of batched concrete at the time of placing shall be kept as low as possible and shall not exceed 30°C.

The recommendations in standard publications on hot weather concreting practice shall be followed.

The temperature of the steel reinforcement shall be cool enough to ensure that the concrete does not dry on contact with it.

Measures shall be taken to provide cool concrete and cool concreting conditions in order to reduce workability loss, plastic cracking, premature drying of concrete and the development of high temperatures and temperature gradients in placed concrete.

Proposed measures must be described in method statements and may include:

- a) Painting white or silver all storage vessels, hoppers, pipes, walls or roofs which contain or convey aggregates, cement or mixing water.
- b) Shading and/or watering of aggregates.
- c) Removal of aggregates from stockpiles by techniques designed to avoid the direct use of surface aggregate.
- d) Use of cooled mixing water or crushed ice.
- e) Shading of formwork for several hours before concrete is poured.
- f) Shading of concrete during and after placement.

- g) Insulation of steel forms to prevent excessive temperature fluctuations at surface of concrete.
- h) Provision of wind breaks.
- i) Night working.

In contracts which include small structures spread over a large site, such as sewerage contracts, where transportation times could be large, dry mixing of concrete with addition of water immediately prior to placing may be proposed. Method statements for such a proposal must describe methods for accurate batching of water.

Notwithstanding the requirements of Clause 14.36, the following curing procedures shall be practiced for high temperature concreting unless otherwise approved or directed:

Exposed Surfaces:

Exposed surfaces of concrete shall be completely covered with polythene sheeting within 20 minutes of placing and compaction and within two or three hours of this shall quickly be replaced by wet hessian covered with polythene. Polythene sheeting may be temporarily removed for surface finishing where required.

The hessian shall be kept damp continuously using water of the quality specified for concreting for a period of at least seven days or such longer period as the Engineer may direct.

When air temperatures exceed 30°C in any part of the day or when lower temperatures in combination with high wind speeds are likely to lead to premature drying, the surface shall be sprayed with an approved curing compound after removal of hessian and polythene. Curing compounds may be applied earlier to supplement use of wet hessian and polythene.

In addition to the above measures, shading from direct sunlight and wind breaks may be required to give added protection.

Formed Surfaces:

Formed surfaces shall be completely covered by wet hessian and polythene within half an hour of stripping the formwork and shall then be treated as described for exposed surfaces above.

Formwork shall be shaded and/or wetted to prevent high temperatures accelerating cure.

For formed surfaces which are to be exposed, effective approved measures shall be taken to prevent concrete surfaces from drying out and to ensure adequate curing whilst rubbing down is taking place and before application of any approved curing membranes or other curing methods.

Article 6.44 Low Temperature Concreting

Concrete shall not be made from materials that have been exposed to freezing conditions unless they are first restored to a suitable temperature.

Concrete shall not be placed on frozen formations or against frozen formwork. At no time shall the temperature of placed concrete at any point in the pour be less than 5°C nor water curing applied until the concrete has reached a strength of 5N/mm².

Concreting at air temperatures below 2°C may only be permitted if:

- a) Aggregates and mixing water are free from snow, ice and frost;
- b) All surfaces with which the fresh concrete will come into contact including formwork, reinforcement, prestressing steel and hardened concrete are free from snow, ice and frost and at a temperature about that of the fresh concrete;
- c) No part of the fresh concrete at the time of placing and when placed in the form is less than 5°C.

Concrete shall be maintained at the required temperature and subject to approval, the following methods may be adopted:

- a) Heating the mixing water and aggregate. If the water is heated above 60°C, it shall be mixed with the aggregate before coming into contact with the cement;
- b) Increasing the cement content of the mix;
- c) Using a rapid hardening cement or chloride free accelerator;
- d) Covering top surfaces of members with insulating material;
- e) Shielding newly placed concrete from the wind;
- f) Using a heated enclosure, completely surrounding the freshly-placed concrete, care being taken to prevent excessive evaporation of water or surface carbonation by the products of combustion;
- g) Using heated formwork panels, precautions being taken to prevent excessive evaporation of water.

Any concrete that is damaged by frost due to non-compliance with this requirement shall be cut out and replaced.

Precaution shall be taken to prevent damage to concrete due to the freezing of accumulated water in boxed-out pockets and other cavities. If a cavity is self-draining the drain shall not be obstructed. If a cavity is not self-draining precautionary works shall be taken if a frost risk could arise.

Article 6.45 Curing and Protection of Concrete

Immediately after compaction and thereafter for the curing time, except where elevated temperature curing is used, concrete shall be protected against harmful effects of weather, including rain, rapid temperature changes and from drying out. The method of curing shall provide a suitable environment for the concrete to mature and prevent harmful loss of moisture.

The curing time shall be the number of days given in Table 23.16 unless the average surface temperature of the concrete during the required number of days falls below

10°C, in which case the period of curing shall be extended until the maturity of the concrete reaches the value given in the table.

The Contractor shall keep records of all curing liquids, compounds and membranes and their subsequent removal from the impregnated areas. Where the Contractor proposes to use a curing liquid, compound or membrane on surfaces on which a waterproofing system is to be laid, it shall be completely removable.

Where the Contractor proposes the use of a curing liquid, compound or membrane on surfaces, it shall be of a film type that fully degrades by exposure to ultra-violet light without leaving any residue that is detrimental to the surface impregnation of the concrete.

Table 23.16: Minimum Periods of Normal Curing for Different Types of Cement

Conditions under which concrete is maturing	Number of days (where the average surface temperature of the concrete exceeds 10°C during the whole period)			Equivalent maturity (degree hours) calculated as the age of the concrete in hours multiplied by the number of degrees Celsius by which the average surface temperature of the concrete exceeds 10°C		
	Other*	SRPC	PC	Other*	SRPC	PC
1. Hot weather or drying winds	7	4	3	3500	2000	1500
2. Conditions not covered by 1	4	3	2	2000	1500	1000

NOTE: Other* includes all permitted cements except PC and SRPC.
(05/02) PC = Portland cement (CEM I).
SRPC = Sulfate-resisting Portland cement.

Accelerated curing. Elevated-temperature curing as described below may be used only with Portland cement (CEM I) or sulfate-resisting Portland cement.

- (i) The formwork may be generally heated to no more than 20°C prior to the placing of concrete.
- (ii) Once placing is complete the concrete shall be left for 4 hours without additional heating. The concrete temperature can then be raised at a maximum rate of 10°C per ½hour.
- (iii) The concrete temperature shall at no time exceed 70°C.
- (iv) The rate of subsequent cooling shall not exceed the rate of heating.
- (v) Cubes shall be manufactured and cured under identical conditions to those to which the concrete is subjected.

The use of accelerated curing methods for concrete containing other types of cement or any admixture shall not be used.

Article 6.46 Damaged Concrete

Measures shall be taken to prevent damage to concrete either in mass or on the surface during the period of setting and thereafter by shock, vibration, water or any other agent and no loads shall be placed on any structure without the prior permission of the Engineer.

Any concrete which is damaged or deemed unsatisfactory due to inadequacies of constituents or any mixing, transporting, placing or curing methods shall be broken out and replaced.

Article 6.47 Striking Formwork

Formwork shall not be struck until the structure has attained sufficient strength to carry its own weight, plus any constructional or other loads likely to come upon it, without excessive deformation. Also the concrete shall have matured sufficiently to resist physical and frost damage.

Permission shall be obtained to strike any formwork. The work of striking or removing such moulds, shuttering or centering shall be conducted only under the personal supervision of a competent foreman.

The method statements for each structure shall include proposals for the methods and times for the striking of shutters. Method statements may include proposals for different periods by reference to recognised standard publications on concreting practice. Where it is proposed to remove soffit shuttering in advance of props the method statement shall clearly indicate the sequence and means of dismantling the soffit shuttering with a view to maintaining adequate support.

Where the concrete compressive strength is confirmed by tests on concrete cubes stored under conditions that simulate the field conditions, formwork supporting concrete in bending may be struck when the cube strength is 10 N/mm² or three times the stress to which it will be subjected, whichever is the greater.

For ordinary structural concrete made with Portland cement (CEM I) or sulfate-resisting Portland cement (SRPC) of strength class 42.5 or above, in the absence of control cubes the period before striking shall be in accordance with the minimum periods given in the table below.

Table 23.17 - Minimum Period before Striking Formwork

	Minimum Period Before Striking		
	Surface temperature of concrete:		
	16°C	7°C	t° C (any temperature between 0°C and 25°C)
Vertical formwork to columns, walls and large beams	12 hours	18 hours	hours: $300 / t+10$
Soffit formwork to slabs	4 days	6 days	days: $100 / t+10$
Props to slabs	10 days	15 days	days: $250 / t+10$
Soffit formwork to Beams	9 days	14 days	days: $230 / t+10$
Props to beams	14 days	21 days	days: $360 / t+10$

Article 6.48 Re-use of Formwork

Care should be taken, when re-using formwork, that its surface shall be smooth and clean and that it shall be free from warping, twisting or other deformations. Any formwork which has, in the opinion of the Engineer, deteriorated sufficiently to render it unsuitable for the work shall be rejected and must be removed from the site within 48 hours or must be broken up at once and new formwork provided.

Article 6.49 Cambers

Unless otherwise directed all formwork to suspended beams and slabs shall be constructed so that the following upward cambers exist immediately before striking:

- a) Spanning between supports 0.1% of span at centre
- b) Cantilevers 0.4% of span at free end.

Article 6.50 Mortices, Holes Chases in Concrete

Fixing blocks and ends of brackets and bars and bolts etc., shall be cast in the concrete at the time of placing and together with all mortices and holes and apertures and chases and grooves etc., shall be accurately set out in the formwork before the concrete is placed. No part of the concrete works shall be cut away for any such item or for any other reason without the Engineer's approval.

The Contractor shall obtain from all sub-contractors complete information of their requirements regarding conduits and pipes and fixing blocks or boxes and chases and holes and any other items to be cast in.

Where conduits are to be cast in slabs they shall be placed above the bottom reinforcement and below the top reinforcement and not within 40mm of the top and bottom surface of the slab.

The Contractor shall ensure that all Sub-Contractors are informed of his programme for the structural works at the commencement of the Contract. He shall also ensure that the Sub-Contractor's requirements relating to concrete members are approved by the Engineer before work is commenced.

At the commencement of the Contract the Contractor shall supply all the Sub-Contractors with written copies of this section of the Specification

Article 6.51 Final Preparations

The internal faces of the formwork may be coated with an approved preparation to prevent adhesion of the concrete to the forms provided that the use of this preparation will not stain the surface of the finished concrete. None of this preparation shall be allowed to touch the reinforcement.

Immediately before the concrete is placed in any section of the formwork the interior of that section shall be completely cleaned of all extraneous materials including water.

Each section of the formwork to structural members shall be inspected by the Engineer immediately before concrete is placed in that section.

Article 6.52 Falsework

6.52.1 Formwork Props

If formwork props are to be left in place when soffit forms are removed they shall not be disturbed during the removal process without approval.

6.52.2 Formwork Props

Formwork props shall be positioned between permanent supports so that all members are supported at no more than 3m centres in both directions.

6.52.3 Removal of Falsework

The responsibility for the safe removal of any part of the falsework shall rest with the Contractor.

Article 6.53 Heavy Duty Concrete (Granolithic) Screeds to Benchings and Channels

The mix for heavy duty concrete screeds shall be 1:3 (by weight) sulphate resisting Portland cement, fine and coarse aggregate (10mm nominal maximum aggregate size). The water content shall be kept to the minimum consistent with the required workability.

Heavy duty concrete screeds should preferably be placed and compacted within three hours of casting the base in which case the base concrete shall be left rough and the screed shall be spread and consolidated on to the whole of each bay or structure.

Where this cannot be achieved the base concrete shall be cast with a rough surface. Weak surface laitance and any other contaminating material must be completely removed and the coarse aggregate cleanly exposed. This surface shall be thoroughly cleaned and then soaked overnight, any surplus water being removed. The surface shall then be brushed with a 1:1 sand/cement grout and the heavy duty concrete screed applied.

The concrete shall be compacted and screeded to levels or falls with a screeding board and wood float. Further trowelling shall be done with a steel trowel after about two hours. The thickness of a surfacing where it is inclined at 45° or greater to the horizontal shall not exceed a nominal 15mm and if this is inadequate to complete the work the surface shall be left rough and keyed with a trowel. A further surfacing coat shall be applied within 24 hours.

Where benchings and channels are to be protected by Epoxy Mortar the final surface of the concrete shall be left rough.

Article 6.54 Cracks in Concrete Structures

The filling of cracks will not be permitted unless approval is given by the Engineer in writing.

JOINTS IN CONCRETE STRUCTURES**Article 6.55 Movement Joints**

Movement joints are provided for expansion, contraction or flexibility. They are detailed in this specification and on the drawings. All movement joints are required to be leakproof.

Expansion and contraction joints shall be formed as detailed in this specification and on the drawings. The Contractor shall ensure that there is no adhesion between the two concrete faces of the joint and that debris does not enter the joints.

A bond breaker shall be incorporated into all expansion and contraction joints to prevent adhesion between the joint sealant and the filler in the case of expansion joints, and the base concrete in contraction joints.

All jointing materials used in a particular joint shall be chemically compatible with each other and with their contact environment.

Article 6.56 Construction Joints

Construction joints are provided for convenience of construction and, in some instances, to assist in the control of shrinkage cracking. Where the positions of construction joints are not shown on the drawings they may be proposed by the Contractor to suit his methods of working.

Construction joints are required to give monolithic construction and to be leakproof.

Method statements for the detailed design of construction joints shall generally comply with the following guidelines.

Where practicable wooden battens of trapezoidal pattern shall be inserted in the face of the unfinished concrete at a construction joint, and later withdrawn, to form a continuous dovetail key. The surface of the previously poured concrete at construction joints must be clean and dry and all laitance and scum must be removed to show the tips of the coarse aggregate before the adjacent concrete is placed; where practicable the aggregate exposure is to be done by wire brushing or water jetting while the concrete is still green. Any defective concrete shall be removed before the adjacent concrete is cast. At horizontal construction joints the first layer of new concrete shall not exceed 150mm in depth and particular care shall be taken to prevent loss of fines from the bottom of the new lift.

6.56.1 Preparation of Construction Joints

The contractor shall obtain approval for his proposals for forming and preparing construction joints prior to the work commencing on site.

6.56.2 Position of Construction Joints

The position of construction joints proposed by the Contractor shall be such as to avoid distress or damage to the works particularly from thermal movement or shrinkage effects.

The position and spacing of joints which will be acceptable will vary from place to place but the following table gives an indication of acceptable limits.

Table 23.18: Acceptable limits for positions and spacing of joints

Construction	Max. Area m ²	Max. Dimension m
Water tight walls	25	5
Water tight slabs	100	10
Slabs with major restraint at both ends	100	13
Slabs with major restraint at one end only	250	20
Slabs with little restraint in any direction	500	30
Walls	40	10

Where the Contractor's proposals result in alterations to the reinforcement the Contractor shall be responsible for providing full revised details for approval prior to the work commencing on site.

Article 6.57 Movement Joints

Concrete shall not be placed on both sides of movement joint at the same time unless otherwise approved.

Article 6.58 Expansion Joints

This work shall consist of supplying and installing a binder and aggregate system composed of specially blended polymer modified asphalt and specific aggregate placed in layers into a prepared expansion joint block-out. The Expansion Joint shall be THORMA joint or equivalent.

6.58.1 Binder

The bridge joint binder shall be a polymer modified asphalt and shall meet the following requirements as set forth is ASTM D6297-01

Table 23.19: Requirement of Binder

TEST METHOD		TYPICAL VALUES
Cone Penetration @ 77°F	ASTM D5/D3407	7.5 Max
Cone Penetration @ 0°F,	ASTM D5/D3407	1.0 Minimum
Flow @ 140°F, 5 Hours, (MM)	ASTM D3407	3.0 Max
Non-Immersed Bond @ 20°F,	ASTM D3405	Pass 3 cycles
Three Cycles		
Resilience @ 77°F	ASTM D3407	40-70
Asphalt Compatibility	ASTM D3407	Pass
Softening Point	ASTM D36	180 Minimum
Flexibility/Pliability @ -10°F	ASTM D5329	Pass
Ductility @77°F	ASTM D113	400 Minimum
Tensile Adhesion @ 77°F	ASTM D5329	700 Minimum
Recommended Pouring Temperature		390°F (199°C)
Safe Heating Temperature		410°F (210°C)

Article 6.59 Size and Sequence of Concrete Pours

The Contractor shall include in his method statement for each structure his detailed proposals for the sequence of placing concrete and for the positions of vertical and horizontal construction joints not shown on the drawings.

The sequence of construction shall be arranged to minimise restraint to early age thermal shrinkage movement.

Article 6.60 Water Bars

Water bars shall be manufactured of extruded PVC or of nitrile rubber. They shall be of the types and general shapes indicated on the drawings. They shall be obtained from experienced manufacturers and shall be to the latest shapes and forms generally adopted in the industry. Water bars shall comply with Table 23.20

Table 23.20- Water Bar Characteristics at 25°C

Property	Material	
	Rubber	PVC
Density	1100 kg/m ³ (±5%)	1300 kg/m ³ (±5%)
Hardness	60-65 IRHD	70-75 IRHD
Softness Number	-	42-52
Tensile Strength	not less than 20 N/mm ²	not less than 15 N/mm ²
Elongation at Break Point	not less than 450%	not less than 285%
Water Absorption (48 hours immersion)	not exceeding 5%	not exceeding 0.7%
Web Thickness	10mm	10mm
Centre Bulb Dimension	18mm	18mm

Rubber and PVC waterstops shall be suitable for storage, handling, installation and service within a range of 0°C to 50°C.

Care shall be taken to prevent damage to water bars. Water bars shall include eyelets for fixing. If eyelets are not provided they shall not be nailed unless they incorporate a reinforced outer nailing flange.

Water bars shall not be displaced during the placing of concrete which shall be fully compacted around them.

Jointing of water bars shall normally be carried out by clamping and welding or adhesion and shall be in accordance with the recommendations of the manufacturer.

Water bars shall be arranged so that there is a minimum distance of 25mm from the water bar to the reinforcement.

Article 6.61 Bond Breakers

Bond breakers shall be polyethylene tape, closed cell expanded polyethylene foam in flat strip or solid circular core section, or other approved material which is suitable for preventing short or long term adhesion between the sealant and the base material of the sealant groove.

Article 6.62 Joint Fillers for Expansion Joints

Unless otherwise shown on the drawings joint fillers will be resin bonded cork with the following minimum characteristics:

Table 23.21 – Minimum Joint Filler Characteristics

Characteristic	Minimum
Density	200kg/m ³
Maximum load to compress to 50% of original thickness	0.55N/mm ²
Recovery after compression	95%

Article 6.63 Joint Sealing

Sealant slots to expansion, contraction and, where included, construction joints shall be carefully constructed to the dimensions detailed on the drawings or, subject to approval by the Engineer, to the manufacturer's recommendations.

The Contractor shall take care to avoid spalling of concrete on the edges of slots. Slots to expansion joints may be formed by installing joint filler to the concrete surface and then using a special cutter to remove filler to the required depth. Alternatively, and for contraction joints, slots may be formed by pre-formed PCC or timber formers with sloping sides to assist removal.

Before placing sealants, the slots must be thoroughly cleaned and all laitance and oil removed by an abrasive method. Immediately prior to sealing the slots, all loose surface debris, sand and dust must be blown out using compressed air, and the slots must be dry and free from collected rainwater etc. to ensure maximum adhesion.

Sealants must in all cases be carefully selected as appropriate for their climatic and environmental exposure and must, where appropriate, be resistant to bio-degradation. The Contractor must supply to the Engineer copies of written recommendation(s) and guarantee(s) from the manufacturer as to the suitability of the product(s) for each individual structure and for the methods of installation.

Where required masking tape shall be applied to protect the concrete surface on either side of the joint during priming and sealing operations. Such masking tape must be carefully stripped away after joint sealing to leave neat edges to the seal.

Article 6.64 Joint Bond Breaking for Contraction Joints and Sliding Joint

Contraction joints to be sealed with polysulphide based sealants shall not have concrete faces painted with bituminous products due to reactivity. In such cases bond breaking shall be achieved by polyethylene tape or a plastic slip membrane.

Sliding joints shall be formed with two layers of an approved plastic slip membrane 1mm thick.

PRECAST CONCRETE

Article 6.65 Precast Concrete Production

Precast concrete units, unless otherwise specified or ordered shall be constructed from Grade C30 or C20 concrete but the coarse aggregate shall be 10mm to 5mm.

Precast units shall be either :

- (i) Cast in vibrated moulds.
- (ii) Formed in hydraulically compressed moulds.
- (iii) Cast in a spun process.
- (iv) Cast in open moulds with approved compaction techniques.

In each case, the formwork shall be of adequate quality to produce a completely smooth finish.

Curing methods shall be as specified elsewhere.

Units shall not be transported until they have matured under suitable conditions for a period of not less than 14 days.

The units shall be so handled, stacked, stored and transported that they are not subjected to undue stress or damaged in any way and large units shall have suitable lifting holes or hooks incorporated into their design. No unit shall be built into the work until it has matured for 28 days.

Units may be rejected if they have any of the following defects:

- (a) Broken edges.
- (b) Cracks (other than hair cracks).
- (c) Repairs.
- (d) Misplaced reinforcement.
- (e) Honeycombing or air holes.
- (f) Finished dimensions different from those specified or shown on the drawings.

The Engineer may order extra precast units to be manufactured for testing to destruction. These units will be paid for if the tests show that they comply with the Specification.

Article 6.66 Bedding Precast Concrete Units

Precast concrete units, except where otherwise specified, shall be bedded and jointed in 1:3 cement mortar true to line and level as shown on the drawings, each unit being firmly pressed into position and the joints flush pointed as the work proceeds.

Where units are to be subjected to internal or external water pressure, joints shall be adequately pressure tight.

Article 6.67 Post-Tensioned Wall Panels, Jointing and Post-Tensioning

Not Applicable

Article 6.68 Chamber Rings and Cover Slabs

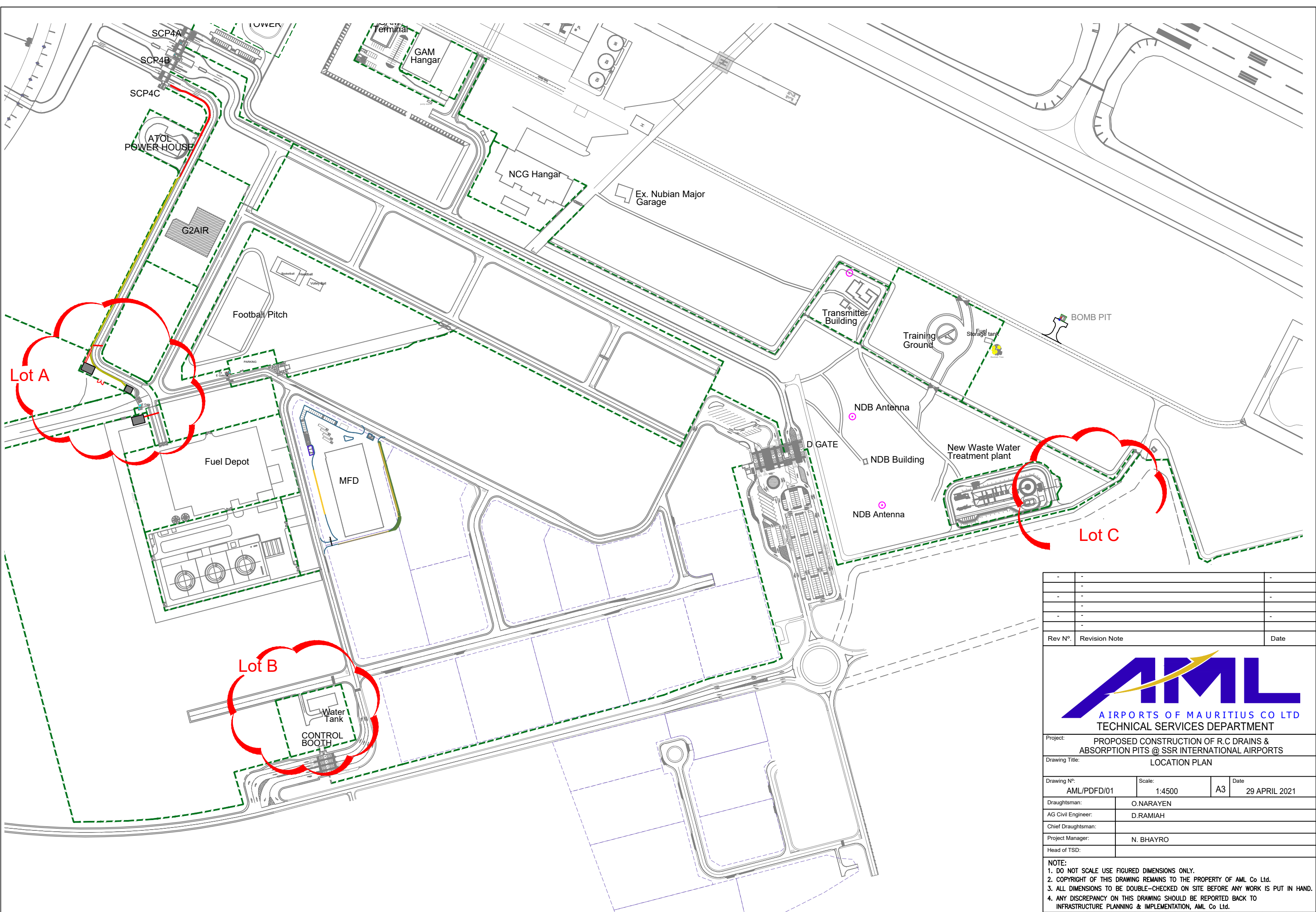
Not Applicable

Article 6.69 Segmental Tunnels and Shafts

Not Applicable

ANNEX 3

DRAWINGS



Project: PROPOSED CONSTRUCTION OF R.C DRAINS & ABSORPTION PITS @ SSR INTERNATIONAL AIRPORTS

Drawing Title: LOCATION PLAN

Drawing N°:	AML/PDFD/01	Scale:	1:4500	A3	Date	29 APRIL 2021
-------------	-------------	--------	--------	----	------	---------------

Draughtsman: O.NARAYEN

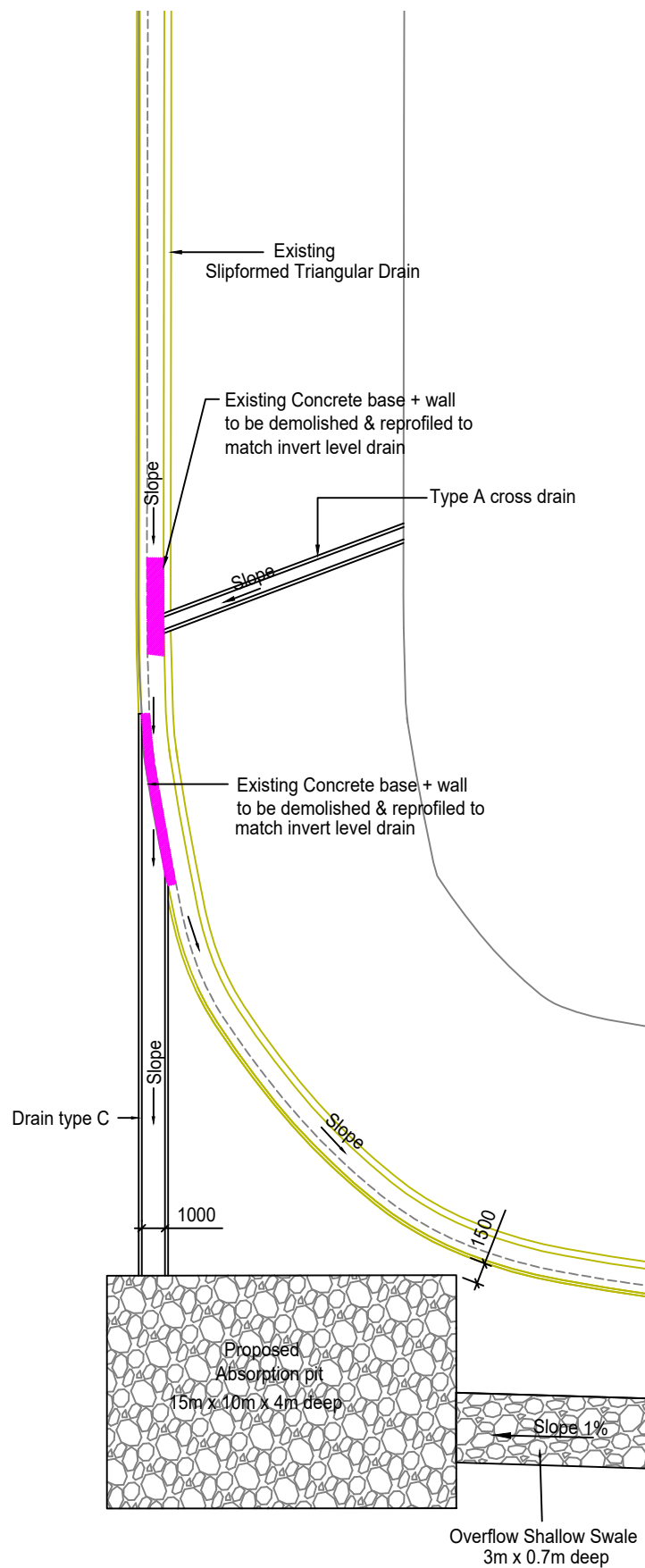
AG Civil Engineer: D.RAMIAH

Chief Draughtsman:

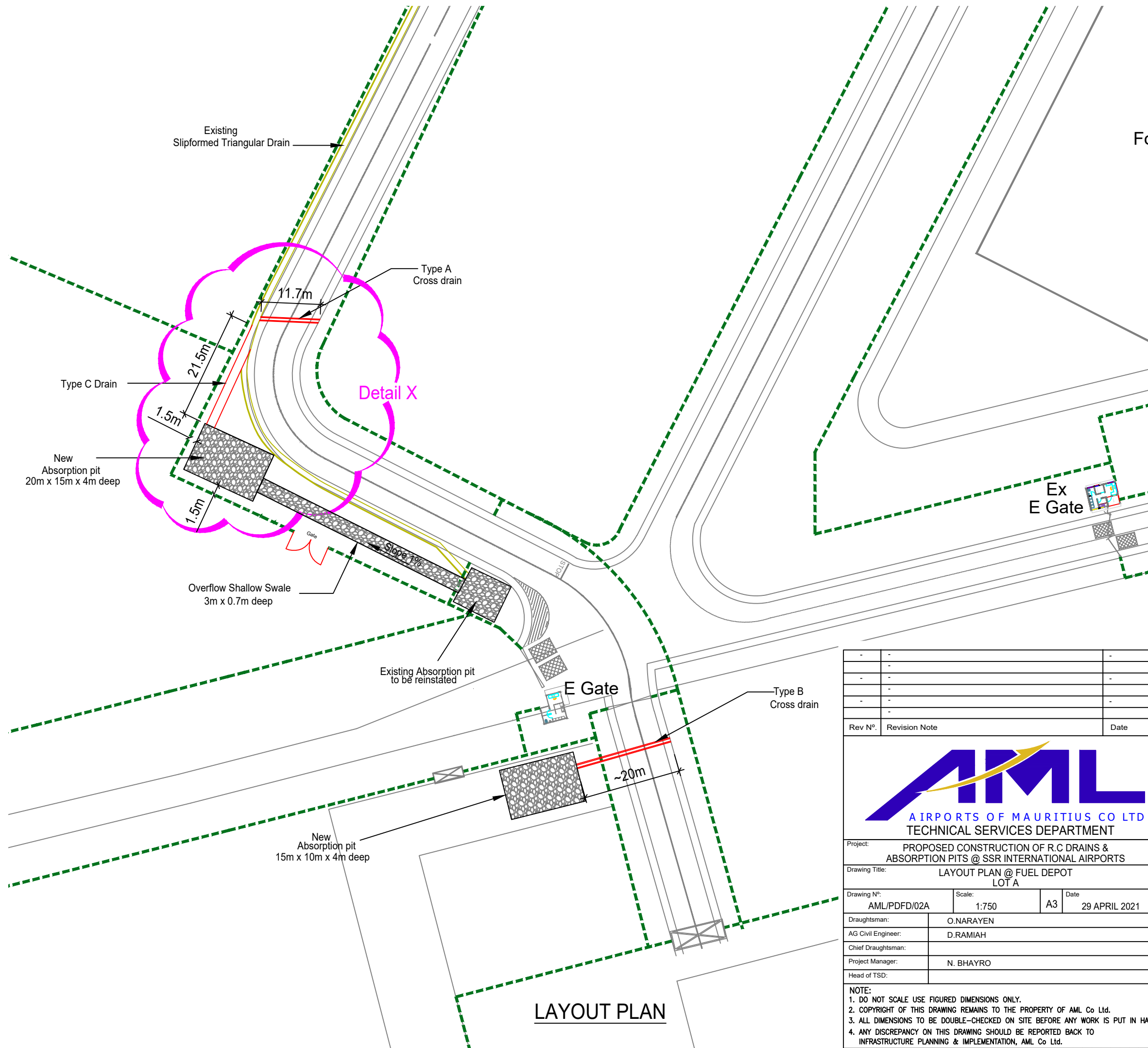
Project Manager: N. BHAYRO

Head of TSD:


- NOTE:
- 1. DO NOT SCALE USE FIGURED DIMENSIONS ONLY.
 - 2. COPYRIGHT OF THIS DRAWING REMAINS TO THE PROPERTY OF AML Co Ltd.
 - 3. ALL DIMENSIONS TO BE DOUBLE-CHECKED ON SITE BEFORE ANY WORK IS PUT IN HAND.
 - 4. ANY DISCREPANCY ON THIS DRAWING SHOULD BE REPORTED BACK TO INFRASTRUCTURE PLANNING & IMPLEMENTATION, AML Co Ltd.



CONNECTION DETAIL @ X



-	-	-
-	-	-
-	-	-
-	-	-
-	-	-
-	-	-
Rev N°	Revision Note	Date



AIRPORTS OF MAURITIUS CO LTD
TECHNICAL SERVICES DEPARTMENT

Project: PROPOSED CONSTRUCTION OF R.C DRAINS & ABSORPTION PITS @ SSR INTERNATIONAL AIRPORTS

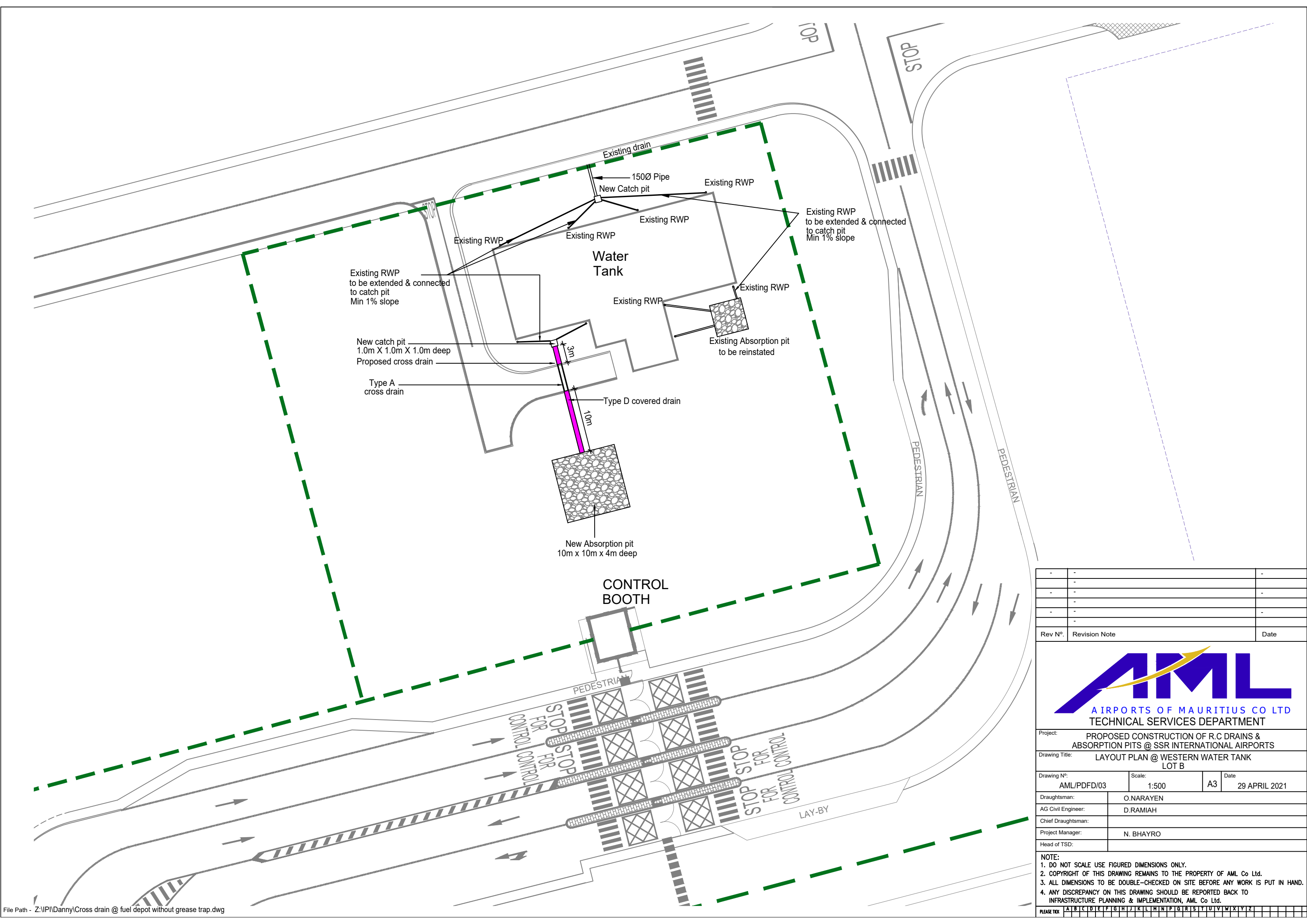
Drawing Title: LAYOUT PLAN @ FUEL DEPOT LOT A

Drawing N°: AML/PDFD/02A	Scale: 1:750	A3	Date: 29 APRIL 2021
--------------------------	--------------	----	---------------------

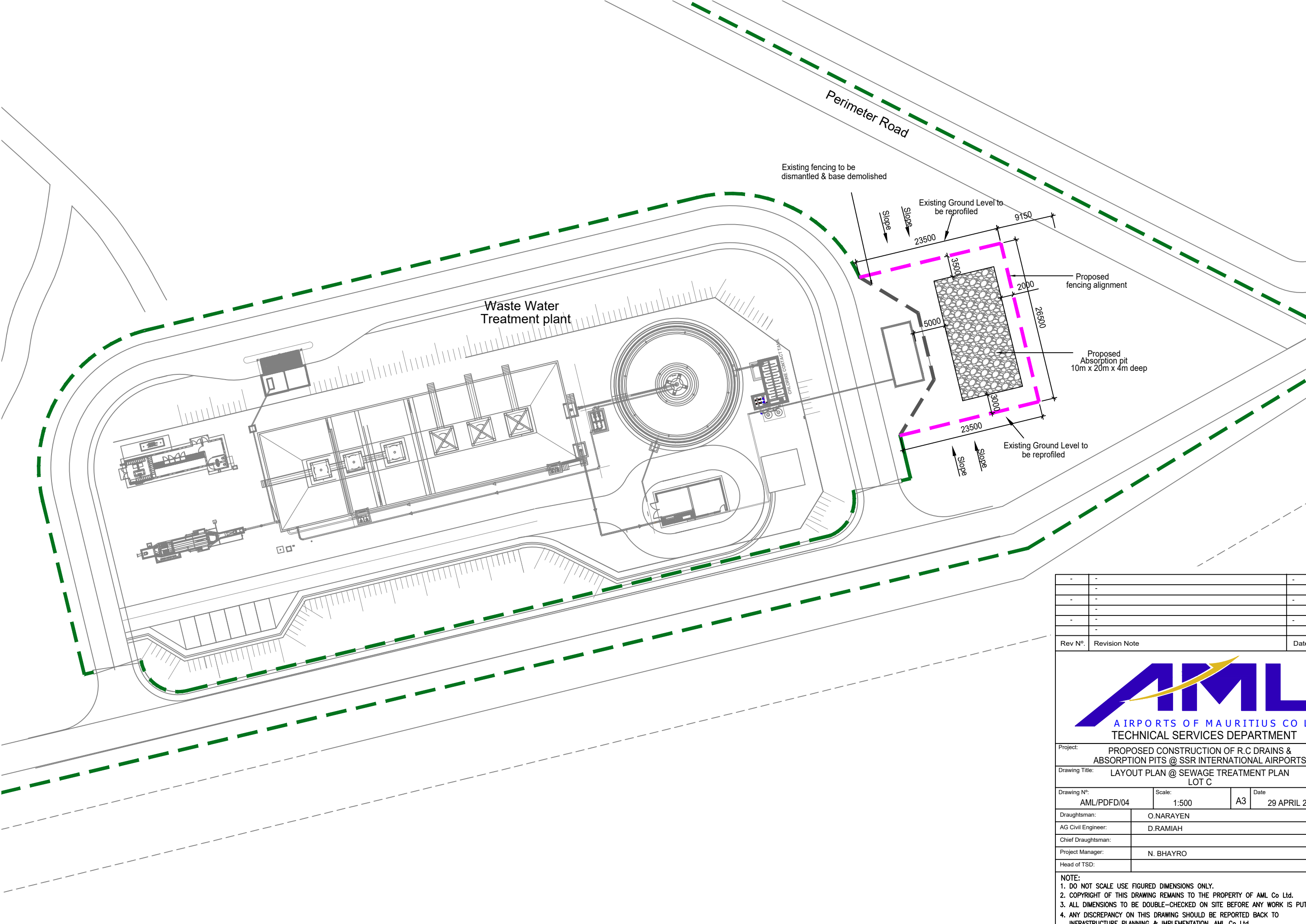
Draughtsman:	O.NARAYEN
AG Civil Engineer:	D.RAMIAH
Chief Draughtsman:	
Project Manager:	N. BHAYRO
Head of TSD:	

NOTE:
1. DO NOT SCALE USE FIGURED DIMENSIONS ONLY.
2. COPYRIGHT OF THIS DRAWING REMAINS TO THE PROPERTY OF AML Co Ltd.
3. ALL DIMENSIONS TO BE DOUBLE-CHECKED ON SITE BEFORE ANY WORK IS PUT IN HAND.
4. ANY DISCREPANCY ON THIS DRAWING SHOULD BE REPORTED BACK TO INFRASTRUCTURE PLANNING & IMPLEMENTATION, AML Co Ltd.

PLEASE TICK	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
-------------	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

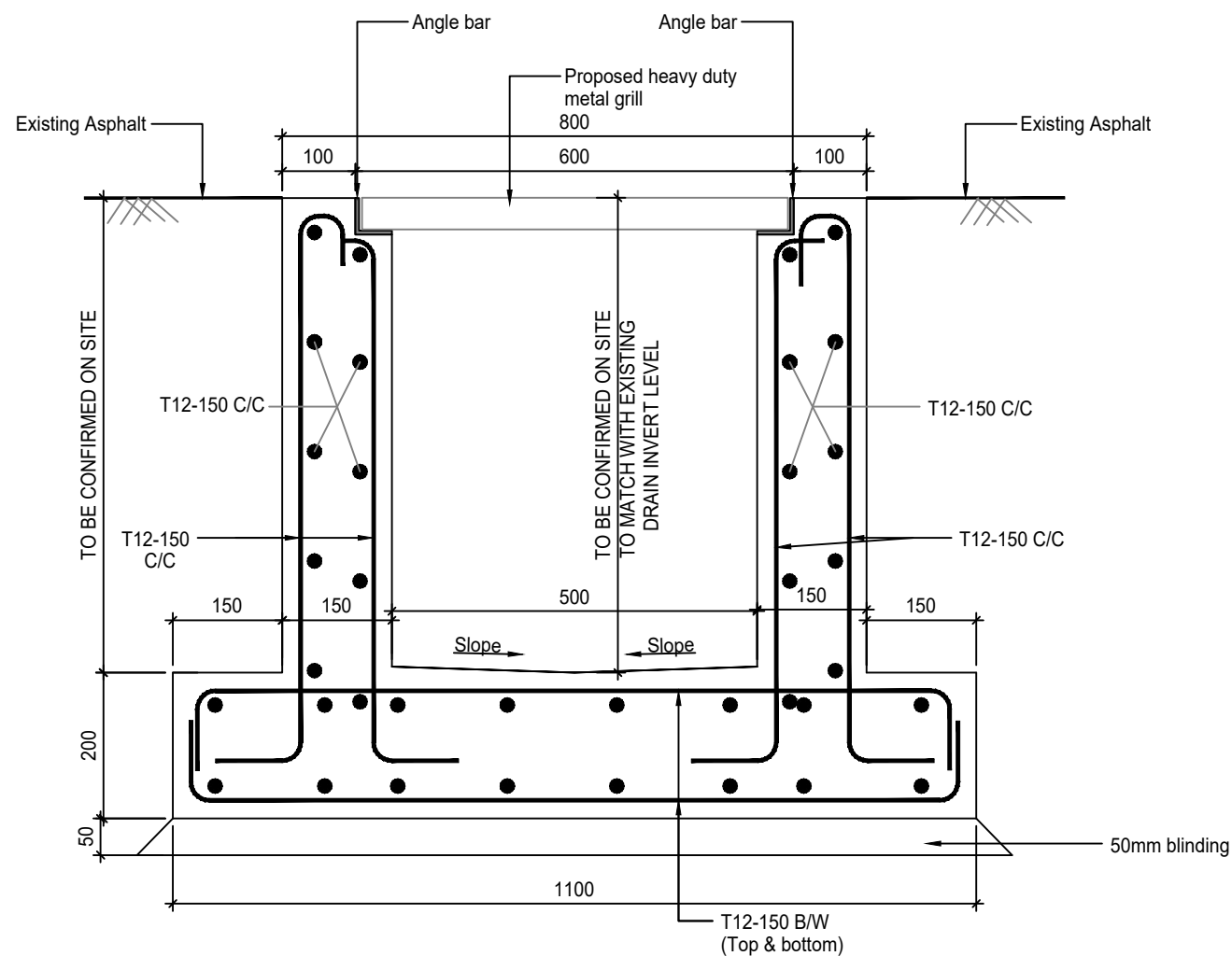


-	-	-
-	-	-
-	-	-
-	-	-
-	-	-
-	-	-
Rev N°	Revision Note	Date
<div><div><div></div><div></div><div></div></div><div><div></div><div></div><div></div></div><div><div></div><div></div><div></div></div></div> <div><div>AIRPORTS OF MAURITIUS CO LTD</div><div>TECHNICAL SERVICES DEPARTMENT</div></div>		
Project: PROPOSED CONSTRUCTION OF R.C DRAINS & ABSORPTION PITS @ SSR INTERNATIONAL AIRPORTS		
Drawing Title: LAYOUT PLAN @ WESTERN WATER TANK LOT B		
Drawing N°: AML/PDFD/03	Scale: 1:500	A3 Date 29 APRIL 2021
Draughtsman:	O.NARAYEN	
AG Civil Engineer:	D.RAMIAH	
Chief Draughtsman:		
Project Manager:	N. BHAYRO	
Head of TSD:		
NOTE: 1. DO NOT SCALE USE FIGURED DIMENSIONS ONLY. 2. COPYRIGHT OF THIS DRAWING REMAINS TO THE PROPERTY OF AML Co Ltd. 3. ALL DIMENSIONS TO BE DOUBLE-CHECKED ON SITE BEFORE ANY WORK IS PUT IN HAND. 4. ANY DISCREPANCY ON THIS DRAWING SHOULD BE REPORTED BACK TO INFRASTRUCTURE PLANNING & IMPLEMENTATION, AML Co Ltd.		
PLEASE TICK	A	B
	C	D
	E	F
	G	H
	I	J
	K	L
	M	N
	O	P
	Q	R
	S	T
	U	V
	W	X
	Y	Z

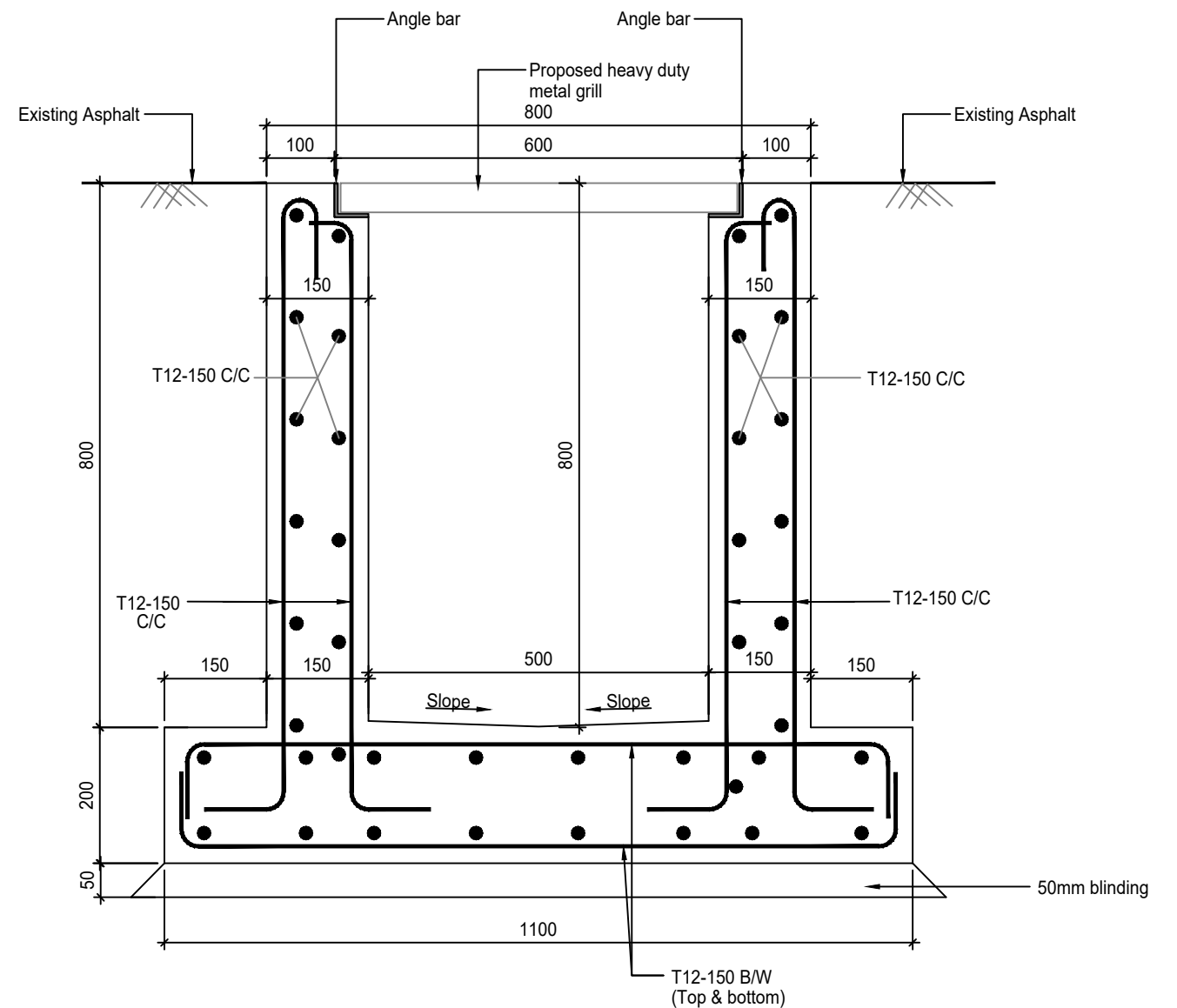


Project: PROPOSED CONSTRUCTION OF R.C DRAINS & ABSORPTION PITS @ SSR INTERNATIONAL AIRPORTS			
Drawing Title: LAYOUT PLAN @ SEWAGE TREATMENT PLAN LOT C			
Drawing N°: AML/PDFD/04	Scale: 1:500	A3	Date 29 APRIL 2021
Draughtsman:	O.NARAYEN		
AG Civil Engineer:	D.RAMIAH		
Chief Draughtsman:			
Project Manager:	N. BHAYRO		
Head of TSD:			

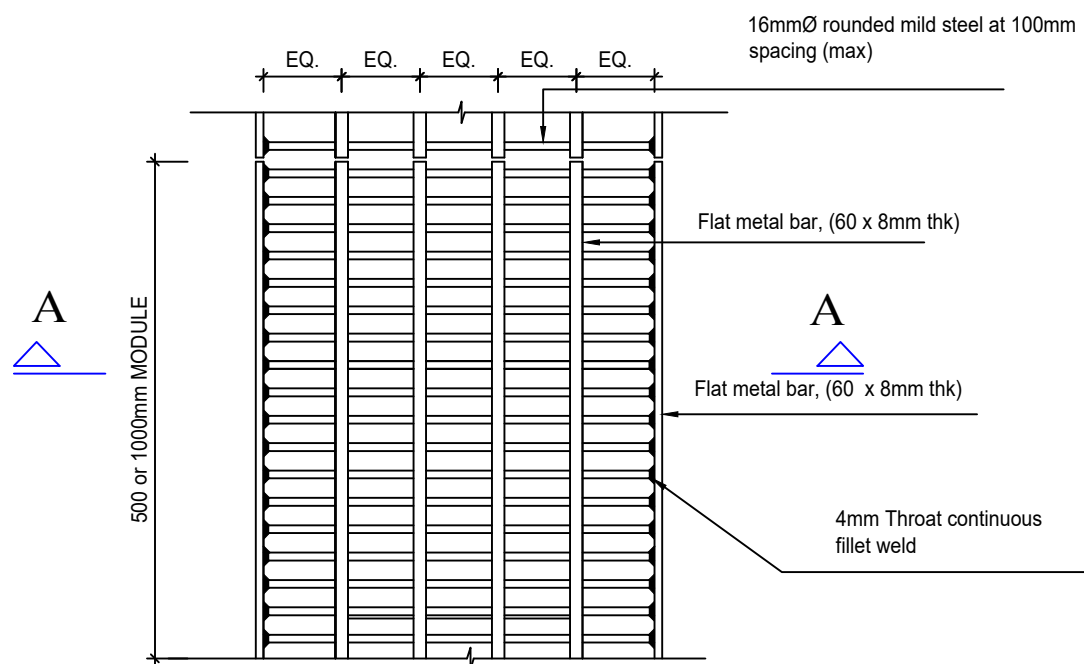
NOTE:
1. DO NOT SCALE USE FIGURED DIMENSIONS ONLY.
2. COPYRIGHT OF THIS DRAWING REMAINS TO THE PROPERTY OF AML Co Ltd.
3. ALL DIMENSIONS TO BE DOUBLE-CHECKED ON SITE BEFORE ANY WORK IS PUT IN HAND.
4. ANY DISCREPANCY ON THIS DRAWING SHOULD BE REPORTED BACK TO INFRASTRUCTURE PLANNING & IMPLEMENTATION, AML Co Ltd.



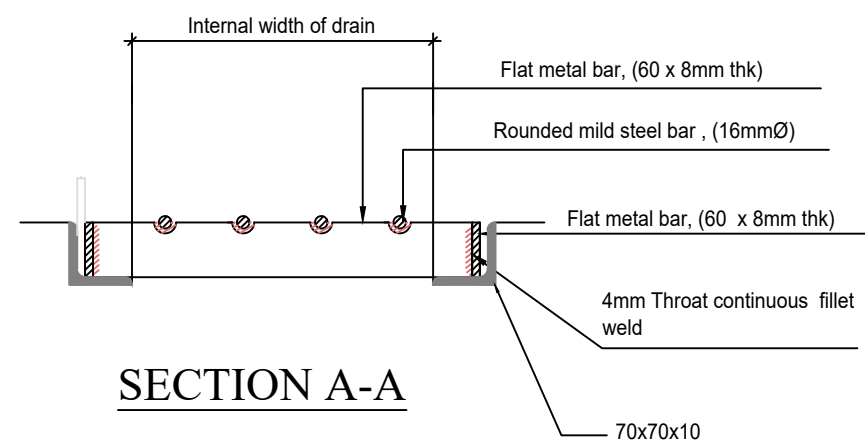
PROPOSED CROSS DRAIN TYPE A



PROPOSED CROSS DRAIN TYPE B



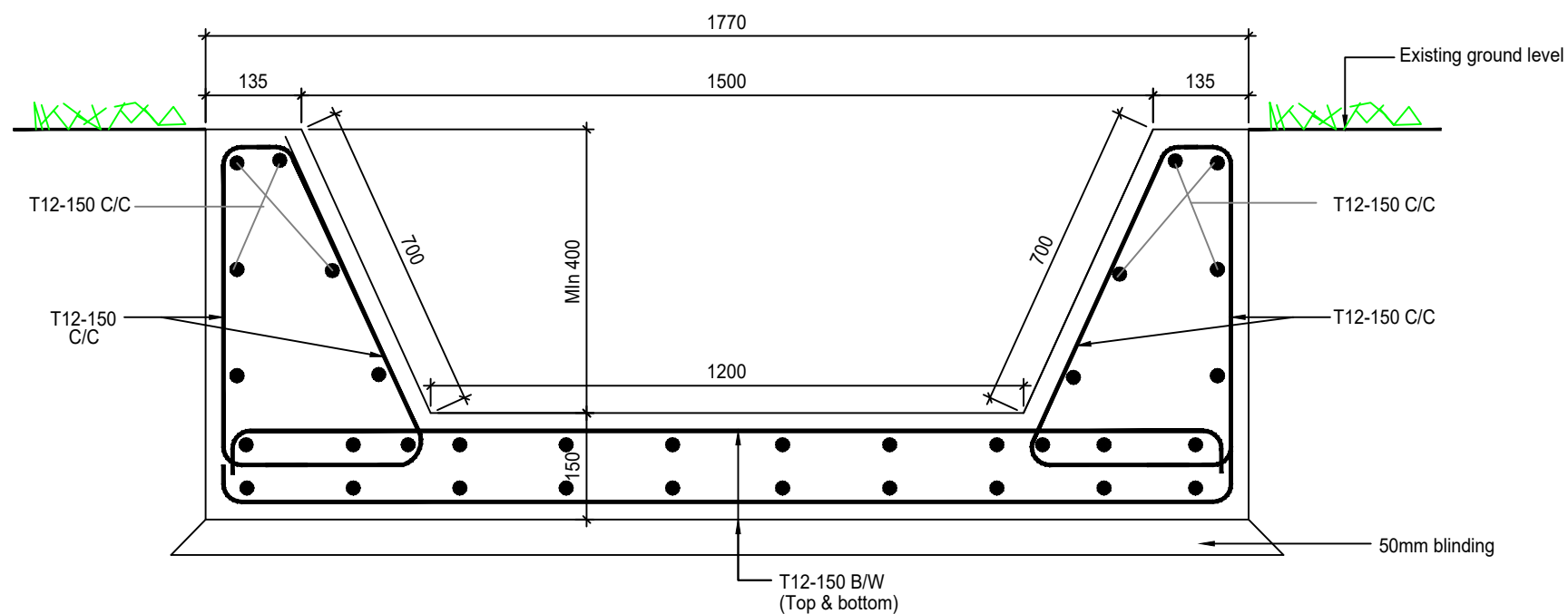
HEAVY DUTY METAL GRILL



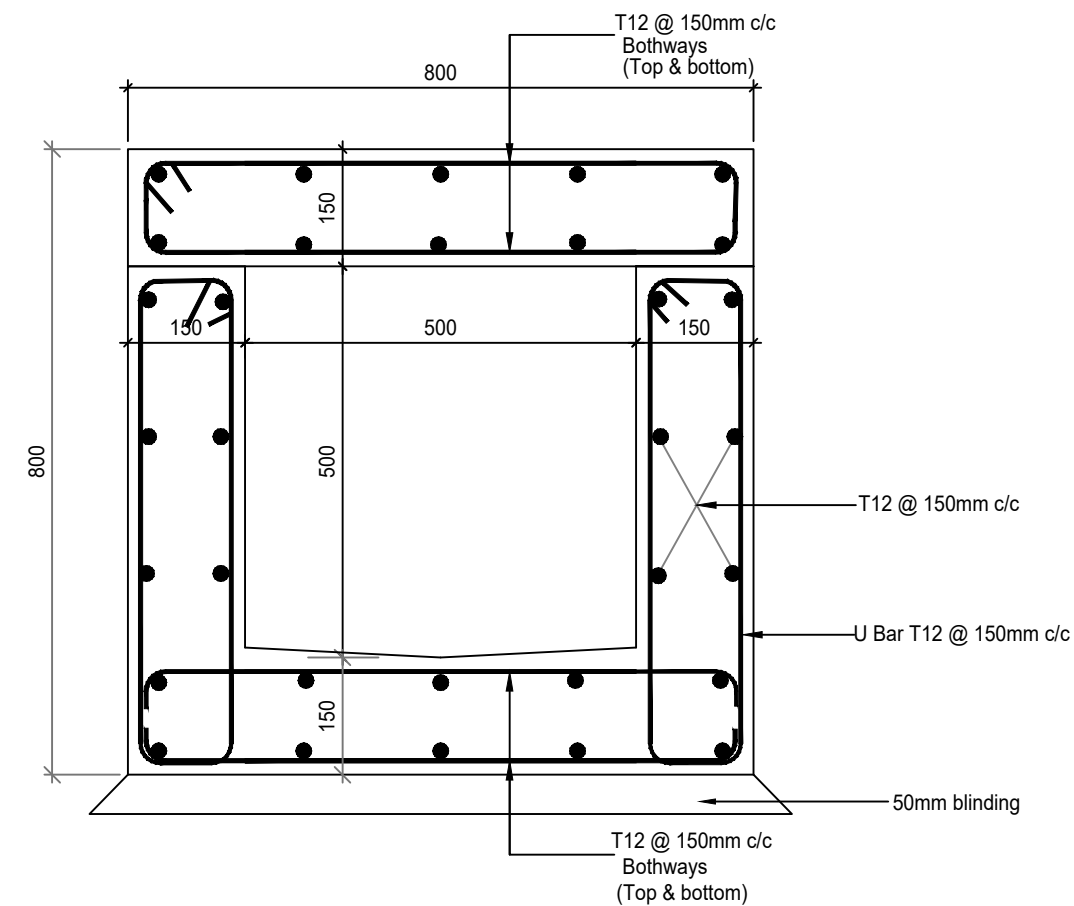
SECTION A-A

-	-	-
-	-	-
-	-	-
-	-	-
-	-	-
Rev N°.	Revision Note	Date

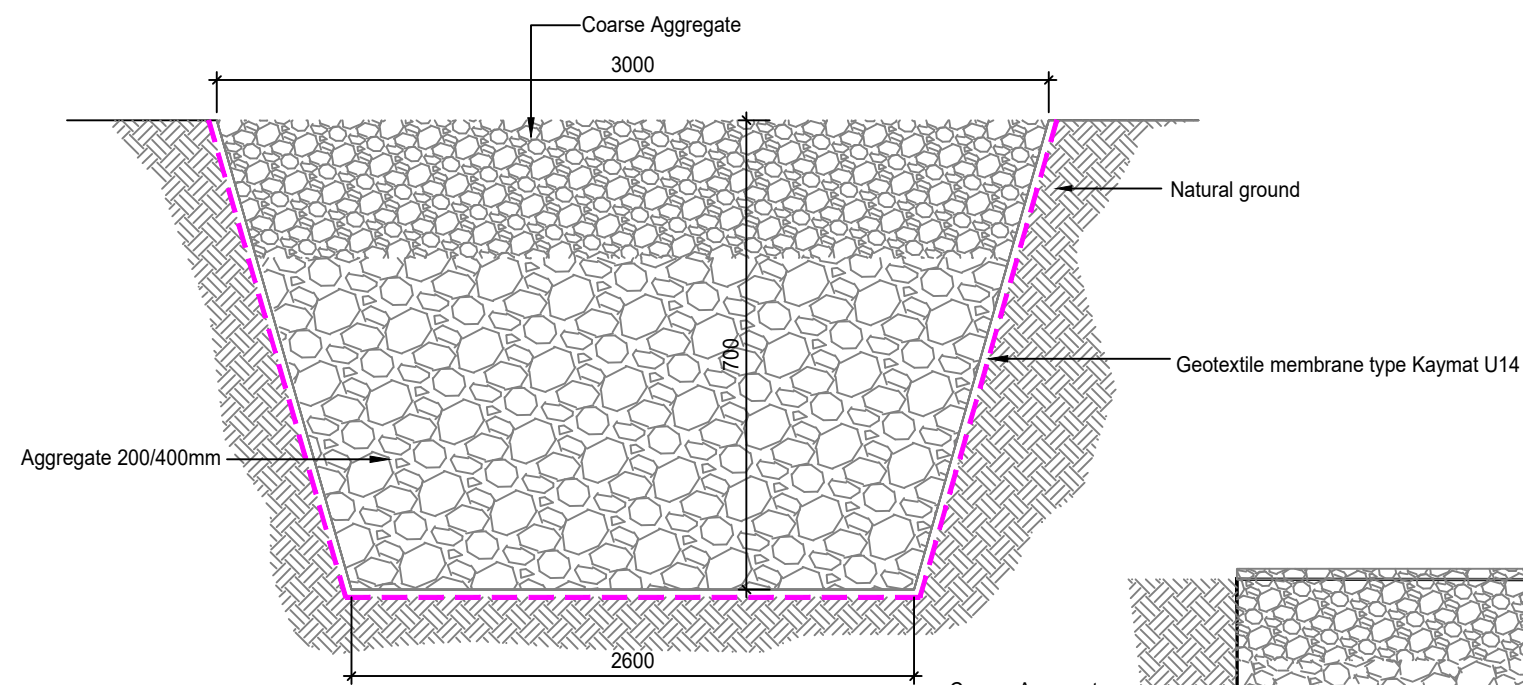
 <p>AIRPORTS OF MAURITIUS CO LTD TECHNICAL SERVICES DEPARTMENT</p>		
Project: PROPOSED CONSTRUCTION OF R.C DRAINS & ABSORPTION PITS @ SSR INTERNATIONAL AIRPORTS		
Drawing Title: R.C CROSS DRAIN DETAILS		
Drawing N°:	Scale:	Date
AML/PDFD/5	1:10	A3 29 APRIL 2021
Draughtsman:	O.NARAYEN	
AG Civil Engineer:	D.RAMIAH	
Chief Draughtsman:		
Project Manager:	N. BHAYRO	
Head of TSD:		
NOTE:		
1. DO NOT SCALE USE FIGURED DIMENSIONS ONLY.		
2. COPYRIGHT OF THIS DRAWING REMAINS TO THE PROPERTY OF AML Co Ltd.		
3. ALL DIMENSIONS TO BE DOUBLE-CHECKED ON SITE BEFORE ANY WORK IS PUT IN HAND		
4. ANY DISCREPANCY ON THIS DRAWING SHOULD BE REPORTED BACK TO INFRASTRUCTURE PLANNING & IMPLEMENTATION, AML Co Ltd.		



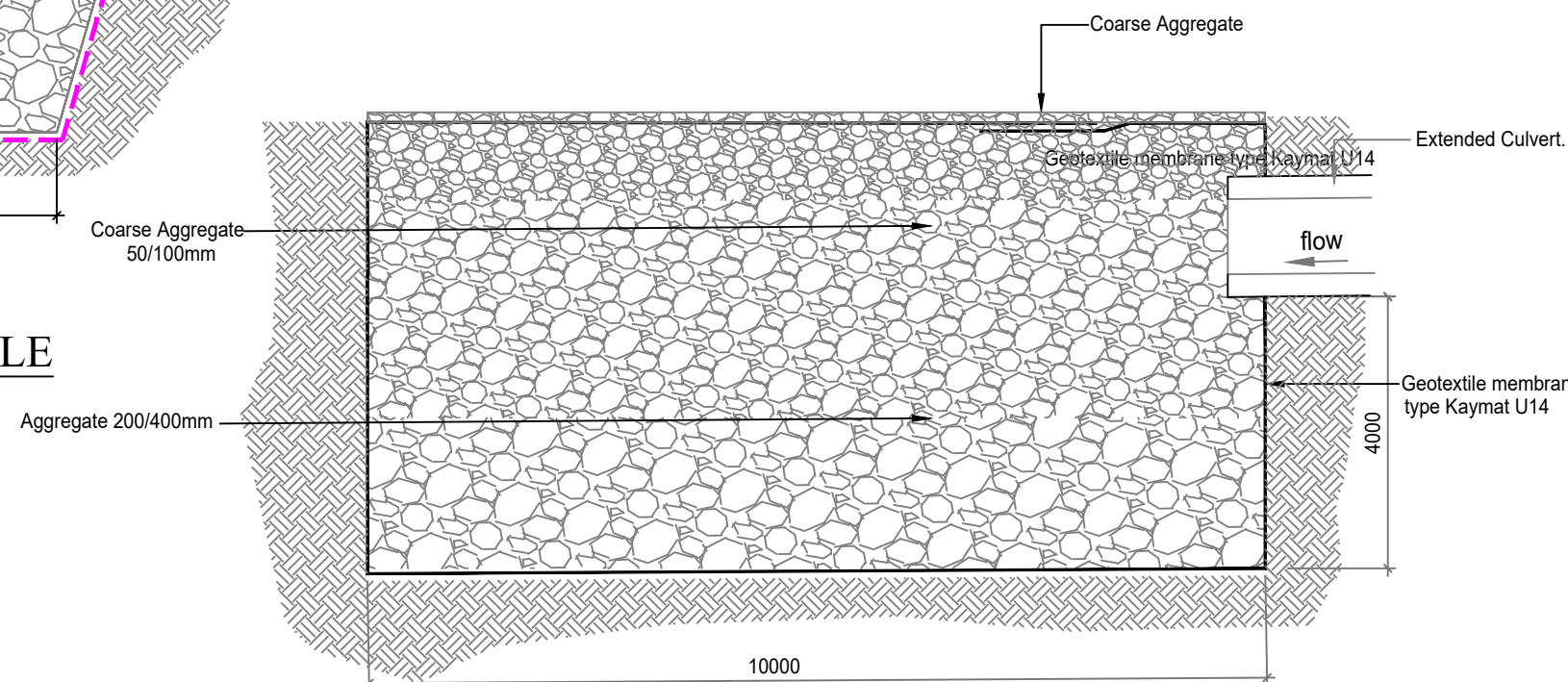
PROPOSED DRAIN TYPE C



PROPOSED COVERED DRAIN TYPE D

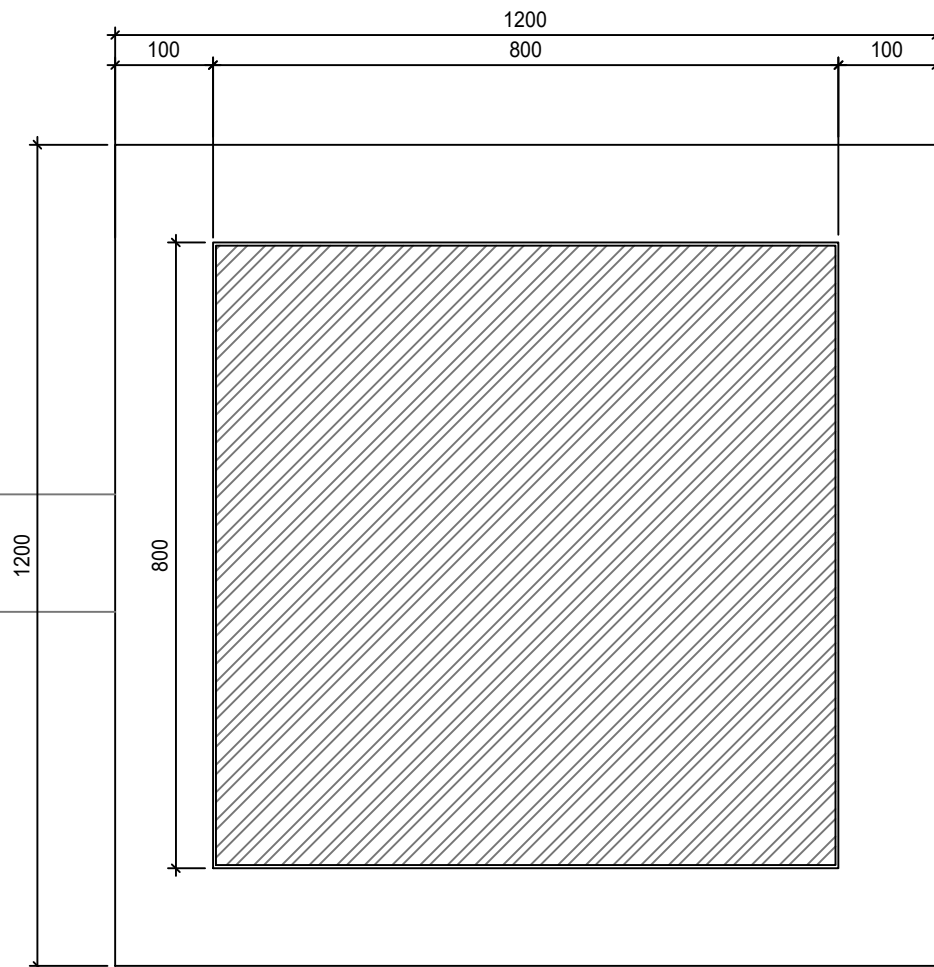


**TYPICAL DETAIL OF
OVERFLOW SHALLOW SWALE**

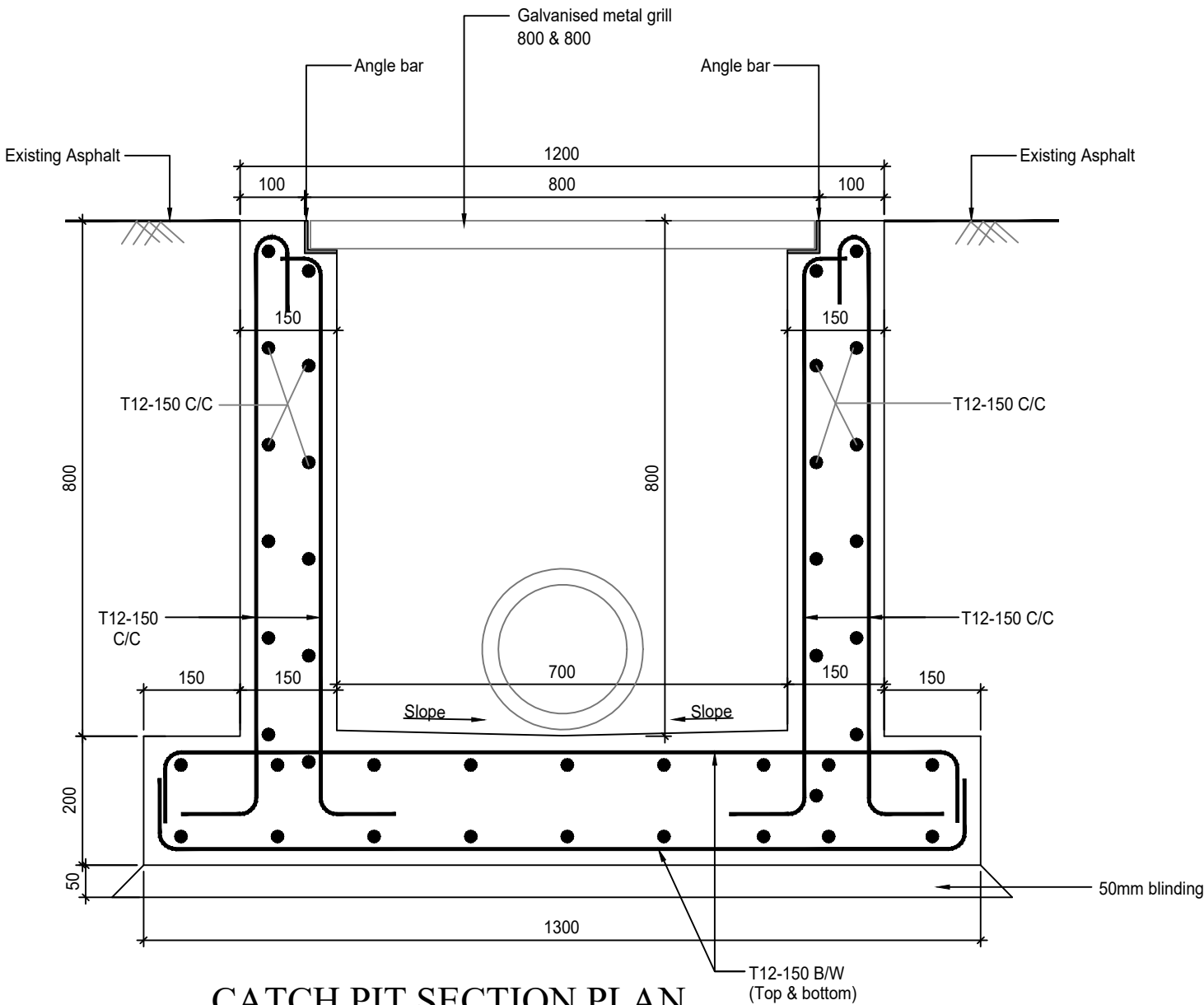


TYPICAL DETAIL OF ABSORPTION PIT

-	-	-
-	-	-
-	-	-
-	-	-
-	-	-
-	-	-
Rev N°	Revision Note	Date
 <p>AIRPORTS OF MAURITIUS CO LTD TECHNICAL SERVICES DEPARTMENT</p>		
Project:	PROPOSED CONSTRUCTION OF R.C DRAINS & ABSORPTION PITS @ SSR INTERNATIONAL AIRPORTS	
Drawing Title:	R.C DRAIN & ABSORPTION PIT DETAILS	
Drawing N°:	AML/PDFD/06	Scale: 1:10
Draughtsman:	O.NARAYEN	Date: 29 APRIL 2021
AG Civil Engineer:	D.RAMIAH	
Chief Draughtsman:		
Project Manager:	N. BHAYRO	
Head of TSD:		
<p>NOTE:</p> <p>1. DO NOT SCALE USE FIGURED DIMENSIONS ONLY.</p> <p>2. COPYRIGHT OF THIS DRAWING REMAINS TO THE PROPERTY OF AML Co Ltd.</p> <p>3. ALL DIMENSIONS TO BE DOUBLE-CHECKED ON SITE BEFORE ANY WORK IS PUT IN HAND.</p> <p>4. ANY DISCREPANCY ON THIS DRAWING SHOULD BE REPORTED BACK TO INFRASTRUCTURE PLANNING & IMPLEMENTATION, AML Co Ltd.</p>		
PLEASE TICK		



CATCH PIT LAYOUT PLAN



CATCH PIT SECTION PLAN

-	-	-
-	-	-
-	-	-
-	-	-
-	-	-
-	-	-
Rev N°	Revision Note	Date



AIRPORTS OF MAURITIUS CO LTD
TECHNICAL SERVICES DEPARTMENT

Project: PROPOSED CONSTRUCTION OF R.C DRAINS & ABSORPTION PITS @ SSR INTERNATIONAL AIRPORTS

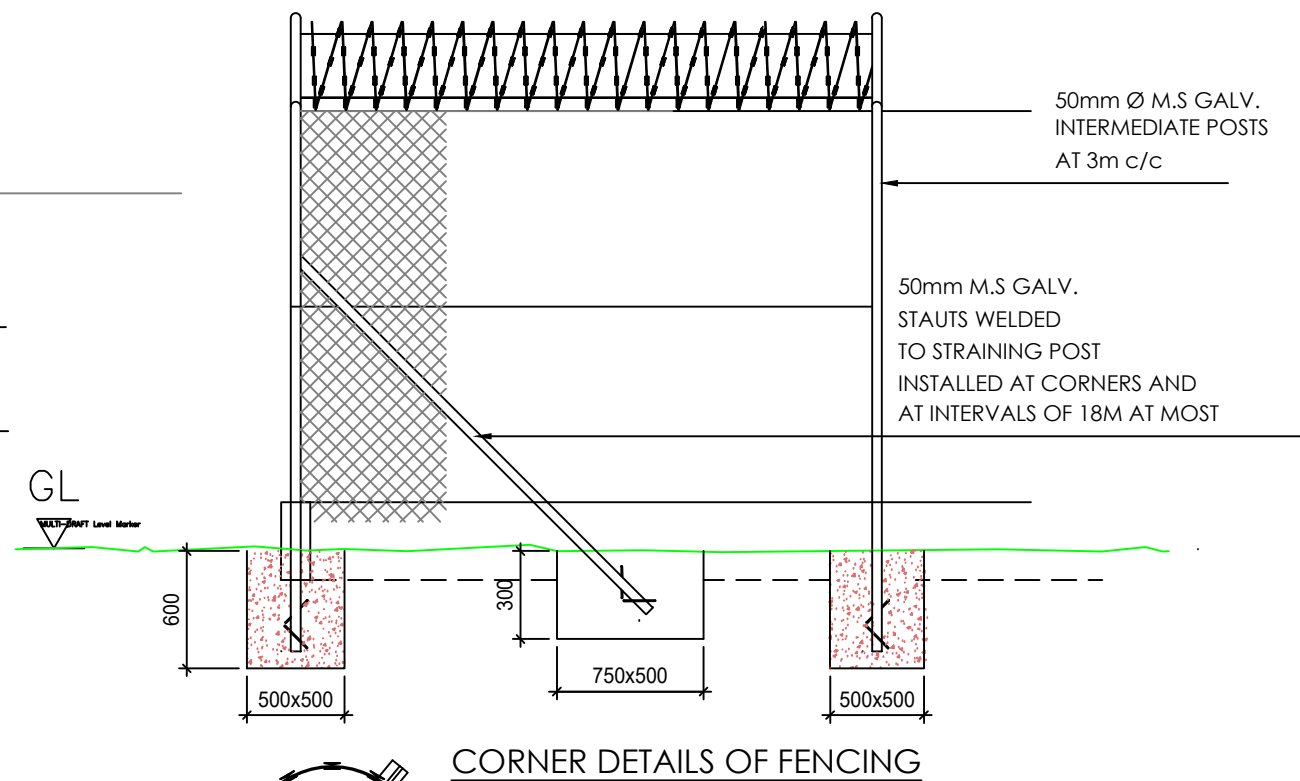
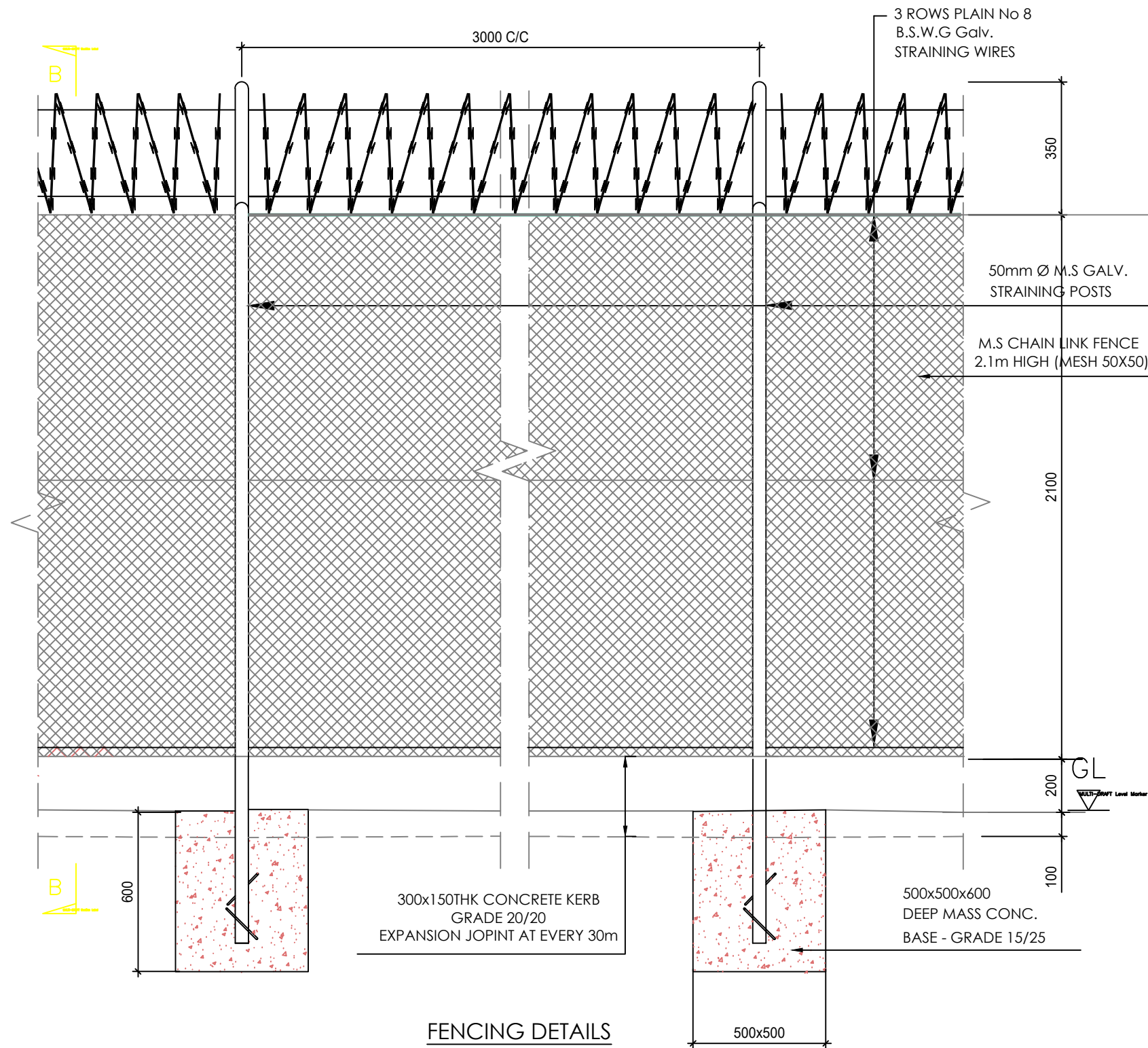
Drawing Title: CATCH PIT DETAILS

Drawing N°: AML/PDFD/07	Scale: 1:10	A3	Date: 29 APRIL 2021
-------------------------	-------------	----	---------------------

Draughtsman:	O.NARAYEN
AG Civil Engineer:	D.RAMIAH
Chief Draughtsman:	
Project Manager:	N. BHAYRO
Head of TSD:	

NOTE:
1. DO NOT SCALE USE FIGURED DIMENSIONS ONLY.
2. COPYRIGHT OF THIS DRAWING REMAINS TO THE PROPERTY OF AML Co Ltd.
3. ALL DIMENSIONS TO BE DOUBLE-CHECKED ON SITE BEFORE ANY WORK IS PUT IN HAND.
4. ANY DISCREPANCY ON THIS DRAWING SHOULD BE REPORTED BACK TO INFRASTRUCTURE PLANNING & IMPLEMENTATION, AML Co Ltd.

PLEASE TICK	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
-------------	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---



MASS CONCRETE CAST
IN LENGTH OF NOT
LONGER THAN 6M AND
IN ALTERNATE LENGTH

SECTION B-B

-	-	-																																																	
-	-	-																																																	
-	-	-																																																	
-	-	-																																																	
-	-	-																																																	
Rev N°.	Revision Note	Date																																																	
<div><p>AIRPORTS OF MAURITIUS CO LTD TECHNICAL SERVICES DEPARTMENT</p></div>																																																			
Project: PROPOSED CONSTRUCTION OF R.C DRAINS & ABSORPTION PITS @ SSR INTERNATIONAL AIRPORTS																																																			
Drawing Title: TYPICAL FENCING DETAILS																																																			
Drawing N°: AML/PDFD/08	Scale: 1:20	Date 29 APRIL 2021																																																	
Draughtsman:	O.NARAYEN																																																		
AG Civil Engineer:	D.RAMIAH																																																		
Chief Draughtsman:																																																			
Project Manager:	N. BHAYRO																																																		
Head of TSD:																																																			
NOTE: 1. DO NOT SCALE USE FIGURED DIMENSIONS ONLY. 2. COPYRIGHT OF THIS DRAWING REMAINS TO THE PROPERTY OF AML Co Ltd. 3. ALL DIMENSIONS TO BE DOUBLE-CHECKED ON SITE BEFORE ANY WORK IS PUT IN HAND. 4. ANY DISCREPANCY ON THIS DRAWING SHOULD BE REPORTED BACK TO INFRASTRUCTURE PLANNING & IMPLEMENTATION, AML Co Ltd.																																																			
PLEASE TICK	<table><tr><td>A</td><td>B</td><td>C</td><td>D</td><td>E</td><td>F</td><td>G</td><td>H</td><td>I</td><td>J</td><td>K</td><td>L</td><td>M</td><td>N</td><td>P</td><td>Q</td><td>R</td><td>S</td><td>T</td><td>U</td><td>V</td><td>W</td><td>X</td><td>Y</td><td>Z</td></tr></table>																										A	B	C	D	E	F	G	H	I	J	K	L	M	N	P	Q	R	S	T	U	V	W	X	Y	Z
A	B	C	D	E	F	G	H	I	J	K	L	M	N	P	Q	R	S	T	U	V	W	X	Y	Z																											