ASHGHAL

Interim Advice Note No. 013/14

Amendments / Additions to QCS 2014

Revision No. A1

Summary
This Interim Advice Note (IAN) provides information and guidance on amendments and additions to QCS (Qatar Construction Specifications) 2014. This IAN takes immediate effect.

Third parties not working on Ashghal projects make use of this document at their own risk. Paper copies of this document are uncontrolled. Refer to Ashghal's website for the most recent version.

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Qatar Deserves The Best

A1	April 2016	Issued for All Relevant Infrastructure Projects	IF	MG	DOR
Rev	**Date**	**Reason For Issue**	**Auth**	**Chk**	**App**

Contents

1. Foreword

1.1 Interim Advice Notes (IANs) may be issued by Ashghal from time to time. They define specific requirements for works on Ashghal projects only, subject to any specific implementation instructions contained within each IAN.

1.2 Whilst IANs shall be read in conjunction with the Qatar Highway Design Manual (QHDM), the Qatar Traffic Manual (QTM) and the Qatar Construction Specifications (QCS), and may incorporate amendments or additions to these documents, they are not official updates to the QHDM, QTM, QCS or any other standards.

1.3 Ashghal directs which IANs shall be applied to its projects on a case by case basis. Where it is agreed that the guidance contained within a particular IAN is not to be incorporated on a particular project (e.g. physical constraints make implementation prohibitive in terms of land use, cost impact or time delay), a departure from standard shall be applied for by the relevant Consultant / Contractor.

1.4 IANs are generally based on international standards and industry best practice and may include modifications to such standards in order to suit Qatar conditions. Their purpose is to fill gaps in existing Qatar standards where relevant guidance is missing and/or provide higher standards in line with current, international best practice.

1.5 The IANs specify Ashghal's requirements in the interim until such time as the current Qatar standards (such as QHDM, QTM, etc.) are updated. These requirements may be incorporated into future updates of the QHDM, QTM or QCS, however this cannot be guaranteed. Therefore, third parties who are not engaged on Ashghal projects make use of Ashghal IANs at their own risk.

1.6 All IANs are owned, controlled and updated as necessary by Ashghal. All technical queries relating to IANs should be directed to Ashghal's Manager of the Design Department, Infrastructure Affairs.

Signed on behalf of Design Department:

Abdulla Ahin A A Mohd
Manager of Roads Design Department
Design Management (Roads Section)
Public Works Authority

Tel: 44950653
Fax: 44950666
P.O.Box 22188 Doha - Qatar
Email:aahin@ashghal.gov.qa
http://www.ashghal.gov.qa

2. Ashghal Interim Advice Note (IAN) – Feedback Form

Ashghal IANs represent the product of consideration of international standards and best practice against what would work most appropriately for Qatar. However, it is possible that not all issues have been considered, or that there are errors or inconsistencies in an IAN.

If you identify any such issues, it would be appreciated if you could let us know so that amendments can be incorporated into the next revision. Similarly, we would be pleased to receive any general comments you may wish to make. Please use the form below for noting any items that you wish to raise.

Please complete all fields necessary to identify the relevant item			
IAN title:			
IAN number:		Appendix letter:	
Page number:		Table number:	
Paragraph number:		Figure number:	
Description comment: Please continue on a separate sheet if required:			
Your name and contact details (optional):			
Name:		Telephone:	
Organisation:		Email:	
Position:		Address:	

Please email the completed form to:

Abdulla Ahin AA Mohd

Manager of Roads Design Department
Design Management
(Roads Section)
Public Works Authority

aahin@ashghal.gov.qa

We cannot acknowledge every response, but we thank you for contributions. Those contributions which bring new issues to our attention will ensure that the IANs will continue to assist in improving quality on Ashghal's infrastructure projects.

3. Introduction

3.1 This Interim Advice Note (IAN), which takes immediate effect, provides information and guidance on amendments and additions to Qatar Construction Specifications (QCS) 2014. This IAN will provide interim guidance prior to issue of a revision to QCS 2014.

4. Amended Standard

4.1 For application to projects which incorporate QCS 2014 which shall be amended by this IAN.

5. Implementation

5.1 This IAN is to be used with immediate effect on projects as follows:

- All Ashghal projects in Design Stage
- All Ashghal projects in Tender Stage

5.2 Ashghal projects in Construction Stage shall be reviewed by the Project Consultant / Contractor and the implications of adoption of this Interim Advice Note discussed with the respective Ashghal Project Manager.

5.3 If in doubt, Consultants / Contractors should seek guidance from the respective Ashghal Project Manager or designated Programme Management Consultant (PMC) on a scheme specific basis.

Appendix A – Amendments / Additions to Qatar Construction Specifications (QCS) 2014

CONTENTS

SECTION 1 GENERAL

PART 1 INTRODUCTION

Add new Clause 1.7 as follows:

1.7 OTHER REQUIREMENTS

1.7.1 Site Specific Geotechnical Requirements

1 The Contractor's attention is drawn to the ground conditions likely to be encountered in the area as provided for information in Geotechnical Investigation Report in the Specification. Construction works may involve excavation in very hard rock and in filled and reclaimed land and excavations below the level of the ground water table. The Contractor should assess and make allowance for working in such conditions.

1.7.2 Blasting Restrictions

1 The Contractor's attention is drawn to the fact that the Works may be constructed in developed areas where blasting may be restricted.

PART 3 SITE ACCESS AND ENTRY ONTO THE SITE

3.2 ACCESS ROADS

3.2.1 Temporary Access Roads

Delete paragraph 2 and substitute with the following:

2 Reinstatement shall include restoring the area of any route to at least the degree of safety, stability, drainage, level, contour and landscaping that existed at the time the Contractor is given Possession of Site.

3.3 SITE ENTRY

3.3.1 Entry onto the Site

Delete paragraph 3.

Add new paragraph 8 as follows:

8 The work permit for plants, which are under operation by PWA Operations and Maintenance Department will be issued as per 'Operations and Maintenance Department Permit Procedure' based on the Contractor's application through the Engineer or his designated representative.

PART 8 BUILDING DEMOLITION

8.1 GENERAL

8.1.5 Materials Arising

Add new paragraph (e) as follows:

(e) The Contractor shall coordinate with the Landscaping Section of the relevant authority for replanting or delivery locations for the trees identified in the Contract to be retained and/or new trees installed.

PART 10 HEALTH AND SAFETY

10.1 GENERAL

10.1.1 Scope

Delete paragraph 2 and substitute with the following:

2 Related Sections and Parts are as follows:

This section	Part 4	Protection
	Part 8	Building Demolition
	Part 9	Materials
	Part 11	Engineer's Site Facilities
	Part 13	Setting-out of the Works
Section 2	Part 3	Hazardous Materials
Section 11	Part 1	Regulatory Document
Section 11	Part 2	SAMAS

PART 11 ENGINEER'S SITE FACILITIES

11.2 ENGINEER'S SITE OFFICES

Add new Sub-Clause 11.2.5 as follows:

11.2.5 Type 3 Offices

1 The Contractor shall provide, maintain and keep clean and in a sanitary condition, temporary site office facilities with all associated equipment and services for the exclusive use of the Engineer's Representative and his staff form the commencement of the Project. The site office facilities shall remain, in whole or in part as required by the Engineer until the end of the Maintenance Period, or such earlier time as the Engineer may approve.

2 The Contractor shall proceed with the site office facilities immediately following the award of the Contract and shall provide temporary alternative accommodation/offices to the Engineer's approval until such time as the site office facilities are made available.

3 The Contractor shall submit all necessary specifications, drawings and calculations for the fabrication and installation of the site office facilities, showing the accommodation proposed with complete furnishings, equipment and fittings for the Engineer's approval before placing any orders or commencing fabrication and construction and shall be responsible for ensuring that the offices are structurally sound. The Engineer may request alterations at this stage. The drawings shall be approved in writing by the Engineer before installation/construction shall commence.

4 The site office facilities shall conform to the general configuration shown below and shall be either prefabricated portable unit/s or of other form of weatherproof design and construction to the approval of the Engineer. The facilities shall have full partitions and room sizes shall be as shown in the attached Schedule of offices. All rooms shall have individual entrance doors. Corridors and entrance areas shall be additional to the office sizes. The Contractor shall ensure the site offices against fire, burglary and other risks.

5 The site office facilities shall be mounted on adequate concrete foundations and shall be provided with concrete access steps where necessary. Walls and roofs of the facilities may be constructed of composite timber framed panels with metal cladding, or alternative forms to the Engineer's approval, with thermal conductance of 0.60 w/m2 °C and fire resistance of one hour. Roof coverings shall be selected for durability, freedom from excessive maintenance, and the ability to withstand extreme exposure to sun, heat and humidity. All rooms shall have glazed windows complete with fly screens.

6 The offices shall be air-conditioned with the exception of toilets and kitchen areas. The offices shall be air-conditioned with dual (cooling/heating) wall mounted/window units to maintain each room at a maximum steady dry bulb temperature between 20°C and 25°C at a relative humidity of 50% under the expected climatic conditions expected at the Site. Extract fans capable of 10 air changes per hour shall be provided in the kitchen and toilets.

7 Adequate fitted hardware, electrical switches, sockets, lighting and plumbing fittings, sanitary ware and fittings and fixtures etc., shall be provided as necessary for the different areas. The electrical installation shall provide for simultaneous use of all electrical appliances. The installation and testing of wiring and electrical equipment in the unit shall be in accordance with the latest requirements of the Qatar General Electricity & Water Corporation.

Section 1: General

8 Throughout the duration of the Contract, the Contractor shall ensure adequate uninterrupted supplies of clean fresh water, electricity, telephones, fax machines, internet connections, photocopiers/plotters, computers and printers, consumables, stationary, refreshments, waste paper baskets, filing trays to the offices.

9 The Contractor shall provide all typical items listed in the following schedules, and final configuration shall be as specified by the Engineer. All keys for the Engineer's site offices shall be held by the Engineer until such offices are removed or vacated by the Engineer.

10 Unless noted otherwise within the following schedules, as a minimum each office shall be provided with the following furniture to the approval of the Engineer:
- 1 No. kneehole pattern desk with lockable drawers, 1500x800x7600mm in size.
- 1 No. swivel chair with armrests.
- 1 No. stacking or folding chairs.
- 1 No. hanging file of plan chest suitable for A0 size prints.
- 1 No. wastepaper basket.
- 1 No. two drawer filing cabinet.
- 1 No. wall mounted pin board, 1000x2000mm in size.

11 Unless noted otherwise within the following schedules, as a minimum, the sample rooms shall be provided with the following furniture to the approval of the Engineer:
- 3 No. low level WC suite.
- 3 No. wash-hand basin.
- 1 No. shower tray, mixer fittings, rose and shower curtains.
- 3 No. toilet roll holder, towel rail, soap dish and mirror.
- 1 No. hand/face dryer.
- Adequate supply of paper towels.

12 Unless otherwise noted within the following schedules, as a minimum, the sample room shall be provided with the following furniture to the approval of the Engineer.
- 2 No. tables, each approximately 1200x2000mm in size.
- Folding or stacking chairs.
- 1 No. wall mounted blackboard, 1000x2000mm in size.
- 1 No. wall mounted pin board, 1000x3000mm in size.
- 1 No. shelf unit for the approved samples with 5 tiers of shelves, 400x2400mm overall.

13 Unless noted otherwise within the following schedules, as a minimum, the meeting room shall be provided with the following furniture to the approval of the Engineer:
- Very long meeting table and chairs to suit room size.
- 42" flat plasma TV, a VCR/DVD, a wall mounted projector, computer connections.
- 1 No. wall mounted white board, 1000x2000mm in size.
- 1 No. wall mounted pin board, 1000x3000mm in size.
- 1 No. wall mounted folding screen, 2000x3000mm in size, for presentations.
- 1 No. shelf unit for approved samples with 5 tiers of shelves, 400x2400mm overall.

14 Unless noted otherwise within the following schedules, as a minimum, the kitchen shall be provided with the following equipment to the approval of the Engineer:
- 1 No. stainless steel dual bowl drainer sink, hot and cold taps, cupboards underneath.
- 4 ring cooker, 1 microwave.
- Cabinets and shelves to match sink, as required.
- 1 No. 20' refrigerator.
- Sufficient pint electrical kettles and crockery and cutlery.
- A suitable number of cups, saucers and drinking glasses.

15 Corridors shall be provided with three portable dry powder fire extinguisher and 3 water coolers.

Section 1: General

16 The site office facilities, including all furniture and equipment shall become the property of the Government on completion of the Contract and shall be repaired and redecorated to the satisfaction of the Engineer and they shall then be delivered to a location designated by the Engineer within 50km of the Site.

Type 3: Engineer's Site Offices

Room No.	Post	Room Size	No.	Remarks
1	Resident Engineer (Roads)	6m x 4m	1	
2	Assistant Resident Engineer (Roads)	4m x 4m	1	
3	Assistant Resident Engineer (Utilities & Structures)	6m x 4m	1	
4	Quantity Surveyor	4m x 4m	1	
5	Planning Engineer	4m x 4m	1	
6	Highway Surveyor and Safety Officer	4m x 4m	1	
7	Inspectors (5 Nos.)	8m x 4m	1	
8	CAD Operator	4m x 4m	1	
9	Bilingual Secretary / Document Controller	6m x 4m	1	
10	Kitchen Complete		1	
11	Toilet and Shower Complete		2	
12	Lobby and Reception		1	
13	Archives		1	
14	Store Room		1	
15	Samples Room		1	
16	Server Room		1	
17	Printing / Plotting Room		1	
18	Conference Room		1	
19	As designated by Engineer		1	
20	As designated by Engineer		1	
21	As designated by Engineer		1	
22	As designated by Engineer		1	
23	Shaded Car Park		30	
24	Elevated Water Tank		1	
25	Underground Septic Tank		1	
26	Generator / Generator Room		1	
27	Paved Walkways, Steps			
28	Lit Parking Lot and Access Road		1	
29	Landscaping Area		1	

Section 1: General

Type 3: Engineer's Site Furniture

Room Number	Post	XLD	LD	D	CHB	CLB	CT	MT	Cub	Cab	AC	PC	Sc	P	S	PB
1	Resident Engineer (Roads)		1		1	8		1	2	2	2S	1*	19"	1*	1	2
2	Assistant Resident		1		1	1			2	2	1S	1*	19"	1*	1	1
3	Assistant Resident		2		2	2			2	2	2S	2*	19"	2*	2	2
4	Quantity Surveyor		1		1	1			1	1	1S	1*	19"	1*	1	1
5	Planning Engineer		1		1	1			1	1	1S	1*	19"	1*	1	1
6	Highway Surveyor - Safety		2		2	2			2	2	1W	2*	19"	1*	2	2
7	Inspectors (5 Nos.)		6		6	4			3	3	2W	6*	19"	2*	6	6
8	CAD Operator		1		1	1			1	1	1W	1*	19"	1*	1	2
9	Bilingual Secretary / Document Controller		2		2	2			2	2	2S	2*	19"	2*	2	2
10	Kitchen Complete	Refer to item 14 of Engineer's Site Office Facilities – Type 3 above														
11	Toilet & Shower Complete	Refer to item 11 of Engineer's Site Office Facilities – Type 3 above														
12	Lobby & Reception										2S					
13	Archives			2							2W				1	2
14	Store Room							1			1W					
15	Samples Room							1			1W					
16	Server Room										1W					
17	Printing / Plotting Room							1			1W					
18	Conference Room					16	1				2S				1	2
19	As designated by Engineer	1			1	2		1	1	1	2S	1**	19**	1**	1	1
20	As designated by Engineer		1			2		1	1	1	1S	1**	19**	1**	1	1
21	As designated by Engineer	1			1	2		1	1	1	2S	1**	19**	1**	1	1
22	As designated by Engineer		1			2			1	1	1S	1**	19**	1**	1	1

XLD	Executive Large Desk with 2x3 locking drawers, L shape	**Sc**	Screen, Size indicated, L for flat LCD
LD	Large Desk with 2x3 locking drawers, L shape	**P**	Printer, HP LaserJet A4
D	Straight Desk with 1x3 locking drawers	**Sh**	Shelves, as required
CHB	Chair, High Back, (Room 19 and 21 leather chair)	**PB**	Pin Board, as required
CLB	Chair, Low Back or Visitor Chair (Meeting Table)		
CT	Conference Table		
MT	Meeting Table / Stacking Table		
Cab	Cabinet, vertical, 2 x 6 locking drawers		
Cup	Cupboard		
AC	S: Split Unit, 2.5 tons W: Window Unit, 2.5 tons (All units heating/cooling)		
PC	Personal Computer with screen, on network, See Specifications		

* Computers and printers will be supplied by the Consultant for the use of his staff. The Contractor shall provide and maintain network cable infrastructure, power and data outlet points, internet connections including payment of bills for the Consultants. Internet connectivity shall be of sufficient bandwidth to enable the timely and efficient uploading/downloading of electronic documents and files into the Programme's internet-based collaboration environment provided by the Engineer.

** Computers and printers for the use of the Engineer shall be provided and maintained by the Contractor, in addition to cabling, internet connections, etc.

PART 13 SETTING OUT OF THE WORKS

13.3 LEVELS AND REFERENCE GRID

13.3.2 Site Grid

Delete paragraphs 1 and 2 and substitute with the following:

1 Should the Contractor choose to establish a local site grid then the grid shall be tied to the Qatar National Grid and a survey report provided to the Engineer which establishes the process for conversion between the two.

PART 16 TRAFFIC DIVERSIONS

16.1 GENERAL

Add new Sub-Clause 16.1.6 as follows:

16.1.6 Traffic Safety and Control Officers

1 The Contractor shall appoint a Traffic Safety and Control Officer at the commencement of the Works. The name, address and telephone number(s) (both on and off-site) of the Traffic Safety and Control Officer shall be notified to the Engineer, the Traffic Police and any relevant authority. The Traffic Safety and Control Officer shall be a direct employee of the Contractor and shall not be an employee of a sub-contractor. He shall be experienced in traffic safety and management on similar highway projects, and shall be responsible on behalf of the Contractor for:

(a) liaison with the Engineer, any relevant highway authority, and the police in all matters relating to traffic safety and management;
(b) the establishment, resourcing commissioning prior to the commencement of any work and the decommissioning and removal of all traffic management systems on completion of that element of work;
(c) the management of traffic during periods when traffic restrictions are in place and for ensuring that all traffic safety and management requirements are met;
(d) immediately notifying the Traffic Police, the Engineer and the Contractor of any accidents, spillages or emergencies;
(e) ensuring the safe working of plant, machinery and personnel and ensuring that all personnel engaged in the Works are aware of the Contractor's obligations and duties in respect of site safety when working on trafficked highways.
(f) notifying the Engineer of any deterioration in Traffic Management Equipment and trafficked road surface;
(g) monitoring the flow of traffic within the Traffic Management Area to detect any incident resulting in stationary or delayed traffic and reporting to the Engineer.
(h) submitting information sheets weekly to the Engineer logging all Traffic Management Operations and advising the expected duration of the current system, together with notice of the programmed commencement/duration of the next system;
(i) submitting information sheets weekly to the Engineer logging all incidents and the consequential effect on the Works and, when called, all movements of the emergency vehicles. For the purposes of this Clause, an 'incident' is defined as a shed load, vehicle breakdown, vehicle abandonment, or traffic accident, whether or not the latter involves personal injury;
(j) assisting any member of the public by ensuring that a breakdown recovery vehicle is called when required;
(k) ensuring that no employee of the Contractor or any sub-contractor (not associated with the Traffic Management Operation) enters any part of a carriageway which is not properly signed and coned off. Ensuring that employees of the Contractor or sub-contractor are individually and specifically warned not to step on to any part of the highway which is open to traffic except to cross at designated crossing points when required to access other parts of the Works;
(l) notifying the Engineer of any deterioration of safety precautions including traffic signs, temporary road markings, road surface, safety zones, works access provisions and ensuring that rectification is carried out in accordance with the relevant specified standards;
(m) ensuring that all standing plant, equipment and materials within closed off areas on the highway are "coned-off", placed tidily and in positions so as to minimise

restrictions on the passage of vehicles using the highway and so as not to inhibit sight lines for traffic;

(n) checking that lanes, carriageways or roads temporarily closed to traffic are to be reopened at the programmed time and confirming this to the Engineer by means of an agreed pro-forma;

(o) informing all personnel employed on the Works of any changes to the Traffic Management System which may affect their access or egress to the Site, or their working conditions.

2 The Contractor shall appoint at least one deputy Traffic Safety and Control Officer who shall be a direct employee of the Contractor, but not a sub-contractor, and be experienced in traffic safety and management on similar highway projects. The deputy shall undertake the responsibilities of the Traffic Safety and Control Officer when the latter is absent. The name, address and telephone number(s) both on and off-site of the deputy Traffic Safety and Control Officers shall be notified to the Engineer the police and any relevant authority. Contact with either the Traffic Safety, Control Officer or his deputy, shall be possible at all times.

3 The Traffic Safety and Control Officer and his Deputy shall be able to contact the Contractor's main office at any time.

4 The Traffic Safety and Control Officer shall patrol all traffic management systems in service at two hourly intervals to ensure that any defect is immediately corrected.

16.2 TEMPORARY TRAFFIC DIVERSIONS

16.2.1 General Requirements

Delete paragraph 3 and substitute with following:

3 Where paved carriageways, unpaved carriageways or ramps are required, they shall be provided and maintained to a standard suitable in all respects for the class or classes of traffic or pedestrians requiring to use them. The surface provided shall be equivalent to the surface of the existing carriageway or footway.

16.2.2 Maintenance of Traffic flow

Delete Sub-Clause 16.2.2 and substitute with the following:

1 The Contractor shall allow for the construction of temporary diversions to permit all existing traffic movements for the full duration of the Contract period. Temporary diversion routes may be required to be altered or rerouted during the course of the Contract and the Contractor shall allow for this as necessary. Prohibition of any traffic movement, including those shown cut off in the traffic diversion drawings shall be to the approval of the Engineer. Cut off traffic movements shall be properly compensated by installing alternative traffic diversion routes.

Section 1: General

2 The Contractor shall prepare and maintain a comprehensive Temporary Traffic Management Plan (TTMP) which shall encompass all traffic diversions required throughout the duration of the contract. It shall provide for working drawings, supporting descriptions and documentation of all proposed traffic diversions within, and outside, the Limit of Works resulting from the Works. The TTMP shall be maintained as a working document that is under continual review. The Contractor shall coordinate the TTMP with, and obtain the approval from the Engineer, Traffic Police and relevant PWA concerned departments and other authorities as may be required.

3 Traffic diversions shall be designed by an International Roads Engineering Consultant accredited by PWA and shall be submitted for both the Engineer and Traffic Police approval prior to implementation. Traffic diversion drawings shall be accompanied by traffic reports prepared by the International Roads Engineering Consultant and presentations to the higher authorities as necessary. The traffic reports shall be supported with data of existing and expected traffic volumes during the course of the contract period. Analysis of traffic volumes at junctions and on road links shall be carried out using industry standard software, or as may be specified by the Engineer.

4 The Contractor shall carryout traffic surveys by an accredited company, including automatic traffic counts and manual classified counts at the main roads, and turning movement counts at the existing junctions, to determine the current level of service and forecast level of service at the junctions upon the implementation of the temporary traffic diversion. Unless otherwise agreed with the Engineer, the main junctions shall perform at a Level of Service “D” as a minimum. Upon the Engineer’s request, the Contractor shall install and commission additional temporary traffic signals capable of handling the diverted traffic.

5 Where traffic diversion drawings are included within the Project Documentation, these shall be considered to be conceptual only, and they shall indicate the main traffic diversion scheme and stages representing the absolute minimum traffic management requirements. At the discretion of the Engineer, the final traffic diversion drawings may show an increased number of lanes at critical locations should the need arise and they may allow for local access points as appropriate. The Contractor shall be responsible for producing drawings which detail the secondary diversions to the local branching roads, and which detail the interim diversions to suit the Contractor’s sequence of work.

6 The temporary traffic diversions shall include, but not be limited to, earthworks, pavement construction, directional signs, traffic signs, road markings, safety barriers, temporary street lighting, temporary traffic signals (if required), relocation of existing street furniture, relocation/protection of underground existing services, reinstatement of permanent works, and subsequent removal of all temporary diversion works, all to the approval of the Engineer, Traffic Police and the other concerned PWA departments and authorities. Power supply for lighting can be from permanent or temporary supplies subject to agreement with the relevant authority.

7 Traffic diversions shall be constructed and maintained in accordance with the UK’s Traffic Signs Manual, Chapter 8 unless otherwise specified by the Engineer. It is the Contractor’s responsibility to ensure that any traffic diversion required is properly signed, demarcated, illuminated and lit as per the category of the diverted road, controlled and maintained at all times. The Contractor shall submit his traffic diversion plans to the Engineer and no diversions shall be put in place until approval is obtained from the Engineer.

8 Special attention shall be given when joining with existing roads and junctions to ensure smooth transitions and ride-ability. Encountered manholes and chambers shall be adjusted to be flush with the traffic diversion. The Contractor shall not open any traffic diversion without the written approval of the Engineer.

Section 1: General

9 Sequential arrow boards operating on a 24-hour basis (engine or solar powered) must be used at all diversion points. The Contractor is to allow for any day-time glare and ensure that arrows are capable of being seen sufficiently by drivers in advance of the diversion and as required by the UK's Traffic Signs Manual, Chapter 8.

10 Within the limits of the project where pedestrian traffic is present, all excavated areas, regardless of depth, must be cordoned off by means of wired mesh panels of a height no less than 1.8 m connected together to form a continuous barrier wall. All existing pedestrian routes shall be kept open at all times for the full duration of the Works. Where a pedestrian route is required to be diverted or realigned, a minimum width of 2.0 m is to be applied to the diverted / realigned route. Where it is impractical to meet the 2.0 m width requirement, a reduced width shall be agreed with the Engineer.

11 The Contractor must ensure that all temporary roads, diversions to be operating in a safe manner. Traffic must be maintained on hard surface asphalt roads free of any dirt, debris, holes and other obstacles. Redundant paint markings are to be removed completely so as not to cause confusion with new temporary paint markings. Redundant paint markings shall not be considered to have been removed completely until written agreement has been provided by the Engineer.

12 Upon approval from the Engineer on any road closure or temporary diversion or realignment for the purpose of carrying out the Works of PWA, the Contractor shall place a sufficient notification to the general public in three local newspapers, coloured, and both in the Arabic and English languages at least on one (1) week and also again on three (3) days prior to the road closure, diversion or realignment. The contents of notification shall be approved by the Engineer and the extent shall not be less than a half of the standard size page of a reputed local newspaper. In order to evident the notification the Contractor shall submit to the Engineer a copy as appeared on the newspaper on the same day of the notification.

PART 20 CLEARANCE OF SITE

20.2 FINAL CLEARING

20.2.3 The Site

Delete paragraph 3(b) and substitute with the following:

3 (b) In the case of Contractor's delay or refusal to carry out such a job, he shall have to pay a penal compensation of QR 5,000 for delay for each day or part of day. This compensation shall be final and the judiciary shall not be entitled to mitigate it and it does not require establishing the occurrence of any damage to the owner.

SECTION 3 GROUND INVESTIGATION

PART 3 PITS AND TRENCHES

3.2 PITS AND TRENCHES GENERALLY

3.2.5 Backfilling and Restoration

Add new paragraph 5 as follows:

5 Restored surfaces shall match the existing surface in both level and appearance.

PART 4 SOIL SAMPLING

4.4 GROUNDWATER SAMPLES

Delete paragraph 1 and substitute with the following:

1 Groundwater samples shall be taken from each exploratory hole where groundwater is encountered. Where more than one groundwater level is found, each one shall be sampled separately. Where water has been previously added, the water shall be baled out before sampling so that only groundwater is present. The sample volume shall not be less than 0.25 litre.

Where groundwater is to be sampled from rotary drilled holes using water flush the sample shall, where practicable, be taken at the start of the subsequent shift; the hole having been baled out at the end of the previous shift. A sample of the flushing water shall be taken for analysis at the same time.

PART 5 IN-SITU TESTING, INSTRUMENTATION AND MONITORING

5.2 TESTING, INSTRUMENTATION AND MONITORING GENERALLY

5.2.2 Instrumentation and Monitoring

Add new paragraph 7 as follows:

7 Previously constructed boreholes and piezometers within the Right of Way as well as those put down by the Contractor shall be suitably marked and protected for as long as practicable during the execution of the Works. The Engineer's written agreement shall be obtained before any of these are destroyed. Any destroyed without prior agreement shall immediately be replaced by the Contractor. Regular monitoring of water levels in these piezometers and boreholes is to be conducted throughout the entire period of the Works. The regularity of the monitoring shall be to the written approval of the Engineer.

5.3 TESTS

5.3.2 Tests in accordance with BS 5930

Add new paragraph 2 as follows:

2 For all in situ permeability testing the Contractor shall establish and record all relevant data relating to the history of boring the hole and the apparent natural groundwater level. He shall interpret the test results only once conditions at the time of test have become established by subsequent monitoring.

SECTION 4 FOUNDATIONS AND RETAINING STRUCTURES

PART 2 CONCRETE WORKS FOR PILING

2.2 MATERIALS

2.2.4 Admixtures

Delete paragraph 1 and substitute with the following:

1 Admixtures, when used, shall comply with BS 5075. For use of admixtures refer to Section 5, Part 5.

PART 4 DEEP FOUNDATIONS

4.3 BORED CAST IN PLACE PILES

4.3.2 References

Delete paragraph 1 and substitute with the following:

1 The following codes of practice are referred to in this Part:

BS 8008, Guide to safety precautions and procedures for the construction and descent of machine-bored shafts for piling and other purposes

BS 5930, Code of practice for site investigations

4.3.3 Quality Assurance

In paragraph 1(a) Inspection, replace BS 5573 with BS 8008.

4.4 BORED PILES CONSTRUCTED USING CONTINUOUS FLIGHT AUGERS AND CONCREET OR GROUT INJECTION THROUGH HOLLOW AUGER STEMS

4.4.3 Boring

Add new Paragraph 6 as follows:

6 Specified Pile Diameter

The diameter of a pile shall not be less than the specified diameter. The cutting head width shall be checked as necessary and recorded for each pile to ensure the specified diameter is achieved and that the width is greater than the diameter of the following flight. A tolerance of + 5% - 0 on the cutting head width is permissible.

SECTION 5 CONCRETE

PART 2 AGGREGATES

2.1 GENERAL

2.1.4 Source Approval

Add new paragraph 9 as follows:

9 The Contractor shall ensure that the sources of all aggregate have been approved by the PWA.

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2.2 QUALITY AND TESTING

Delete Table 2.1 and substitute with the following:

No.	Requirement	Test Methods[1]		Permissible Limits	
		BS / EN	ASTM	Fines	Coarse
1.	Grading	933		Standard	Standard
2.	Natural: material finer than 0.063 mm.	933		3% max	2% max
	Crushed rock: materials finer than 0.063mm			7% max	2% max
3.	Fines quality (a) Structural Concrete Sand Equivalent (%)	933-8		60% min[2]	
	(b) Non-structural Concrete Methylene blue absorption value[3] (0/2mm)	933-9		1.0 g/kg max	
4.	Clay lumps and friable particles		C142	2% max	2% max
5.	Lightweight pieces		C123	0.5% max	0.5% max
6.	Organic impurities for fine aggregates		C40	Color standard not darker than plate No. 3[4]	N/A
7.	Water absorption (saturated surface dry)	1097-6		2.3% max	2.0% max
8.	Particle density for normal weight concrete.	1097-6		2.0 min	2.0 min
9.	Shell Content:	933-7		3% max	3% max
10.	Particle Shape	933-3			
	Flakiness index				35% max
	Elongation index (reinforced concrete)				35% max
	Elongation index (unreinforced concrete)				45% max
11.	Acid-soluble chlorides:	1744-5			
	a) Reinforced concrete and mass concrete			0.06% max	0.03% max
	a) Prestressed concrete and steam cured structural concrete[5]			0.01% max	0.01% max
12.	Acid-soluble sulphate	1744-1		0.4% max	0.3% max
13.	Soundness by magnesium sulphate (5 cycles)	1367-2		15% max	15% max
14.	Mechanical Strength:				
	10% fines value (dry condition)[6]	812- 111			150 kN min[7]
	Loss by Los Angeles abrasion Aggregate Crushing Value	1097-2			30% max
15.	Drying shrinkage	1367-4			0.075% max
16.	Potential reactivity:	See Note 8 below			

Section 5: Concrete

Notes:

1. Use of BS EN or relevant GSO standards.
2. If the Sand Equivalent value is less than 60% and greater than or equal to 50%, the sand shall be considered non-harmful and is accepted provided that the Methylene Blue value is less than or equal to 1.0 (g/kg).
3. Not required when the fines content in the fine aggregate, or in the all-in aggregate, is 3% of less.
4. Organic impurities: use of a fine aggregate failing in the test is not prohibited, provided that:
   a. The discoloration is due principally to the presence of small quantities of coal, lignite, or similar discrete particles.
   b. When tested for the effect of organic impurities on strength of mortar, the relative strength at 7 days, calculated in accordance with ASTM C87, is not less than 95 %.
5. If the chloride content is higher than 0.01% the following steps may be taken:
   a. The aggregates may be washed by suitable water (Sec 5 Part 4) before mixing to lower the chloride content to the specified value (0.01%).
   b. If the washing process does not reduce the chloride content to the required value, then the Acid Soluble Chloride content in the concrete ingredients (the sum of the contributions from the constituent materials) shall be tested as mentioned in BS 8500-2. The allowable Acid Soluble chloride content limit shall not exceed the values given in Section 5, Part 6, Para 6.5.3.
6. The limit of 10% fines value (dry condition) is for 20mm aggregates. Reference BS 812-111.
7. Applicable only for 20mm aggregate, for high strength concrete using 10mm aggregates the 10% fines value shall be at least 100Kn.
8. The alkali-aggregate reactivity shall be assessed at source in accordance with BS 206-1 and BS 8500-2. Certification shall be obtained from the aggregate source indicating absence of deleterious expansion of concrete due to alkali aggregate reactivity.

PART 3 CONCRETE PLANTS

3.2 SOURCE APPROVAL

Insert the following sentence at the start of paragraph 1:

All cement shall be manufactured by Qatar National Cement Company or other manufacturer as approved by the PWA.

PART 7 BATCHING AND MIXING

7.4 READY-MIXED CONCRETE

7.4.1 General

Add new paragraph 17 as follows:

17 Dry batch mixing shall not be permitted.

PART 8 TRANSPORTATION AND PLACING OF CONCRETE

8.3 PLACING CONCRETE

8.3.3 Placing

Delete paragraph 21 and substitute with the following:

21 Wherever necessary and as required by the Engineer, waterstops of a type acceptable to the Engineer shall be embedded in the concrete. The waterstop should be made of a high quality material, which must retain its resilience through the service life of the structure for the double function of movement and sealing. The surface of waterstops should be carefully rounded to ensure tightness of the joint even under heavy water pressure. To ensure a good tightness with or without movement of the joints, the waterstop should be provided with anchor parts. The cross-section of the waterstops should be determined in accordance with the presumed maximum water pressure and joint movements. The complete works of fixed and welded connections must be carried out strictly in accordance with the manufacturer's instructions.

Water stops shall be carefully maintained in position prior to concreting on accurately profiled stop boards to create rigid conditions.

PART 9 FORMWORK

9.3 CLASS OF FINISH AND MATERIALS

9.3.1 Unformed Surfaces

Delete paragraph 1 and substitute with the following:

1 Unformed surfaces shall be classified as either

Class U1 finish. The concrete shall be levelled and screeded to produce a uniform surface to the profile shown on the Drawings. No further work shall be applied to the surface unless it is used as a first stage for another class of finish.

Class U2 finish. After the concrete has hardened sufficiently, the Class U1 finish shall be floated by hand or machine sufficiently only to produce a uniform surface free from screed marks.

Class U3 finish. When the moisture has disappeared and the concrete has hardened sufficiently to prevent laitance from being worked to the surface, a Class U1 finish shall be steel-trowelled under form pressure to produce a dense, smooth uniform surface free from trowel marks.

Class U4 finish. The concrete shall be levelled and screeded to produce a uniform surface. When the concrete has sufficiently hardened and the bleed water evaporated the surface shall be trowelled to produce a hard dense surface, free from screed marks and exposed aggregate. Finally the surface shall be lightly textured with a wooden float or equivalent.

Alternatively the concrete shall be levelled, screeded and floated to produce a uniform surface and immediately before the waterproofing operation this surface shall receive surface preparation by water jetting or grit blasting to provide a lightly textured finish.

The finished surface shall not deviate from the required profile by more than 10 mm over a 3 m gauge length or have any abrupt irregularities more than 3 mm.

Class U5 finish. The concrete shall be levelled and screeded to produce a uniform finish. When the concrete has sufficiently hardened to prevent laitance being worked to the surface it shall be floated to produce a surface free from screed marks and exposed aggregate. Finally the surface shall be textured to suit the requirements of the particular waterproofing and surfacing system. The accuracy of the finished surface shall be such that it does not deviate from the required profile by more than 5 mm over a 3 m length or have any abrupt irregularities.

Other classes. The finishes shall comply with the specific requirements and approved by the Engineer.

Delete paragraphs 6 and 7.

9.3.2 Surface Finish Classifications

Delete paragraph 2 and substitute with the following:

2 Class F1. Formwork for Class F1 finish shall be constructed of timber, or any suitable materials which will prevent loss of grout when the concrete is vibrated.

Class F2. The irregularities in the finish shall be no greater than those obtained from the use of wrought thickness square edged boards arranged in a uniform pattern. The finish is intended to be left as struck but imperfections such as fins and surface discolouration shall be made good.

Class F3. The resulting finish shall be smooth and of uniform texture and appearance. The formwork lining shall leave no stain on the concrete and shall be so joined and fixed to the backing that it imparts no blemishes. It shall be of the same type and obtained from only one source throughout any one structure. The Contractor shall make good any imperfections in the finish. Internal ties and embedded metal parts shall not be used.

Class F4. The requirements for Class F4 are as for Class F3 except that internal ties and embedded metal parts shall be permitted. The ties shall be positioned only in rebates.

Class F5. The resulting finish shall be smooth and of uniform texture. Any blemishes and imperfections, such as discolouration and fins, shall be made good. Provision for the embedment of metal parts in the Permanent Works on a regular spacing, shall be allowed.

Other classes. The finishes shall be approved by the Engineer.

Permanently exposed concrete surfaces to all Classes of finish other than F1 shall be protected from rust marks and stains of all kinds. All formwork joints for all classes of finish other than F1 shall form a regular pattern with horizontal and vertical lines continuous throughout each structure and all construction joints shall coincide with these horizontal or vertical lines.

9.3.3 Formwork Materials

Delete paragraphs 1, 2 and 3 and substitute with the following:

1 Design and construction. The formwork shall be sufficiently rigid and tight to prevent loss of grout or mortar from the concrete at all stages and for the appropriate method of placing and compacting. The plywood at the external sides of the box girder or voided slab bridges shall be (18 mm thick) marine ply. Treated Commercial plywood with polyurethane varnish (3 coats) coating or other approved lining may be permitted at curved faces and internal web faces, subject to Engineer's approval.

2 The formwork shall be so arranged as to be readily dismantled and removed from the cast concrete without shock, disturbance or damage. Where necessary, the formwork shall be so arranged that the soffit form, properly supported on props only, can be retained in position for such period as may be required by maturing conditions and Cl 9.5.2 of the QCS Section 5. If the component is to be prestressed whilst still resting on the soffit form, provision shall be made to allow for elastic deformation and any variation in weight distribution.

3 Where it is intended to re-use formwork it shall be thoroughly cleaned and made good.

4 Internal metal ties which require to be withdrawn through hardened concrete shall not be used where either face is permanently exposed. Where internal ties are left in, they shall be provided with a mortar cover of at least 50 mm. The pocket shall be scabbled and dampened immediately prior to mortar filling. Cleaning and treatment of forms. The faces of the forms in contact with the concrete shall be clean and treated with a suitable release agent.

5 Immediately before concreting, all form shall be thoroughly cleaned out. The source of any compressed air used for clearing of foreign matter from formwork shall be free from oil and other contaminant.

6 Projecting reinforcement and fixing devices. Where holes are needed in forms to accommodate projecting reinforcement or fixing devices, care shall be taken to prevent loss of grout when concreting or damage when striking forms.

7 All void forming material shall be expanded polystyrene with properties as detailed below:

Cross breaking strength – kN/m² minimum	140
Compressive stress kN/m² minimum at 10% compression	70
Water vapour transmission at 38 °C and 90% relative humidity, microgramme metres/newton hour (Mgm/Mh), maximum per 50 mm sample thickness	25
Thermal conductivity W/m² °C at 10 °C mean temperature, maximum	0.037
Dimensional stability at 80 °C per cent maximum	0.5

9.3.4 Exposed Concrete Surfaces Finishes

Delete paragraphs 1 and 4.

9.4.11 Cambers

Delete paragraph 3 and substitute with the following:

3 Allowance shall be made for compression and settlement of the formwork on line and level.

The Contractor shall carry out required investigation (such as plate bearing tests, etc.) to confirm the bearing capacity and settlement of the formwork/falsework supporting ground as instructed by the Engineer.

PART 10 CURING

10.2 CURING

10.2.3 General Requirements

Add new paragraph 9 as follows:

9 In exceptional weather or other conditions the curing period may be varied by the Engineer or his designated representative without additional payment to the Contractor.

10.2.4 Curing of Formed Surfaces

Delete paragraph 2 and substitute with the following:

2 When the forms are stripped within 10 days of the pour, curing shall continue by the same method as unformed surfaces for the remainder of the 10 days.

PART 11 REINFORCEMENT

11.2 REINFORCING MATERIALS

11.2.1 Reinforcing Bars

Add new paragraphs 5 & 6 as follows:

5 Mild steel bars, if used, shall have a minimum yield stress of 250n/mm^2.

6 Plain round bars shall not be used.

11.5 FIXING OF REINFORCEMENT

11.5.2 Welding

Add at the beginning of paragraph 1:

Welding shall not be used in bridge decks reinforcement.

11.5.3 Mechanical Splices

Add new paragraph 3 as follows:

3 Mechanical splices shall have satisfactory fatigue properties for their location in the structure.

11.5.7 Cover

Delete paragraph 2 and substitute with the following:

2 Minimum cover to ends and sides of reinforcement shall be as follows:

- To deck reinforcement (all types) 50 mm
- To foundation, piers and walls within the groundwater and capillary rise zones 75 mm
- To backfilled areas which are above the groundwater and capillary rise zones 50 mm
- To abutting faces at movement/contraction joints 50 mm
- To exposed faces of walls and piers 50 mm
- To exposed faces to marine environment in direct contact with soil 100 mm
- Bored or cast piles 75 mm

PART 12 JOINTS

12.1 GENERAL

12.1.3 Submittals

Delete paragraph 1.

12.2 CONSTRUCTION JOINTS

12.2.1 General

Delete paragraphs 1 to 9 inclusive and substitute as follows:

1 The position of construction joints shall be as shown on the Drawings. When concrete is placed in vertical members, walls, columns and the like, the lifts of concrete shall finish level or, in sloping members, at right angles to the axis of the members, and the joint lines shall match features of the finished work, if possible, or be formed by grout checks. Kickers shall be constructed integrally with the lift of concrete below.

2 Concreting shall be carried out continuously up to construction joints.

3 Construction joints shall be prepared in either of the following ways

(i) When the concrete is self-supporting but still sufficiently green, the formwork shall be removed, as necessary to expose the construction joint, subject to the requirements of QCS Section 5, Part 10. The concrete surface shall be sprayed with a fine spray of water or brushed with a stiff brush, just sufficiently to remove the outer mortar skin and expose the larger aggregate without disturbing it. Alternatively where this preparation proves impracticable the hardened surface skin and laitance shall be removed by grit blasting or a needle gun. Hardened surfaces shall not be hacked.

(ii) By the use of proprietary steel open-mesh permanent formwork.

4 Retarding agents shall not be used unless approved by the Engineer.

5 The joint surface shall be clean and damp but free of standing water immediately before any fresh concrete is placed against it.

12.2.2 Construction Joints in Water Retaining Structures

Add the following paragraphs after paragraph 9:

10 Where the Contractor wishes to introduce a construction joint between movement joints he shall submit his proposals to the Engineer for approval.

11 Water stop shall be incorporated into construction joints in water retaining structures. Any joint that leaks or weeps shall be rectified by the Contractor to the Engineer's satisfaction.

12 Where the Contractor is responsible for the design of the structure, control of early thermal contraction and restrained shrinkage shall be by Options 2 or 3 of Table 5.1 of BS 8007.

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12.3 MOVEMENT JOINTS

12.3.1 General

Add new paragraph 4 as follows:

4 Stainless steel dowels where shown in joints shall be Steel Designation 1.4429 or 1.4436 and Grade 200 or 500 steel bars complying with BS 6744.

12.3.2 Joint Filler

Add new paragraph 5 as follows:

5 All materials shall be of proprietary manufacture.

12.3.3 Joint Sealants

Delete paragraphs 1 and 5 and substitute with the following:

1 All joints to be sealed shall be formed and the groove grit blasted to remove all traces of deleterious materials such as from oil or curing compounds and also to remove any surface laitance from the sides of the joints. The joint shall be dry prior the application of priming. Where the use of grit blasting is not possible the Contractor may propose alternative methods subject to the approval of the Engineer. At least 28 days shall be allowed for initial shrinkage of new concrete prior to sealing the joint.

5 The sealant material shall be a non-biodegradable multi-component pitch polyurethane elastomeric joint sealant, carefully selected as appropriate for the specific climatic and environment exposure conditions expected. Alternative types of sealant will be considered, including epoxy-polyurethane, rubber bitumen and acrylic, subject to the requirements of the specification and the approval of the Engineer. Where the joint sealant is to be in contact with a protective coating the Contractor shall satisfy the Engineer that the sealant and protective coating are compatible.

PART 14 PROTECTIVE TREATMENTS FOR CONCRETE

14.1 GENERAL

14.1.8 General Requirements for all Treatment

Delete paragraph 4 and substitute with the following:

4 The Engineer shall specify the required final colour of the coating and the Contractor shall submit samples showing the colour before ordering the materials. If not specified elsewhere the final colour shall be white.

14.3 WATERPROOF MEMBRANE

14.3.1 General

Delete paragraph 2 and substitute with the following:

2 All foundations, abutments, and wing walls in contact with the ground shall be protected by a waterproofing membrane.

14.3.3 Waterproofing Membrane

Add new paragraph 3 as follows:

3 All field and laboratory testing of the waterproofing membrane shall be carried out by an independent laboratory approved by the Engineer.

14.3.4 Application

Delete paragraph 1 and substitute with the following:

1 Waterproofing membrane shall be protected by preformed asphaltic boards. On foundation bases the boards shall be placed over the membrane within 24 hours of its installation. Alternatively, waterproofing membrane applied at horizontal surfaces shall be protected by cement-sand protection screed.

Add new Sub-Clause 14.7 as follows:

14.7 WATERPROOFING BELOW GROUND CONCRETE SURFACES

14.7.1 General

1 Waterproofing for below ground concrete surfaces shall be in accordance EXW IAN 004 “Specification for Waterproofing of Cut and Cover Tunnel and Underpass Highway Structures”.

PART 15 HOT WEATHER CONCRETING

15.1 GENERAL

15.1.2 References

Include the following reference; BS 5400 Part 4, Code of Practice for design of concrete bridges, wherever it appears in this Part.

15.1.4 System Description

Add new paragraph 2 as follows:

2 In general the recommendations of "The CIRIA guide to Concrete Construction in the Gulf Region", ACI 305R-91 "Recommended Practice for Hot Weather Concreting" and ACI 308 "Recommended Practices for Curing Concrete" shall be followed. In case of conflict, the provisions of the QCS shall prevail.

15.2 PLACING TEMPERATURE

Add new paragraph 6 as follows:

6 Every effort shall be made by the Contractor to keep the temperature of the concrete at the time of placing as low as possible. If the temperature of the concrete is likely to exceed 24 °C at the time of placing, special measures shall be taken to control the temperature. Such measures shall be approved by the Engineer and shall include some, and if decided necessary by the Engineer, all of the following:

(a) Aggregate stockpiles shall be protected from the direct rays of the sun by shades. The stockpiles shall not be watered.
(b) Water for mixing concrete shall be cooled by means of mechanical equipment or the addition of ice. Storage tanks shall be painted white or sited under shade and distribution pipes shall be insulated or painted white
(c) Cement shall be stored in the shade. Bulk storage containers shall be painted white.
(d) The mixing plant and delivery equipment shall be painted white and sited under shade wherever possible. The interval between mixing and placing shall be kept to a minimum.
(e) Reinforcement, metal conduit, etc., shall be kept in the shade for a minimum period of four hours before concreting.
(f) Immediately before the concrete is placed, formwork, conduit, etc., shall be sprinkled with cool water.
(g) During the curing period, exposed concrete surfaces shall always be protected from the direct rays of the sun, and the formwork shall also be protected.
(h) In a prevailing arid wind, temporary wind breaks shall be provided.

15.8 PLACING AND FINISHING

Add new paragraph 4 as follows:

4 Covers shall be placed over reinforcement and steel formwork to shade it from the sun 24 hours prior to concreting. Immediately before the Concrete is placed, formwork, construction joints, etc. shall be sprinkled with cool water complying with QCS Section 5 Part 4. The Contractor shall provide and use an ample and clear water supply, hose and fog nozzle. Fogging equipment to be furnished shall be capable of applying water to the concrete in the form of a mist in sufficient quantity to curb the effects of rapid evaporation

of mixing water from the concrete resulting from wind, high temperature, low humidity or a combination of these factors. The fog mist shall be applied at times and in a manner directed by the Engineer.

PART 16 MISCELLANEOUS

16.1 GENERAL

16.1.2 References

Add new tests as follows:

ASTM C150:09, Type V	Standard Specification for Portland Cement, Sulphate Resisting Portland Cement (SRC)
AAHTO T26 Standard	Method of Test for Quality of Water to be used in Concrete

16.2 PAVEMENT QUALITY CONCRETE

16.2.3 Cement

Delete paragraph 1 and substitute with the following:

1 The general term 'cement' in this Part means the materials shown below.

Cement	Complying with
Sulphate Resisting Portland Cement (SRC)*	ASTM C150:09 Type V.
Portland blast furnace cement	BS 146 or BS EN 197-4
Specification for pozzolanic pulverised-fuel ash cement (grades C20 or below)	BS 6610

* SRC: This type of cement is a type of Portland cement in which the quantity of Tricalcium Aluminates is less than 5%.

16.2.4 Water

Delete paragraph 1 and substitute with the following:

1 Water for use in the making and curing of concrete shall conform to the requirements of AAHTO T26 “Standard Method of Test for Quality of Water to be used in Concrete".

16.6 REPAIR OF CONCRETE

16.6.1 General

Delete paragraphs 1 and 2 and substitute with the following:

1 The extent and nature of the defects in the concrete shall be established in accordance with Part 13 of this Section 5 for new concrete or following an inspection jointly undertaken by the Engineer and the Contractor where existing concrete is to be refurbished. Typical details to be noted during this inspection are:

(a) Crack less than 0.5 mm
(b) Crack greater than 0.5 mm
(c) Surface staining
(d) Crazing
(e) Surface honeycombing
(f) Extensive honeycombing
(g) Local spalling
(h) Voids greater than 10 mm deep
(i) Voids greater than 15 mm deep
(j) Exposed reinforcement
(k) Significant spoiling
(l) Displaced cracks greater than 5 mm
(m) Any other notable defect
(n) Any area that is beyond refurbishment

2 If remedial works are required the Contractor shall submit a detailed method statement identifying the specific materials to be used and the sequence of activities for the repair to the Engineer for approval. No work shall commence until the method statement has been approved. The method statement shall include but not necessarily be limited to:

(a) Material Details:

(i) Manufacturer
(ii) Product name
(iii) Application procedure
(iv) Primers required
(v) Method of application
(vi) Special precaution required
(vii) Technical details and properties
(viii) References or case studies of previous applications of a similar nature
(ix) Guarantees applicable to the use of the product in the locations to be repaired.

(b) Installation:

(i) Details of temporary scaffolding
(ii) Details of formwork
(iii) Method of mixing
(iv) Method of placing
(v) Equipment to be used
(vi) Method of supporting and protecting existing plant and equipment.

16.6.2 Honeycombing or Spalling

Delete paragraph 1 and substitute with the following:

1 Where there is honeycombed concrete or concrete damaged by physical forces such as impact that has caused spalling, the concrete shall be replaced using a high strength free flowing c**ementitious** micro-concrete. This section also applies to damage caused by gases and chemicals, notably hydrogen sulphide and chlorine.

16.6.5 Repair Methodology

Include after paragraph 4 the following:

The preferred method is high pressure water jetting specifically developed for cleaning concrete. Light mechanical breakers may be used but the use of heavy breakers shall not be allowed.

Delete paragraph 5 and substitute with the following:

5 Water jetting equipment shall be capable of using an entrained abrasive to aid cutting and cleaning. Only potable water shall be used. Provision for protecting the rest of the structure shall be made.

Delete paragraph 9 and substitute with the following:

9 Exposed reinforcement shall be blast cleaned using grit or water to Swedish Standard SIS 05 5900 Sa 2.5 (near white metal). Two coats of zinc based primer shall be applied making sure that the back face of the steel is also coated. Time between coats shall be as the manufacturer's instructions.

Delete paragraph 10 and substitute with the following:

10 Reinforcement damaged during the removal of concrete or eroded by chemical attack shall, if required by the Engineer, be repaired or replaced. Concrete breakout along the reinforcement shall continue a minimum of 100 mm past the point where non-corroded reinforcement is reached, or as directed by the Engineer. Unless otherwise directed by the Engineer, primary tension or compression reinforcement which displays a reduction in diameter due to corrosion of more than 10% shall be supplemented by reinforcement of size suitable to make up the reduction. Such new reinforcement shall be lapped with the existing sound bars for a distance of 600 mm in either direction.

Delete paragraph 17 and substitute with the following:

17 The formwork shall be inspected by the Engineer and, if approved, filled with clean water which demonstrates that the formwork is grout-tight and saturates the prepared concrete surfaces. The existing concrete shall be saturated with potable water for a period of not less than 24 hours. Where formwork is not used saturation shall be by spray. The formwork shall then be completely drained and resealed.

Add new paragraphs 27, 28, 29 and 30 as follows:

27 Where mortar is used for repair polymer modified mortar shall be mixed in a high shear pan-type mixer for the minimum time necessary to produce the required consistency. Free fall mixers may cause air entrainment and shall not be allowed. For quantities of less than 10 kg, hand mixing may be used.

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28 The mortar shall be applied by trowel over tacky bond coat in layers not exceeding the thickness recommended by the manufacturer. Each layer shall be surface scored, coated with bonding agent and allowed to take up its initial set prior to the application of subsequent layers. If sagging occurs due to the applied layer being too thick, the material shall be completely removed and fresh mortar re-applied at a reduced thickness.

29 Any fine hair cracks which develop around the perimeter of the repaired area shall be sealed after 28 days by cement grout gauged with a suitable acrylic emulsion.

30 Repairs which do not adhere and display a hollow sound when tapped with a light hammer shall be broken out completely and repeated.

PART 17 STRUCTURAL PRECAST CONCRETE

17.1 GENERAL

17.1.2 References

Delete BS 8110 and substitute BS5400 Part 4, Code of practice for design of concrete bridges.

Include BS 5400 Part 2, as implemented by BD 37/01, Loads for Highway Bridges.

The above substitutions shall apply to all references in subsequent clauses in this Part.

17.1.9 Design Loadings, Actions and Structural Members Selection

Delete paragraph 7 and substitute with the following:

7 Cover to steel shall be in accordance with QCS Section 5 Part 11.

PART 18 PRESTRESSED CONCRETE

18.1 GENERAL

18.1.2 References

Include after paragraph 1 the following:

BS 4447, Specification for the performance of prestressing anchorages for post tensioned construction
BS 4486, Specification for hot rolled and processed high tensile alloy steel bars for the prestressing of concrete

18.1.3 Submittals

Add new paragraphs 4 and 5 as follows:

4 Working Drawings

Whenever the plans do not include complete details for a prestressing system and its method of installation, or when complete details are provided in the plans and the Contractor wishes to propose any change, the Contractor shall prepare and submit to the Engineer working drawings of the prestressing system proposed for use. Fabrication or installation of prestressing material shall not begin until the Engineer has approved the drawings. The working drawings of the prestressing system shall show complete details and substantiating calculations of the method, materials and equipment the Contractor proposes to use in the prestressing operations, including any additions or rearrangement of reinforcing steel and any revision in dimensions from that shown on the plans. Such details shall outline the method and sequence of stressing and shall include complete specifications and details of the prestressing steel and anchoring devices, working stresses, anchoring stresses, tendon elongations, type of ducts, and all other data pertaining to the prestressing operation, including the proposed arrangement of the prestressing steel in the members. Working drawings shall be submitted sufficiently in advance of the start of the affected work to allow time for review by the Engineer and correction by the Contractor of the drawings without delaying the work.

5 Composite Placing Drawings

When required by the special provisions, in addition to all required working drawings, the Contractor shall prepare composite placing drawings to scale and in sufficient detail to show the relative positions of all items that are to be embedded in the concrete, and their embedment depth, for the portions of the structure that are to be prestressed. Such embedded items include the prestressing ducts, vents, anchorage reinforcement and hardware, reinforcing steel, anchor bolts, earthquake restrainers, deck joint seal assemblies, drainage systems, utility conduits and other such items. Such drawings shall be adequate to ensure that there will be no conflict between the planned positions of any embedded items and that concrete cover will be adequate. If during the preparation of such drawings conflicts are discovered, the Contractor shall revise his working drawings for one or more of the embedded items or propose changes in the dimensions of the work as necessary to eliminate the conflicts or provide proper cover. All such revisions shall be approved by the Engineer before work on any affected item is started. All costs involved with the preparation of such drawings and with making the necessary modifications to the work resulting there from shall be borne by the Contractor.

18.2 PRESTRESSING

18.2.1 General

Delete paragraph 3 and substitute with the following:

3 The system of pre-tensioning and post–tensioning shall be of an internationally recognised manufacturer and acceptable to the Engineer. Such system shall be used strictly in accordance with the manufacturer's recommendation and guidance.

18.2.3 Sheaths and Cores

Add new paragraph 8 as follows:

8 Deflected tendons. For pre-tensioning single tendons the deflector in contact with the tendon shall have a radius of not less than 5 times the tendon diameter for wire or 10 times the tendon diameter for strand. For post tensioning the deflector in contact with the tendon shall have radius of not less than 50 times the diameter of the tendon. The total angle of deflection shall not exceed 15 °C in both cases.

18.2.4 Anchorages

Add new paragraphs 4 and 5 as follows:

4 Anchorages shall be tested in accordance with BS 4447 or FIP/FIB or AASHTO-LRFD Bridge Construction Specifications. The Contractor shall furnish test certificates having endorsement of a recognised independent testing / verification agency. For each anchorage system used in the Works, the characteristic value for the anchorage efficiency shall not be less than 90%. Strength requirements for the anchorages shall be specified on the Drawings.

5 Proprietary anchorages shall be handled and used in accordance with the manufacturer's instructions and recommendations.

Delete Sub-Clauses 18.2.7, 18.2.8 and 18.2.9 and substitute with the following:

18.2.7 Grouting and Duct Systems for Post-tensioned Tendons

Planning, Trials and Basic Requirements

1 The Contractor shall undertake full-scale trials of the grout mix and of the grouting operations as required for duct installation, testing, concreting, grouting and any other associated problems. The trials are required to demonstrate that the grouting methods and procedures proposed by the Contractor will ensure that grout fills the ducts and surrounds the prestressing steel.

2 The Contractor shall submit a detailed method statement; at least 4 weeks prior to use in any trials in the Works, covering proposed materials, ducts, anchorage and vent arrangements, personnel, equipment, grouting procedures and quality control for the approval of the Engineer.

3 Full-scale trials shall be commenced at least 56 days before the planned commencement of fixing ducts for prestressing for the permanent works.

4 The trials shall incorporate all relevant details of ducts, vents, duct supports, prestressing anchorages and couplers, prestressing strands, grout inlets and outlets. The tendons shall be sufficiently tensioned such that the strands within the duct take up a representative alignment. All systems, methods and materials are to be those proposed for the permanent works and shall have been submitted to the Engineer as part of the detailed method statement required.

5 After three days the Contractor shall carefully cut or core the trial section to expose cross sections and longitudinal sections of the duct, anchorages and any other locations where required, or as further directed by the Engineer, to demonstrate that the duct is satisfactorily grouted. A report shall be prepared by the Contractor giving full details of the trial, testing results and photographs of the exposed sections.

6 Grouting of the ducts shall be shown to leave no void which has a radial dimension greater than 5% of the duct diameter (or appropriate dimension, in the case of oval ducts, anchorages, etc.) or which poses a risk to the protective system. The location of any voids with respect to grout vents and their adequate grouting and subsequent sealing, and the disposition of the steel tendons within the body of the grout shall be reported.

7 Prestressing for the permanent works will not be permitted without the prior written approval of the Engineer grouting procedures and formal acceptance of the results of the grouting procedures and formal acceptance of the results of the grouting trial.

8 The Contractor shall carry out a materials suitability assessment in accordance with the 'Grout Materials' section below.

9 Full-scale trials shall be undertaken to demonstrate that the ducts are satisfactorily grouted.

Grout Materials

10 The properties of the grout, made with the materials, and using the plant and personnel proposed for use on-site, shall be assessed for suitability for the intended purpose. This assessment shall be carried out sufficiently in advance of grouting operations to enable adjustments to be made in use of materials or plant or personnel.

11 Common and special grouts shall comply with the requirements in the 'Properties of Grout' section below. The materials assessment shall consist of the preparation of the grout, made with the materials, and using the plant and personnel proposed for use on-site, and the testing of it in accordance with 'Testing of Grout' below. The preparation shall be carried out under representative conditions of temperature expected on-site. If grouting operations are likely to cover different seasons, the assessment shall be carried out for the expected range of temperatures.

12 No departures from the sources of the materials and procedures approved as a result of satisfactory trials will be permitted without the written approval of the Engineer.

13 The grout shall consist only of Portland cement (CEM I) complying with BS EN 197-1 Class 42.5 N, admixtures complying with the 'Admixtures' section below and water complying with BS 3148.

14 Special grout shall not contain a chloride ion content of more than 0.1% by mass of the cement.

Duct Systems

15 The system of ducts, duct connectors, grouting connections, vents, vent connections, drains, transitions to anchorages and caps for anchors shall form a complete encapsulation for the tendons which is resistant to the ingress of air and water. Ducts shall be of proven corrosion resistant durable material. Ducting which may degrade or corrode during the expected life of the structure will not be permitted. The system shall be fully compatible with the prestressing anchorages, couplers and other details. Where ducts are non-conductive, metal parts of anchorages shall be electrically bounded to the adjacent reinforcement at each end of the tendon and electrical continuity of the structure over the length of the tendon shall be confirmed by testing.

16 The following air pressure tests shall be carried out on site.

Duct Assembly Verification Tests

17 Each complete duct system including vents, anchorages, anchorage caps, and where appropriate couplers and their connections, shall be air-pressure tested before concreting. Testing to a pressure of 0.01 N/mm² shall demonstrate that the system is undamaged and has been correctly assembled. The testing shall demonstrate that a loss of pressure no greater than 10% occurs after 5 minutes.

18 The minimum manufactured wall thickness of ducting shall be 2 mm. The duct rigidity and type and spacing of fixings and supports shall be such as to maintain line, position and cross section shape during concreting. Local deformation of the duct at supports shall be avoided.

19 The Contractor shall provide evidence of testing to demonstrate the following requirements:

(a) Wall thickness of ducts after tensioning of the tendons shall be not less than 1.5 mm

(b) The duct shall transmit full bond strength from the tendons to the surrounding concrete over a length no greater than 40 duct diameters.

20 Vents providing an air passage of at least 20 mm internal diameter shall be provided at the anchorages and in the troughs and crests and beyond each intermediate crest in the direction of flow of the grout at the point where the duct is one half diameter lower than the crest, (but no further than 1m from the crest). The maximum spacing of vents shall be 15 m.

21 The vent diameter and spacing may be varied in full-scale trials demonstrating the suitability of alternatives. The vents shall be rigidly connected to the ducts. Holes in the ducts shall be at least the internal diameter of the vents and shall be formed before pressure testing. All ducts shall be kept free from standing water at all times and shall be thoroughly clean before grouting. All anchorages shall be sealed by caps and fitted with grouting connections and vents. Sealing of anchorages shall permit the flow of grout through the anchor head.

22 Vents on each duct shall be identified by labelling and shall be protected against damage at all times.

23 Vents at high points shall extend to a minimum of 500 m above the highest point on the duct profile.

Grouting Equipment

24 Grouting equipment shall consist of a mixer, a storage reservoir and a pump with all the necessary connection hoses, valves, measuring devices for water, dry materials, admixtures and testing equipment.

25 The mixing equipment shall be capable of producing grout of homogenous consistency and shall be capable of providing a continuous supply to the injection equipment. The capacity of the equipment shall be such that each duct can be filled and vented without interruption and at the required rate of injection.

26 The injection equipment shall be capable of continuous operation and shall include a system for re-circulating the grout when grouting is not in progress.

27 The equipment shall provide a constant delivery pressure; it shall have a pressure gauge and a pressure relief valve to prevent pressure gauge and a pressure relief valve to prevent pressures exceeding 1 N/mm². All piping to the grout pump shall have as few bends, valves and changes in diameter as possible, and shall incorporate a sampling Tee with a locking-off valve.

28 The equipment shall be capable of maintaining pressure on completely grouted ducts and shall be fitted with a valve that can be locked off without loss of pressure in the duct.

29 During the grouting operation the Contractor shall provide adequate flushing-out plant to facilitate complete removal of the grout in the event of a breakdown of the grouting equipment or other disruption before the grouting operation has been completed. The Contractor shall demonstrate that this equipment is in full working order.

30 All equipment shall be kept free from build-up of adhering materials.

Batching and Mixing Grout

31 All materials shall be batched by mass except the mixing water and liquid admixtures which may be batched by mass or by volume. Bagged materials shall be weighed before use. The accuracy of batching shall be:

Description	% of specified quantity
(i) Dry materials, cement and admixtures	± 2%
(ii) Mixing water	± 1%

The total amount of mixing water shall include the water content of liquid admixtures.

32 Depending upon environmental or material influence (e.g. temperature, configuration of the tendon and properties of the materials used), the water/cement ratio shall be kept as low as possible having regard to the required plastic properties of the grout.

33 The maximum water/cement ratio shall be 0.40 for common grout unless specified otherwise. For special grout, the maximum water/cement ratio shall be 0.35.

34 The material shall be mixed to produce a homogeneous grout and kept in slow continuous agitation until pumped into the duct. Unless manufacturers specify otherwise, water shall be added to the mixer first, followed by the dry materials which may be added as a whole or in part in sequence until the total quantities are added. The minimum mixing time determined from grouting trials shall be adhered to.

35 The temperature of freshly mixed grout shall be between 5 ºC and 25 ºC. The maximum temperature may be increased provided trials demonstrate that the grout meets the requirements of 'Properties of Grout' below.

Injecting Grout

36 A check shall be made to ensure that the ducts, vents, inlets and outlets are capable of accepting injection of the grout. This check shall be achieved by blowing through the system with dry, oil-free air and testing each vent in turn.

37 Any water in the ducts shall be removed before grouting operations commence.

38 Grouting of the ducts shall be carried out within 28 days of installation of the tendon or as soon as is practicable thereafter, in which case additional measures shall be taken to avoid corrosion of the prestressing steel. The Engineer's written agreement to commence grouting operations shall be obtained. Injection shall be continuous and the rate of injection slow enough to avoid segregation of the grout.

39 Unless otherwise agreed by the Engineer, grout injection shall not result in more than 10 m of duct being grouted per minute. For certain applications, where ducts are outside the normal range of size (i.e. not multi-strand tendons in 80 mm - 125 mm ducts) this limit may be increased to 15 m of duct per minute.

40 The method of injecting grout shall ensure filling of the ducts and that the tendons are surrounded by grout. Grout shall be allowed to flow from each vent and the remote end of the duct until its fluidity is visually equivalent to that of the grout being injected. In the event of disagreement, testing may be carried out in accordance with 'Testing of Grout' below.

41 Following this, a further 5 litres of grout at each vent, shall be vented into a clean receptacle and then discarded. The opening shall be firmly closed. All vents shall be closed in a similar manner one after another in the direction of the flow except that at intermediate crests the vents immediately downstream shall be closed before their associated crest vent.

42 The injection tubes shall then be sealed off under pressure with a pressure of 0.5 N/mm² being maintained for at least one minute. Grout vents at high points shall be reopened immediately after 1 minute, while the grout is still fluid. Any escape of air, water or grout shall be recorded and reported immediately to the Engineer. A further pumping of grout shall then be carried out to expel bleed water - and/or entrapped air. This shall be carried out with the vents open one at a time sequentially in the direction of grouting with a further 5 litres being released at each vent.

43 The injection tubes shall then be sealed off under pressure, with a pressure of 0.5 N/mm² being maintained for at least one minute.

44 The filled ducts shall not be subjected to shock or vibration or at least 24 hours from the time of grouting.

45 When the grout has set, the grout vents shall be reopened and left open. The Engineer may require all or some of the end caps to be removed to demonstrate that they are satisfactorily filled with grout. End caps which have been removed shall then be replaced and permanently sealed against ingress of contaminants, such sealing to be proved to the Engineer.

46 If the method of demonstrating filling of the anchorage caps involves their removal, a photographic record shall be made. The record shall clearly identify the individual anchorages, and shall be included in the report to the Engineer.

47 If, in the opinion of the Engineer, there is doubt that the ducts or any part of the system are not satisfactorily filled with grout, the Engineer may require investigations to be carried out.

48 The Contractor shall keep full records of grouting for each duct in accordance with the certification scheme requirements for the installation of post-tensioning systems. Copies of these records shall be supplied to the Engineer within 24 hours of completing grouting to each duct.

49 On completion of grouting, grout vents shall be positively sealed and water proofed by a means separate from the concrete waterproofing.

Properties of Grout

The following criteria shall apply:

50 Fluidity: When tested by the method specified in 'Testing of Grout' below, the fluidity of the grout shall meet the criteria given in Table 18/1. Additionally, the fluidity (flow cone passage time) at outlets shall not vary from that of the injected grout by more than 20%.

Table 18/1: Test Requirements for Fluidity of Grout

Test Method	Immediately after mixing	At the end of the injection period subject to a minimum of 30 minutes after mixing*	At duct outlet
Cone	$\leq$ 25 s (see note)	$\leq$ 25 s (see note)	$\geq$ 10 s
*Mixing time shall be measured from the time when all of the materials are in the mixer. For pre-bagged grout the minimum time shall be 90 minutes.			
NOTE: The mixer and these limits shall be subject to the approval of the Engineer.			

51 Bleeding: When tested by the method referred to in paragraph 60 below the bleeding for common grout shall be less than 2% of the initial volume of the grout and the average of 4 successive results shall be less than 1%. The water shall be reabsorbed by the grout during the 24 hours after mixing.

For special grout there shall be no bleeding.

52 Volume Change: The volume change assessed may be either an increase or decrease. When tested in accordance with the method referred to in paragraph 60 below the volume change of common grout shall be within the range - 1% to + 5%. For grouts containing expanding agents there shall be no decrease in volume. For special grout the volume change shall be between zero and + 5%.

53 Strength: The compressive strength of 100 mm cubes made of the grout shall exceed 27 N/mm² at 7 days. Cubes shall be made, cured and tested in accordance with BS 1881.

54 Sieve Test: The grout shall contain no lumps. This shall be verified by testing as referred to in paragraph 60 below.

55 Sedimentation Test: When tested by the method referred to in paragraph 60 below the grout shall not exhibit variation in density in excess of 10% within a single test sample.

Testing of Grout

56 General: Suitability and acceptance tests for the properties of grout shall be determined in accordance with the Concrete Society Technical Report 47 "Durable Bonded Post-Tensioned Concrete Bridges". The testing requirements are summarised in Table 18/2.

Table 18/2: Minimum Test Requirements for Grout

Suitability Testing	
Fluidity	Sampled immediately after mixing, one test. Common grout: after estimated time to grout duct or minimum of 30 min. Special grout: after 90 min, two tests averaged in both cases.
Bleed Volume change Sedimentation Strength	Each sampled immediately after mixing, 3 tests averaged.
Acceptance Testing	
Fluidity	Sampled immediately after mixing, one test from mixer. After flow through duct, one test from each anchorage outlet. On completion, one test from the mixer.
Bleed Volume Change Strength	Two tests per day, one of which shall be from grout after flow through duct, taken from end anchorage outlet, the other from the mixer.
Sedimentation	One test per day for common grout, or one test per pre-bagged supplied batch (by manufacturer's reference number); subject to a minimum of one test per continuous grouting operation.

Admixtures

The following criteria shall apply:

57 General: Admixtures shall be used where required to achieve a low water/cement ratio and impart good fluidity, minimum bleed and volume stability or expansion to the grout to comply with paragraphs 54 to 59 above. For common grout admixtures should be added on-site during the mixing process and used in accordance with the manufacturer's recommendations. For special grout the admixtures shall form a pre-blended component.

58 Types: Admixtures are divided into two types, expanding and non-expanding and they may be used to obtain the required grout performance. Admixtures used in combination shall be checked for compatibility.

59 Chemical Composition: Admixtures shall not contain substances in quantities which will adversely affect the grout or the corrosion protection of the prestressing steel.

60 Material Requirements: The admixture shall not segregate and shall be uniform in colour. The composition shall not change and the supplier shall operate a quality system

complying with BS EN ISO 9001: 1994 or BS EN ISO 9002: 1994. The quality system shall be certified by an accredited third party acceptable to the Engineer.

Where appropriate, admixtures shall comply with BS EN 934-4. Other admixtures shall be permitted provided they satisfy Clause 8 of BS EN 934-2 and full account is taken of their effects on the finished product and their fitness for purpose. Data on their suitability, including previous experience with such materials, shall be made available and records of the details and performance of such materials shall be maintained.

It should be noted that additional information beyond that required by Clause 8 of BS EN 934-2 must be provided by the manufacturer for admixtures bearing CE marking (see ZA.2.2 and ZA.3 of BS EN 934-2).

61 Corrosion: Grout admixtures shall not cause the grout to promote corrosion of the prestressing steel by rusting, pitting, stress corrosion or hydrogen embrittlement.

62 Dosage: The optimum dosage of any admixture shall be determined by trial mixes with the cement to be used in the grout. This dosage shall be expressed as per cent by mass of the cement. It shall be within the range recommended by the supplier and shall not exceed 5% by mass of the cement. The method of measuring dosage and checking weights of pre-packed dry materials shall comply with section 'Batching and Mixing of Grout' above.

SECTION 6: ROADWORKS

PART 1 GENERAL

1.6 TEMPORARY FENCING

Delete paragraphs 1 and 2 and substitute with the following:

1 Temporary fencing shall be appropriate to the usage of the adjoining land and unless otherwise described on the Drawings shall be a post and six wire (strained) fence, 1.2 m high subject to the approval of the Engineer.

2 As soon as the Contractor is placed in possession of any part of the Site he shall immediately erect fencing on the Site boundaries. In places where permanent fencing cannot be erected immediately or where none is required, the Contractor shall erect, and when and where required re-erect and maintain, temporary fencing and subsequently take down and remove as necessary.

PART 10 VEHICLE CRASH BARRIERS

10.1 GENERAL REQUIREMENTS

10.1.3 Performance Requirements

Delete paragraph 4 and substitute with the following:

4 The Contractor shall refer to EXW IAN 002 for safety barrier performance levels.

PART 11 KERBS, FOOTWAYS AND PAVED AREAS

11.1 GENERAL

11.1.4 Quality Assurance

Delete paragraph 1 and substitute with the following:

1 The Contractor shall carry out tests on the concrete mix before beginning manufacture of precast kerbs and other items to prove that strength and surface finish requirements can be met. The Contractor shall recommend an alternative tested mix to the Engineer for approval should the strength and finish not meet the specification.

11.2 KERBS

11.2.3 Laying

Delete paragraphs 1, 2 and 6 and substitute with the following:

1 Kerbs shall be laid to the design levels and lines by means of survey. Kerbs shall not be laid by means of direct measurement from pavement layers.

2 Unless otherwise indicated, elements shall be laid directly onto a wet-concrete base or onto a sand/cement (3:1) mortar bedding, 25 mm thick, on a previously laid concrete base or approved subbase.

6 Immediately after any concrete is in place, and for seven days thereafter, the kerbs, base, and backing shall be fully cured and protected from drying out and against the harmful effects of weather, including rain and rapid temperature changes to the requirements of QCS Section 5 Part 10 Curing.

11.4 LAYING PRECAST CONCRETE BLOCKS

Delete paragraph 2 and substitute with the following:

2 A laying course consisting of washed sand, which complies with Table 8.2, shall be constructed. The sand shall be placed in a moist but not saturated condition and shall be compacted so that a laying course thickness of 50 mm is formed. This sand shall be placed on a compacted aggregate subbase or base 200 mm thick to greater than 95% of maximum dry density unless otherwise specified by the Engineer.

11.6 CAST IN PLACE CONCRETE PAVED AREAS

Delete paragraph 3 and substitute with the following:

3 Paving shall be cast in sizes to avoid the formation of shrinkage cracks. The Contractor may be permitted to cast using non-metallic fibers added to the concrete mix to eliminate cracking. In all cases the Contractor shall be responsible for prevention of shrinkage cracks and rectifying cracked works including breaking out and replacing cracked paved areas.

PART 12 FENCING

12.2 FENCING GENERALLY

Delete paragraph 2 and substitute with the following:

2 Where necessary, existing fences, gates and stiles, with posts shall be carefully taken down, laid aside, removed and later re-erected. Fences, gates, stiles and posts which are to be re-erected shall be handled carefully to avoid any damage. Fences, gates, stiles and posts which are in poor condition shall be replaced to the approval of the Engineer.

12.3 CHAIN LINK FENCING

12.3.1 General

Delete paragraph 1 and substitute with the following:

1 This work consists of the supply and installation of all plastic coated chain link fencing complete with all necessary hardware and appurtenances as per the Engineer's drawings and to the lines and levels designed by the Contractor and approved by the Engineer.

PART 13 TRAFFIC SIGNS, MARKINGS AND STUDS

Replace "Qatar Traffic Control Manual" with "Qatar Traffic Manual" wherever it appears in this Part.

13.1 GENERAL

13.1.2 References

Delete paragraph 1 and substitute with the following:

1 The following manuals and standards are referred to in this Part:

Qatar Traffic Manual

BS 381C, Colours for identification purposes
BS 729, Hot dipped galvanizing
BS 873, Road traffic signs
BS 1470, Wrought aluminium for general engineering purposes; plate sheet and strip
BS 1474, Wrought aluminium for general engineering purposes; bar extruded round tubes and sections
BS 1490, Aluminium and aluminium alloy ingots for general casting purposes BS 2000, Part 58, Determination of softening point of bitumen (ring and ball) BS EN 1871:2000, Road marking materials – Physical properties
BS EN 1423:1998, Road marking materials – Drop on materials – Glass beads, antiskid aggregates and mixtures of the two
BS EN 1436:1998, Road marking materials – Road marking performance for road users
BS EN 591-1:2000, Titanium dioxide pigments for paint - Specifications and methods of test
BS EN 1463-1:1997, Road marking materials – Retro-reflecting road studs

ASTM A307, Steel anchor bolts

CML 14-97, Standard method of test for determination of appearance, shape, dimensions and compressive strength of ceramic non-reflecting road studs.

TRL Road Note 27, Skid resistance portable tester.

13.2 TRAFFIC SIGNS

13.2.1 Scope of Work

Delete paragraphs 1, 4 and 6 and substitute with the following:

1 This work shall consist of the design, supply and installation of all road signs and posts. All sign faces and lettering shall be in accordance with the most recent edition of the Qatar Traffic Manual. The required post sizes for different sign sizes shall be as tabulated in the Qatar Traffic Manual. Where in this section of the specification the term 'as designated' is used, this refers to the Contract Drawings and the Qatar Traffic Manual.

4 Permanent traffic signs shall be reflectorised or non-reflectorised and/or illuminated and except where modified herein, shall comply in respect of quality to the requirements of the following documents:

BS 873
Qatar Traffic Manual
Any other Interim Advice Note (IAN) as issued by the Engineer

6 All foundations, posts, framing and fixings shall be suitable for local conditions and be designed to a design wind speed of 120 km/h with gusts to 160 km/h. The Contractor shall supply the calculations confirming this requirement and shall confirm that the nomograms in the Qatar Traffic Manual meet these requirements if he chooses to use them.

Add new paragraphs 9 and 10 as follows:

9 Coefficient of reflectorisation for new sheeting shall not be as per BS 873. Table 2.3 of the Qatar Traffic Manual shall be replaced with the following:

Entrance Angle	Observation Angle	Minimum Coefficient of Retro-reflection (candelas/lux/m²)									
		White		Yellow		Red		Green		Blue	
		Class of Material									
Degrees °	Minutes'	1	2	1	2	1	2	1	2	1	2
-4°	12'	750	380	560	300	150	98	75	45	34	22
	30'	240	275	180	220	48	70	24	32	11	17
	60'	12	80	18	60	3.0	20	1.0	9.0	0.5	4.5
30°	12'	430	225	320	180	86	65	43	28	20	14
	30'	135	135	100	100	27	32	14	16	6.0	8.0
	60'	10	45	8	35	2.4	11	0.8	6.0	0.4	3.0
40°	12'	165	90	130	70	40	26	15	9.8	9.0	4.5
	30'	75	35	65	27	18	10	7.0	3.5	3.0	1.5
	60'	10	10	8.0	8.8	2.4	3.0	0.8	1.6	0.4	0.8

Note: Test to be in accordance with ASTM E-810 "Test Method for Coefficient of Retro-reflection of Retro-reflective Sheeting".

10 After 12 years the minimum percentage of coefficient of reflectorisation retained shall be 70%.

13.2.3 Traffic Sign Materials

Delete paragraphs 3 and 4 and substitute with the following:

3 Illuminated signs shall be covered with Class 1 reflective sheeting.

4 Signs shall be covered over the whole front face with Class 1 or Class 2 reflective sheeting. The rear faces shall be non-reflective grey.

Add new Sub-Clause 10.2.6 as follows:

13.2.6 High Intensity Grade Prismatic – Reflective Sheeting

1 Properties

The initial minimum coefficient of retro-reflection, when measured according to CIE 54.2 conforms to Table 9 of EN 12899-1 for Class Ref. 2 materials (Table A).

Geometry of Measurements		**COLORS**					
α	B_1 (B_2=0)	**White**	**Yellow**	**Red**	**Green**	**Blue**	**Orange**
0.2°	+5°	250	170	45	45	20	100
	+30°	150	100	25	25	11	60
	+40°	110	70	15	12	8	29
0.33°	+5°	180	120	25	21	14	65
	+30°	100	70	14	12	8	40
	+40°	95	60	13	11	7	20
2°	+5°	5	3	1	0.5	0.2	1.5
	+30°	2.5	1.5	0.4	0.3	-	1
	+40°	1.5	1.0	0.3	0.2	-	-
"-" indicates "Value greater than zero but not significant or applicable"							

Table A: Minimum Coefficient of Retro-reflection [cd/(lx · m²)]

The above angular definitions apply for the CIE Goniometer System (Co-planar Geometry). The sheeting shall be mounted in 90° rotation on the Goniometer (as shown below).

The initial chromaticity coordinates and luminance factor conform to the values of Table 6 of EN 12899-1 for Class Ref. 2 materials (Table B).

COLOR	**1**		**2**		**3**		**4**		**Luminance Factor**
	x	**y**	**x**	**y**	**x**	**y**	**x**	**y**	**B**
White	0.305	0.315	0.335	0.345	0.325	0.355	0.295	0.325	≥ 0.27
Yellow	0.494	0.505	0.470	0.480	0.513	0.437	0.545	0.454	≥ 0.16
Red	0.735	0.265	0.700	0.250	0.610	0.340	0.660	0.340	≥ 0.03
Blue	0.130	0.090	0.160	0.090	0.160	0.140	0.130	0.140	≥ 0.01
Green	0.110	0.415	0.170	0.415	0.170	0.500	0.110	0.500	≥ 0.03
Orange	0.610	0.390	0.535	0.375	0.506	0.404	0.570	0.429	≥ 0.14

Table B: Chromacity and luminance factors

13.3 PAVEMENT MARKINGS

Delete Sub-Clauses 10.3.2, 10.3.3, 10.3.4 and substitute with the following:

13.3.2 Materials for Permanent Pavement Markings

1 Permanent pavement markings shall be thermoplastic road marking material in accordance with BS EN 1871, except that they shall be white or yellow (Class Y1) complying with BS EN 1436 Table 6.

2 All line markings shall be reflectorised with glass beads in accordance with BS EN 1423 by incorporation into the road marking mixture and into the wet surface of the marking.

3 Glass beads shall be specified by the Contractor to meet the requirements of Sub-Clause 10.3.4.

4 The pavement marking materials shall be such that the final product, when in a molten state, can be sprayed onto the surface at a thickness of 1.5 mm.

5 The capacity of the containers containing the materials shall be not less than 25 kg or more than 100 kg. Each container shall be clearly marked with the manufacturer's name, batch number and date of manufacture.

13.3.3 Application of Thermoplastic Road Marking Materials

1 Road markings shall only be applied to surfaces which are clean and dry and free of all loose and extraneous matter.

2 Markings shall be free from raggedness at their edges and shall be uniform and free of streaks.

3 In addition to the glass beads included in the mix, an additional quantity of glass beads shall be sprayed on to the hot thermoplastic marking at the time of application. The rate of application shall be determined by the Contractor to meet the requirements of Cl 10.3.4, but shall be at the rate of about 0.5 kg/m².

4 Application shall be by mobile sprayer except for special lettering, arrows and symbols which shall be hand applied.

5 Longitudinal markings shall be laid to the lines shown on the Drawings without deviation.

6 The thermoplastic material shall be applied to intermittent and continuous lines to a thickness of 1.5 mm ± 0.3 mm

13.3.4 Performance Requirements and Testing

1 Road markings shall have the following road performance as defined in BS EN 1436 and shall be tested using the methods in that standard:

Property	BS EN 1436 Ref.	Requirement*	Value
Colour	Table 6	1. White 2. Yellow Class Y1	Co-ordinates given Co-ordinates given
Luminance Factor	Table 5	1. Class B2 2. Class B1	≥ 0.3 ≥ 0.2
Skid Resistance	Table 7	1. Class S1 2. Class S1	≥ 45 ≥ 45
Retro-reflectivity	Table 2	1. Class R2 2. Class R1	≥ 100 ≥ 80

* Note: 1 = White, 2 = Yellow

2 Road marking materials shall have the following physical properties as defined in BS EN 1871 and shall be tested using the methods in that standard:

Property	BS EN 1871 Ref.	Requirement*	Value
Luminance Factor	Table 5	1. LF3 2. LF1	≥ 0.65 ≥ 0.4
Softening Point	Table 6	1. Class SP4 2. Class SP4	≥ 110 °C ≥ 110 °C
Cold Impact	Table 7	1. Class CI1 2. Class CI1	0 °C 0 °C
UV Ageing	Table 3	1. Class UV1 2. Class UV1	≤ 0.05 Δß ≤ 0.05 Δß

* Note: 1 = White, 2 = Yellow

3 In addition to the properties in paragraph 2 above, the following physical properties shall be tested:

Flow Resistance Test: The material shall be cast into a conical mould having an apex angle of 60 °C and a vertical height of 100 mm. After cooling and setting for 24 h the cone shall be removed from the mould, placed on a flat level surface and maintained at a temperature of 23 °C ± 2 °C for 48 h. There shall be no slump.

Abrasive Test: A3 mm thick coating of material shall be screeded on to a Monel alloy panel and subject to wet (water lubricated) abrasion at 23 °C on a Taber Model 503 standard abrasion tester using H-22 Calibrade wheels, refaced between tests. The loss in weight after two successive tests of l00 revolutions shall be recorded and the average taken as the abrasive wear. The abrasive wear shall be less than 0.3 g/100 revolutions.

13.4 TEMPORARY ROAD MARKING

13.4.1 Road Marking Paint

Delete paragraph 7 and substitute with the following:

7 Where markings are to be reflectorised with ballotini it shall be sprayed uniformly on to the wet paint film at the rate of 400 - 500 g/m². Ballotini shall be graded medium to comply with the requirements of BS EN 1423.

13.5 REFLECTIVE STUDS

Delete paragraphs Sub-Clause 10.5.1, 10.5.2, 10.5.3 and 10.5.4 and substitute with the following:

13.5.1 General

1 Reflective road markers shall comply with the requirements of BS EN 1463-1 Road Marking Materials – Retro-reflecting road studs. They shall; be capable of withstanding the climatic conditions of Qatar and be maintenance free.
A performance guarantee of five years is required.

2 The road stud dimensions exposed to traffic after installation shall measure 130 mm (across the direction of traffic flow) x 115 mm x 25 mm.

3 All reflective road markers shall be anchored within the road surface. The minimum anchor length below road surface shall be 65 mm.

4 The anchorage part of the stud shall be shaped to prevent rotation of the stud when located on the road surface.

5 The body of the stud shall be constructed in one integral part.

6 The profile of the stud shall be smooth and present no sharp edges to traffic.

7 The studs shall be non-depressible.

8 The Contractor shall submit a sample of the proposed reflective studs to the Engineer for approval before commencing procurement.

13.5.2 Reflectors

1 The reflectors shall be rectangular in shape. The reflective unit shall be firmly located into a recess within the body of the stud.

2 The colour limits of the reflectors shall comply with the chromacity region coordinates in Table 9 of BS EN 1463-1.

3 White (uncoloured) reflectors shall not produce a selective reflection; that is to say, the trichromatic co-ordinates X and Y shall undergo a change of more than 0.91 after reflection by the reflector.

13.5.3 Reflectivity

1 The retro-reflective face of the road stud shall have a coefficient of luminous intensity meeting or exceeding the requirements of a Type 2 reflector in Table 4 of BS EN 1463-1.

2 The daytime visibility of the road stud shall comply with Class DCR 1 of BS EN 1463-1.

Add new Sub-Clause 10.7 as follows:

13.7 SPECIFICATIONS FOR GLASS SPHERES (BEADS)

1 Type I is not coated and Type II is coated to provide moisture proofing for high humidity conditions, where sphere flow may be impaired.

13.7.3 Requirements

1 Glass spheres Type I and Type II shall meet the following requirements:

2 General: Glass spheres shall lend themselves readily to firm embedment in the traffic paint when dropped on a freshly placed paint line. The embedment shall be of such character as to provide a highly reflectorized surface on the paint with reserve reflectorizing capacity in the lower sections of the paint film. The reflection shall be effectively manifest to the operator of a motor vehicle when the headlights of the vehicle are shown on the marking.

3 Appearance: A minimum of 85% of the beads by count shall be colourless, true spheres, free of dark spot, milkiness, air inclusions and surface scratches when viewed under 20 x magnifications. The beads shall be clean and free from foreign matter in accordance with high grade commercial practice.

4 Gradation: The glass spheres shall conform to the following grading requirements:

Sieve Size	% By Weight Passing
600 µm	100
250 µm	40 – 70
180 µm	15 – 35
106 µm	0 – 5

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5 Physical Properties: Glass sphere shall conform to the following properties:

Refractive Index, minimum	1.50
Specific Gravity	2.40 to 2.60
Moisture Content, maximum	0.01%

6 Chemical Stability: Refluxing a sample of beads for 8 hours with distilled water shall not produce more than a very slight reduction in luster or reflecting power of the beads.

7 Flow: Beads shall be free flowing. A 23 kg sample of beads, emptied into a service box screen, Sieve Size 1.18 mm shall pass completely through the screen without shaking or any excessive hand manipulation.

8 Type II (Moisture Proof): The Type II beads shall conform to all the requirements for Type I beads and the following requirement for moisture resistance.

9 Moisture Resistance Test (Flow): Moisture resistance of the beads shall be determined by the following procedure:

(a) Use a pre-washed 267 mm x 444 mm unbleached cotton sheeting bag having a 48 x 48 thread count.

(b) Turn the bag inside out to prevent water plus beads from being entrapped within the seams.

(c) Place 907 g of beads in the cotton bag.

(d) Immerse the bag containing the sample in a bucket of water at room temperature 21-22 °C for 30 seconds, or until the water covers the beads (whichever is longer).

(e) Remove the bag and sample from water and squeeze the excess water out of the bag by twisting the neck of the bag.

(f) Allow the bag to be suspended for 2 hours at room temperature. Do not allow the neck to loosen.

(g) Mix the sample thoroughly by releasing the tension in the neck and shaking the bag, thus loosening the beads from bottom and sides.

(h) Transfer the sample to the clean dry funnel (150 mm top diameter, 120 mm deep and 6.35 mm ID stem).

(i) If the beads bridge in the funnel while pouring the sample, the funnel can be tapped lightly to start the flow.

(j) After flow stops, the funnel must be essentially empty of glass spheres.

13.7.4 Quality Assurance Provision

1 Inspection: The material shall be inspected and tested as specified by the Engineer.

2 Index of Refraction: The beads shall show a minimum index of refraction of 1.5 by the oil immersion method using tungsten light, per ASTM Special Publication 500 Paragraph 1.3.2.1.

3 Specific Gravity: The beads shall have a specific gravity from 2.4 to 2.6 at 25 °C per ASTM D-153 Method A.

4 Moisture Content: As determined by weight loss of 25 g of beads in an oven at 105 °C for 3 hours, shall not exceed 0.01%.

5 Chemical Stability: Refluxing of a 50 g sample of beads in a Soxhlet extraction apparatus for 8 hours with distilled water shall not produce more than a very slight reduction in luste.

PART 14 WORKS IN RELATION TO SERVICES

14.1 GENERAL

14.1.4 Notification to Service Authorities & Statutory Bodies

Delete paragraph 1 and substitute with the following:

1 All works in relation to services shall be carried out by a contractor or sub-contractor prequalified and approved by the concerned service authority. Proof of such approval shall be required in writing before the start of Works on the Site. The name of any sub-contractor to be used shall be designated. Any design work to be undertaken for the relocation or protection of an existing or proposed service as part of the Works shall be undertaken by a consultant appointed by the Contractor who is approved by the relevant service authority or statutory body. Written proof of a consultant's approval shall be provided by the Contractor.

14.3 PARTICULAR REQUIREMENTS

14.3.2 Qatar General Electricity and Water Corporation, Water Network Affairs, QGEWC (WNA)

Add new paragraph 4 as follows:

4 The Contractor is to obtain the most recent approved list of manufacturers / suppliers of materials for water works projects from QGEWC. All relevant water works materials used on the project will be obtained from a manufacturer / supplier which is included on this list. The Contractor shall provide a copy of the list to the Engineer prior to ordering any material.

PART 15 ROAD LIGHTING

15.5 HIGH MAST LIGHTNING

Add new Sub-Clause 15.5.19 as follows:

15.5.19 Luminaires

1 General

(a) The Specifications contained in this sub-section are typical for all luminaries to be supplied and utilised. All luminaries supplied and installed shall be in accordance with the Drawings and Bills of Quantities unless specified otherwise by the Engineer.

(b) The luminaries shall be designed to receive one high pressure sodium lamp and internal control gear necessary for the operation of the lamp. Luminaires shall operate on 220/230V AC ± 10% at 50 Hz ± 5%, with 150w/250w/400w/600w HPSV lamps or as otherwise specified by the Engineer.

(c) The street lighting luminaires shall follow the provisions of the latest versions of the following standards:

(i) BS 4533-101:1990, EN 60598-1:1989
(ii) BS 4533-102.1:1990, EN60598-2-1:1989
(iii) BS 1615: 1987
(iv) BS EN 147000: 1995
(v) BS EN 60922: 1997, IEC 60922: 1997
(vi) BS EN 60923:1996
(vii) BS 6500: 2000
(viii) BS EN 60598-2-3:1994, IEC 60598-2-3:1993
(ix) BS 5489 Part 1, 2, 3, 4, 5, 6 and 7: 1992
(x) BS 5225: 1975
(xi) BS 5101–4:1980, BS EN 60061-4:1992, IEC60061-4:1992
(xii) BS 2011-2.1 and IEC 60068-2

2 Construction

Luminaires shall be complete with following assembly:

(a) The luminaires shall accommodate lamps having cap base E40 size.
(b) Body made of die cast aluminium alloy casting in two compartments.
(c) Super purity one piece aluminium reflector of grade S1 with an anodic coating of not less than Grade AA10 of BS 14 1615: 1987.
(d) Strong, very high thermally resistant and mechanically transparent protector. The protector shall be made of clear toughened curved glass with a transparency of no less than 90%. The protector shall be smooth on both sides to minimize dirt accumulation.
(e) Neoprene gaskets or high quality felt gaskets silicon.
(f) Stainless steel hinges, mounting clips and fastening bolts, grade AISI 316.
(g) Movable porcelain Lamp Holder with position markings and anti-vibration fixation device.
(h) Complete control gear mounted on easily removable tray.
(i) A terminal block for the connection of incoming supply cables shall be provided in luminaires incorporating auxiliaries. It shall be situated as close as possible to the point of entry of the supply cable and shall be readily accessible.
(j) A means of clamping the electrical supply cables shall be provided in the lantern where necessary to relieve the termination of strain. The cable clamp arrangement shall not damage the insulation of the cable.
(k) Brass earth terminal set-in housing.
(l) Protective sheath for power supply cable, and expandable nylon cable grip for wiring,

conforming to BS 6500:2000.

(m) The lamp caps and the lamp holders shall meet the requirements of BS EN 60061-4:1992, IEC 60061-4:1992.

3 Mechanical Requirements

(a) Luminaires shall be with separate compartments for the optical system and for the control gear.

(b) The tightness of the optical compartment shall be IP66 class as per IEC 598-1 standard. The access to control gear compartment shall be without using any tools.

(c) The tightness of the control rear compartment shall be IP65 or better, according to the IEC 598-1 and 2 standards.

(d) Access to lamp shall be by rotating the lampholder support plug and extracting it from the sleeve. Clips shall not be used for closing the lampholder support plug as clips cause abnormal stress on the gasket and thereby affecting IP rating of optic compartment.

(e) The mechanical strength of the body and its accessories and the protector of the luminaire shall be sufficient to withstand without any damage a mechanical shock having an impact energy complying with BS 2011, and BS EN 60068-2-31:1993.

(f) Special precautions shall be given to the choice of materials which shall be able to resist without any damage or aging or alteration in its structural or physical properties, the severe Qatar climatic conditions, in addition to the heat emitted by the lamp.

(g) Fixing on the bracket shall be of an effective locking means using stainless steel bolts grade AISI316.

(h) All fixings which carry the weight of the lantern and internal accessories shall be provided with suitable locking devices to prevent the dislodgement of any part of the lantern by vibration either in service or in maintenance. Compliance shall be checked as per BS 2011, and BS EN 60068-2-31:1993.

4 Electrical Requirements

(a) Provision for one lamp for each lantern shall be made. The electrical accessories such as ballasts, ignitors and capacitors shall be prewired using heat resistant glass fibre insulated wire and preassmebled on metallic supports that are fixed into the control gear compartment.

(b) Special care shall be taken to allow easy maintenance and quick replacement of the accessories. All control gear accessories shall be bolted (and not riveted) on the removable supports.

(c) All electrical accessories shall be able to withstand in continuous operation and without any damage, the temperature existing inside the control compartment, in an ambient temperature of 50 °C. All wires inside the HPSV luminaires shall be of the heat resistant type with silicon and glass fibre insulated. The arrangement shall comply with BS 4533–102.1:1990 and EN 60598-2-1:1989.

(d) The cable feed terminals and the earth screw shall be fixed inside the control gear compartment. A cable holder shall be mounted near the terminals.

(e) A separate set of control gear shall be provided for the lamp comprising one choke associated with one capacitor and one ignitor. The control gear should be encapsulated in an approved enclosure conforming to IP 65 or better.

(f) Terminals of all ballasts, capacitors, ignitors and starters, if any, shall be shrouded. The ballast shall be designed to operate the lamp and control it continuously in ambient temperatures ranging from 0 °C to 80 °C.

(g) The ignitors used for HPSV lamps shall consist of built-in timer so that; it shall automatically stop its function if lamp does not get ignited within pre-set time period.

(h) The choke shall be tropicalised of Class H insulation and vacuum impregnated. The capacity of the choke should be such as to keep the illumination of the lamp within the design limit.

(i) The capacitor shall be of the diphyenyl impregnated type and shall be in a leak proof metal container fitted with an internal discharge resistor. The permitted operating temperature of the capacitor shall be marked on its case and shall be 85 °C. The capacitors shall have value sufficient to raise the power factor of the complete luminaire to 0.90 or better. Each lamp shall operate using only one capacitor. Any combination of two or more capacitors to have the equivalent value of capacitance will not be accepted. Chokes and capacitors shall comply with the latest BS EN 60922: 1991 and BS EN 60923: 1991.

(j) Complete luminarie assembly shall have a power factor of minimum 0.9 without the need of any power factor correction at mains.

(k) The control gear shall be supplied by the lantern manufacturer and shall be incorporated in a way that heat emitted by lamp is not conducted or transferred to the gear components.

(l) The luminaires shall have a screw type lamp holder. The lead at the higher potential above earth shall be connected to the centre contact.

(m) The operating temperature and thermal endurance characteristics shall conform to Part 2 of BS 4533 Section 102.3: 1990.

5 Photometrical Requirement

(a) The lamp holder position shall be adjustable to allow the luminous flux distribution to be adapted to the geometrical installation condition.

(b) The adjusting device of the lamp shall be sufficiently sturdy, and designed in a way it cannot be disturbed, during its normal life time or during maintenance operations.

(c) The device shall have permanent marking so that the lamp position recommended by the manufacturer can be easily realized.

6 Photometrical Performance Requirement

(a) Computer calculations relating to illuminance and luminance results indicating overall luminance uniformity ratio (Uo) and longitudinal luminance uniformity ratio (Ul) which will be achieved on the roadway, values of threshold increment (TI) shall be submitted by the Contractor for Engineer's approval.

(b) The calculations shall be performed in accordance with CIE Nr. 30 Publication and shall be based on actual dimensions of the roads, and shall demonstrate that the lighting installation shall achieve the standards required for all parts of the Project**,** as specified in the Qatar Highway Design Manual, the Contract Documents to the requirements of the Engineer. The results are to be achieved taking into consideration a total Maintenance Factor as agreed with the Engineer.

7 Documents to be submitted

The Contractor shall supply the following technical documentation and information for each type of luminaire for the approval of the Engineer.

(a) Original catalogue sheet of the luminaire.
(b) Detailed construction drawing of the luminaire.
(c) Polar diagram of luminous intensity in roadway vertical plan and transverse vertical plans.
(d) Utilisation factor curve for actual inclination of luminaire.
(e) Isolux diagram for actual inclination of luminaire.
(f) Intensity table, in the C-gamma co-ordinates recommended by CIE Nr. 27 Publication.
(g) Calculation printout showing the illuminance and luminance levels, Longitudinal Uniformity Ratio (Ul), overall Uniformity Ratio (UO) and threshold increment (TI).
(h) Tightness test certificate conforming to IP66 protection for the optical and control gear compartments of luminaire.

(i) Shock test certificate confirming the resistance of the body to impact energy as per Clause 4.4 Section 1.4 of BS 4533, Part 1.
(j) Total weight of the luminaire (with lamp and control gear).

(k) Power factor of one complete luminaire.
(l) Total electric consumption of the luminaire, including control gear losses.
(m) Rated lumen output of lamps under nominal conditions.
(n) Depreciation curve of the luminous flux with burning hours.
(o) Luminous flux variation with the main voltage.
(p) Make and type of lamp, ballast, ignitors and capacitors separately with their electrical characteristics e.g.: Impedance, power factor, Temperature rise (t), max. Temperature (tw) and power losses.
(q) Specification Compliance Statement covering each clause of this specification.
(r) The Contractor shall submit full details of areas using the same type of luminaires in the Middle East and Gulf Area.
(s) The supplier shall submit for the Engineer's approval dimensioned drawings of the control gear arrangements showing the exact positions of chokes and capacitors within the lantern.
(t) The Contractor shall submit a sample of each type of proposed luminaire for the approval of the Engineer.

Street light fittings shall be from suppliers approved by the PWA.

15.10 UNDERPASS LIGHTING SYSTEM

Add new Sub-Clauses 15.10.9 and 15.10.10 as follows:

15.10.9 Description of Lighting System for Underpass

1 The tunnel lighting is designed for the road design speed.

2 The tunnel lighting at and near the approach shall be used to maintain a sufficiently high lighting level inside the tunnel.

3 This shall enable the driver approaching the tunnel to see into the tunnel thus avoiding the "black hole effect".

4 The level of reinforcing lighting shall be continuously adjustable, using lighting control system.

5 Luminaires shall be selected and positioned to provide a continuity of lighting through traffic routes and lanes.

6 The lighting design and control shall ensure that energy will be conserved and running costs optimized.

15.10.10 Materials

1 Tunnel Lighting Luminaires

(a) Totally enclosed, dust and jet proof, conforming to at least IP65 of IEC529, shock resistant and specially designed to house the required lamps, electrical gear and accessories. Body to be one piece extruded aluminium (Magnesium – silicon alloy) having a wall thickness of not less than 2.5 mm.
(b) Exposed metal parts of luminaries are to be factory finished, stove enameled, with corrosion resisting paint capable of resisting heat emitted by lamp during continuous operation. The whole assembly shall be treated against corrosion by anodizing the aluminium.
(c) Mirror reflectors are to be 99.5% purity, polished aluminium reflectors and coated with transparent layer of silicon protection against wiping.

(d) Optical system and electrical control gear and lamp are to be mounted on a “plug-in” type control gear tray which will have locating pins to ensure alignment when being fitted into the body.

(e) Ground wire is to be connected through the cable connector to ensure that the ground potential is maintained on the gear tray when it is being removed from the luminaire for maintenance purposes.

(f) Luminaires are to have a hinged front glass assembly which shall comprise of a clear toughened glass plate, not less than 5.0 mm thick fixed into an aluminium frame which shall have a full length closing device. The front glass assembly shall seat on to a neoprene non rotting type gasket and once seated shall provide the required degree of protection. Glass used is to be of the type which once broken, no part of the glass will fall on the carriageway. Each lamp is to have an independent HRC fuse for protection. The luminaries shall have radio interference suppression in accordance to CENELEC EN 55014 and EN 55015 and CISPR Publication 14 and 15. The glass shall be parallel to the road surface. The housing shall be suitable for mechanical cleaning.

(g) Luminaires are to be complete with their mounting accessories and are to be supported from unistrut steel channel fixed to the soffit of the tunnel. Fixing details to be submitted for approval by the Engineer. Numbers of mounting brackets shall be a minimum of four pieces. The fixing device shall be removable without any tools.

(h) Luminaires having one circuit for supply and where applicable are to be through wired via a 5 core, LSF/PVC cable, heat resistant rubber insulated. The earth wire shall be solidly bonded to the earthing stud inside the luminaire.

(i) Luminaires shall be aligned to the satisfaction of the Engineer and any necessary realignment shall be made with no additional cost.

(j) Fixings are to be approved by the Engineer and all bolts used are to be stainless steel, painted after installation with a two pack anti-corrosion paint to be approval of the Engineer.

(k) Fixings are to be such that the installation of luminaries, trays, etc. is capable of being carried with a minimum of safety factor 3 to 1 per fixing.

(l) Luminaires are to be wired with approximately one meter length of 2.5 sq. mm / 1.5 mm high temperature flexible copper cable (LSF) insulated and sheathed to be terminated in the junction box as per the drawings. The earthing wire is to be solidly connected to the earthing stud inside the luminaire.

(m) Luminaires having two circuits taken into them are to have proper colour coding. Circuitry within the luminaire is to be designed so that segregation of the two supplies is maintained.

(n) Ballast and control gear are to be mounted in luminaire in separate compartment, isolated from lamp, and with enclosed terminal blocks fitted with quick disconnect electrical leads. Control gear is to be plug-in type for operation at 240 V, 50 Hz ballast is to be specially designed and selected for the particular types of lamps used, and lamps are to be able to start with at least ± 10% variation of nominal voltage and continue in normal operation with dips attaining 20% for four seconds. Control gear losses are not to exceed 10% of normal lamp wattage. RFI suppression device is to be provided. Power factor is to be compensated to at least 0.9 logging.

2 Lighting Control Systems

(a) Luminance Meter

Sensor:
Temperature stabilized photocell measuring range:
1 to 9 000 cd/sqm for use outside the tunnels and

Output:
Load independent current 4 – 20 mA,
Working resistance max. 550 ohm

Housing shall be of stainless steel according to AISI 316 TI with window heating and lens shade.

System of Protection: IP 55
Vario optic with adjustable measuring field 160 to 320.

For each entrance portal there shall be placed one sensor on a column height of 4 m, 110 m before the portals with stainless steel pan/tilt support. Work shall include the column as well as all required civil works as excavation, foundation and back filling.
Microprocessor: 19" plug in unit.
Microprocessor pre-programmed, site programmable by hand, for all necessary functions and placed in the Distribution Buildings. Fault output shall be provided.

Calibrated light sources for testing luminance meter shall be provided.

(b) Tunnel Lighting Control

Entrance Lighting – Automatic

The lighting system shall be controlled in a number of stages in dependence of the access zone luminance. This access zone illuminance shall be measured continuously by the luminance meter in front of the portal. The difference between the required luminance and the effective luminance in the threshold zone shall control the switching of the lighting.

In the event of a failure to the outside sensor, the control shall be done by adjustable switch steps; also a fault alarm shall be transmitted.

(c) Control Unit: A microprocessor controlled 19" unit shall be provided to control the entrance and interior lighting. The lighting control shall fulfill all control work described in the item above.

The control unit shall have a digital display of the external luminance measured by the photometers, switch-on and switch-off level presets for various switching stages, LED indicators show to indicate the activation of a switching stage, delay-on, delay-off and minimum burning time presets with a range of 15 seconds to 15 minutes for each switching stage, automatic switch over to a preset lighting level upon detection of failure of the system, with time delay and fault indication.

The control unit shall send at least the following information to the Bahce Maintenance Centre:
(i) Luminance meter fault indication
(ii) Control unit fault indication
(iii) Control unit watch dog reset indication
(iv) Control unit configuration parameters shall be down loaded from the sub-control centres.

15.20 INSTALLATION

15.20.5 Road Lighting Column/Lantern Installation

Add new paragraph 13 as follows:

13 Mast raising cable must pull through the head frame to lantern without exposing to the sun light. Head frame shall be fabricated to facilitate the above.

Add new Sub-Clause 15.23 and 15.24 as follows:

15.23 Road Lighting Quality Assurance

Add new paragraph 15.23 as follows:

1 Road lighting works shall be carried out by specialist contractors or sub-contractors having experience in the provision and installation of lighting columns, provision and laying of cables and ducts, and provision and installation of supply connections to all electrical equipment. Specialist contractors or sub-contractors for installation of new street lighting works shall be pre-qualified by the PWA.

2 Climatic conditions – All cables shall be certified by the manufacturer as suitable for installation in Qatar.

3 All material shall be approved by the PWA before ordering. Only products with a proven record of performance, efficiency and long life will be considered for approval by the PWA.

4 All works, equipment and materials shall comply with statutory and other regulations, Codes of Practice and Standards current at the date of Contract signing including the Qatar Wiring Regulations.

5 All columns and brackets shall be produced by lighting column manufacturers registered and certified for the manufacture, supply and certification of lighting columns under their quality assessment schedule to ISO 9000:2000.

6 Column manufacturers not registered and certified accordingly will only be permitted if a satisfactory submission is made for quality assurance and performance within the climatic conditions in Qatar.

7 Facilities shall be provided for the Engineer to inspect the lighting columns during the course of their manufacture and application of the protective treatment.

8 Any equipment or items damaged in transit will not be acceptable for incorporation in the Works and the Engineer shall have the right to reject such items. In the case of minor damage to galvanizing or painting the Engineer may permit repairs to be carried out. Any such repairs shall be carried out in accordance with the recommendations of the supplier and to a recognized internationally accepted repair treatment.

15.24 LIGHTING COLUMNS (MULTI-FUNCTION SMART POLES)

15.24.1 General

1 The pole system shall be decorative type with multi-functionality features to accommodate a variety of services at any one time. All poles shall be designed to accept following services:

(a) Street lighting
(b) Illuminated advertisement banners 1.5 m x 3 m size
(c) CCTV cameras
(d) Street signs
(e) Traffic signs
(f) Traffic signal heads
(g) Street names
(h) Microcells
(i) Antennas, etc.

2 The poles shall be made up of a structural galvanized steel core and an extruded aluminium mast that enables accessory's to be mounted along its length at any height and position.

3 Multi-function poles shall be specially designed for 160 kph with maximum load configuration. By combining different steel cores with the mast profiles, poles shall be suitable for the heights

as specified in the Contract Documents. The multi-function shall be decoratively designed with 2 m cladding made of extruded aluminium.

4 The poles shall comply with the requirements of BS 5649: 1985, BS EN 40-3-1:2000, BS 5950: Part 1 1985 and BS 8118: Part 1 1991 and the relevant AASHTO standard.

15.24.2 Materials

1 Structural Steel - All Smartpole steelwork shall be manufactured out of Grade 275 mild steel. Hot dipped galvanising shall be the surface treatment both inside and out.

2 Aluminium Mast - The poles external mast shall be made up of extruded aluminium alloy which has an anodised protective coating to 25 microns.

3 Service Hatches - Each pole shall have a service hatch approx. 600 mm from ground level for installing the service cut-outs (size 300 mm height x 110 mm width x 70 mm depth) where the connection of cables can be made between the outside network and the poles accessories. The service hatch shall be accessible by removing a cover plate or cladding from the pole base. The cover shall be fixed by 2 No. security screws. Poles used for vehicular traffic signals shall have additional hatch to terminate traffic and surveillance related cables.

15.24.3 Bracketry

1 Bracketry required for attaching various other functions on the pole shall be as specified by the Engineer.

15.24.4 Fasteners

1 All fasteners are supplied in stainless steel grade AISI 316. The exception to this is on the cantilever assembly's where the use of high-tensile fixings have been adopted. These fasteners are finished with metal plating to resist corrosion.

15.24.5 Electrical Equipment

1 M8 x 30 mm long threaded stud carrying 2 nuts and 2 washers shall be provided as an earth point. It shall be located within the service hatch.

2 Fuse cut-outs shall be supplied along with poles. Single lantern pole shall have single fuse cut-out and double lantern pole shall have double fuse cut-out.

3 Each pole shall be fitted with polyester "draw wire" to assist in feeding electrical and service cables should they be required.

15.24.6 Light Outreach

1 Suitable type of light outreach shall be supplied with each pole to fix specified number of fittings on that pole. The attachment of the outreach arms shall be made using 4 No. standard fasteners through the arm tube. In turn the light fitting shall be connected to the arm tube end and wired. The light outreach design shall be as shown on the drawings.

15.24.7 Pole Top Feature

1 Where the Engineer specifies, there shall be a decorative pole top feature. This feature shall be made of cast aluminium.

15.24.8 Warranty

1 Manufacturer shall provide 10 year warranty for the poles.

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15.24.9 Make and Type

1 Smartpole system by Streetscape.

PART 17 ROAD DRAINAGE

17.4 ROAD GULLIES

Add a new paragraph 9 as follows:

9 Grating for gullies that are flush with the pavement surface shall be of ductile iron and shall comply with loading category D400 as defined in Table 14.1. Gratings set adjacent to kerbs shall have as a minimum bases on 3 sides of the frame.

17.5 MANHOLE COVERS AND GULLY GRATINGS

Delete paragraph 11 and substitute with the following:

11 The manhole covers shall meet Loading Category D400 as defined in Table 17.1.

12 For a manhole entry to sewer and surface / ground water manholes a minimum of 750mm diameter clear opening shall be provided. For entry to TSE chambers a minimum of 675mm square opening shall be provided.

17.8 TESTING AND CLEANING SURFACE WATER DRAINS

Add the following:

4 All highway carrier drains shall be watertight and shall be tested in sections, e.g. between chambers, by means of the air test described in paragraph 4 of this Clause. If a pipeline is rejected because of a failed air test, as part of the rectification work, a water test as described in paragraph 5 of this Clause may be carried out as an alternative acceptability test. Before testing, the ends of the pipeline to be tested, including short branches, shall be plugged and sealed.

5 For the pipeline air test, air shall be pumped in by suitable means until a stable pressure of 100 mm head of water is indicated in a U-tube connected to the system. The air pressure shall not fall to less than 75 mm head of water during a period of 5 minutes without further pumping, after an initial period to allow stabilization. Drains with traps shall be tested to 50 mm head of water and the permissible loss shall then be no more than 13 mm head of water in 5 minutes without further pumping after the initial stabilizing period.

6 For the pipeline water test, the pipes shall be filled with water under a head of not less than 1.2 m above the crown of the pipe at the high end and not more than 6 m above the pipe at the low end. Steeply graded pipelines shall be tested in sections so that the above maximum is not exceeded. The test shall commence not less than two hours after filling the test section at which time the level of water at the vertical feed pipe shall be made up to produce the required 1.2 m minimum test head. The loss of water over a 30 minute period shall be measured by adding water at regular 10 minute intervals to restore the original water level and recording the amounts so added. The drain will have passed the test if the volume of water added does not exceed one litre per hour per linear metre of drain per metre of nominal internal diameter.

7 All pipelines less than 350 mm diameter shall be checked by drawing through each completed length of pipe a spherical mandrel of a diameter 10% less than the nominal bore of the pipes being tested.

8 Chambers for carrier drains shall be watertight. Chambers shall be tested as described in paragraph 9 of this clause.

9 Chambers shall be tested hydraulically to a depth of water 1.2 metres above the soffit of the highest pipe entry with all pipe openings plugged. Unless otherwise agreed by the Engineer, the test shall commence two hours after filling the chamber at which time the water level shall

be made up to the above stated level. The loss of water over a 30 minute period shall be measured by adding water at regular 10 minute intervals to maintain the original water level and recording the amounts so added. The chamber will be deemed to have passed the test for water tightness if the volume of water added does not exceed one litre per hour per linear metre of depth of water in the chamber per metre of nominal internal diameter of the chamber.

SECTION 8 DRAINAGE WORKS

PART 1 GENERAL

1.2 TESTING OF MATERIALS

Add new Sub-Clause 1.2.3 as follows:

1.2.3 Approved laboratories

Testing of concrete and other materials shall only be undertaken by laboratories approved by the PWA.

PART 9 TRENCHLESS PIPELINE CONSTRUCTION

9.3.5 Grout

Add new paragraph 3 as follows:

3 Unless agreed to the contrary in writing by the Engineer, the annulus around the installed pipes shall be filled with cement grout installed under pressure by an approved means.

SECTION 19 PLUMBING WORK

PART 1 GENERAL

1.3 CONTRACTOR'S RESPONSIBILITY

1.3.4 Notice of Intent

Delete paragraph 1 and substitute with the following:

1 The Contractor shall notify QGEWC in writing at least 28 days prior to the commencement of any plumbing work.

SECTION 21 ELECTRICAL WORKS

PART 1 General Provision for Electrical Installation

1.1.1 Scope

8

9 Add new paragraph 3 to 6 as follows:

3 The electrical design drawings and specifications are categorised as follows:

(a) The STL package, which includes road lighting, traffic signals, and the Motor Control Centre for the drainage pumping stations. For all major further details related to road lighting, refer to Section 6, Part 12, Road Lighting.
(b) The MV package, which includes power supply requirements for road lighting and other loads as well as the existing MV cables and the proposed diversion schemes where necessary.
(c) The EHV package, which includes the existing EHV services and the proposed relocation schemes for EHV cables, HV cables, and HV/MV substations.
(d) The TEL package, which includes the existing telecommunication services. Relocation schemes of telecommunication utilities are left exclusively to Q-Tel.

4 The Scope of Works related to QGEWC is as shown on the Contract Drawings or as specified by the Engineer, and will include the power supply requirements for the road lighting and the miscellaneous loads.

5 The Scope of Works related to Q-Tel will include all necessary relocation works for the fibre optic and copper transmission and distribution lines, as will be designed by Q-Tel.

6 It is the Contractor's responsibility to ascertain that all the authorities' requirements are complied with and that any additional works not specifically mentioned herein are covered within his prices and quoted for.

1.1.16 Quality of Materials

Add new paragraph 5 as follows:

5 Supplies of electrical distribution equipment to be as per QGEWC document Assessment of Manufacturers of Electrical Distribution Equipment.

1.1.21 Electricity Supply

Add new paragraph 11 as follows:

11 Allow for adequate appropriate glands, lugs, and boxes for the cables to be supplied to the Motor Control Centre.

Add new Sub-Clause 1.1.28 as follows:

1.1.28 Testing and Commissioning

1 Testing and Commissioning of the installation shall be carried out in accordance with the regulations and standards listed in the documents after completion of the work to prove compliance with the Specification. The tests will be carried out in the presence of and to the satisfaction of the Engineer.

2 Manufacturer's test certification for appropriate equipment shall be handed to the Engineer prior to the site testing being carried out.

3 All results of the tests shall be recorded on-site and signed by all witnessing parties. Subsequently, three copies of all such documents shall be submitted to the Engineer.

4 Prior results of the tests shall be recorded on-site and signed by all witnessing parties. Subsequently, three copies of all such documents shall be submitted to the Engineer.

5 Prior notice shall be given to the Engineer of proposed tests together with a list of the equipment to be used. In particular proposals shall be submitted for measuring the luminance and illumination levels and for calculating the average levels as specified elsewhere in the Specification.

6 All tests including, where applicable, insulation tests, continuity tests, effectiveness of earthing, measuring of earth electrode resistance, shall be carried out.

7 No repeat test shall be carried out until the cause has been established and rectification of the failure has been carried out.

8 The following tests shall be carried out on-site

(a) Switching Station, Sub-Station:
- (i) Insulation resistance test with 1000 volts megger.
- (ii) Phasing out and polarity check.
- (iii) Operation and protection tests.
- (iv) Primary/Secondary Injection tests.

(b) EHV Cables:
EHV cables shall be tested in accordance with the requirements in Part 35 below.

(c) HV Cables:
HV cables shall be tested to the requirements of I.E.C. 502 and shall include:
- (i) HV d.c. test between conductors to earth.
- (ii) Di-electric leakage current at the test voltage.
- (iii) Insulation resistance test after above tests taken with a 1 000 volts megger.
- (iv) Upon completion of all tests the cables shall be left in a fully discharged condition.

(d) MV Cables:
Insulation resistance test taken between conductors and between conductors and separate earthing cable taken with a 500 volt megger.
Continuity tests:
Approval shall be obtained from the Engineer before starting any tests, for authorisation of connection of the power supply to the installation.

(e) Lighting equipment and Visual Inspection:
The following tests shall be carried out in addition to those previously called for:
- (i) Condition of the equipment and quality of the workmanship.
- (ii) Level, perpendicularity and alignment of the poles and luminaires.
- (iii) Actual characteristics of the equipment.

(f) Lighting circuits:
Measurement of Insulation Resistance: Insulation resistance test on the various MV circuits. The tests shall be performed after installation, in accordance with approved standards to determine the adequacy of insulation between phases and also between phases neutral and earth (lamps shall be removed during the test where applicable). Resistance of the earthing of all metallic frames shall also be carried out.

(g) Operational Tests of lighting fixtures:
Normal functioning of all lamps.
Operation test on all power equipment including recording the voltage at the terminals of each ballast on the final column in each circuit.

(h) Performance Tests of lighting levels after 100 hours normal functioning:

Measurement of the lighting levels and uniformities on the road surfaces.
The result of which should be submitted to the Engineer in tabulated form.

(i) Operational Tests on pumps:
After checking insulation resistance of motors and control gear and proving it to be satisfactory, all pumps should be operated by means of automatic control and proved to be performing to specification. Pump failure to be simulated and operation of standby system proved.
The Engineer will reserve the right to take any action he may consider necessary, in the event of the measure values not conforming with the lighting design criteria D.2 Section 7.01. Any other tests found necessary by the Engineer to verify conformity of the installation with the specifications, shall be carried out by the Contractor as necessary.

(j) Earthing Tests:
After installation of the individual earthing system in accordance with the above for the various parts of the Specification and after the whole installation has been connected up, an earth resistance test shall be carried out on the earth bar and the readings obtained officially recorded. Three readings shall be obtained for each sub-station relating to the two earth paths connected individually and in parallel. An Evershed and Vignoles or similar earth tester shall be used and all results tabulated and handed to the Engineer.

PART 2 MV Factory Built Assemblies (FBA's)

2.2 PRODUCTS

2.2.2 Motor Control Centres

1 General

Add the following new items:

(f) The electrical feed to the MCC panel shall be a 415 V, 3 phase, 4 wire, 50 Hz public electricity supply. The introduction of the supply shall be by MCCB. The supply incomers shall be rated to carry the full installed pumping station load including the starting load.

(g) The panel shall be of the composite front access, cubicle type and shall comprise several sections of equal depth and height arranged to stand side by side to form a uniform panel of pleasing appearance. The panel shall be arranged for full front access with removable back covers and hinged doors.

(h) The panel shall be provided with feeders for, pumps, pump house equipment, instrument distribution board, lighting and small power distribution board and spare feeders as indicated in the Drawings or as specified by the Engineer.

(i) The different panel compartments shall be arranged in the following order when facing the front of the MCC and reading from left to right:
- (i) Electricity Supply Authority metering.
- (ii) Supply incoming MCCB and mobile generator incoming.
- (iii) Pump starters (current pump installation)
- (iv) Pump starters (future pumps) - only cubicle with feeder MCCB to be provided.
- (v) Miscellaneous feeders / valve actuators, etc.
- (vi) PLC
- (vii) Instrumentation

(j) The units shall incorporate adequate damping to override transient disturbances.

(k) All control circuits shall be so arranged as to be "dead" when the door is open. A test switch shall be incorporated to override this. The switch shall be suitably labelled to draw attention to its function.

Add new Sub-Clause 2.2.5 as follows:

2.2.5 Free Standing LV Feeder Pillar

Refer to QGEWC up-to-date version of Specification No. ED/02-10.

PART 3 Protective Devices

3.2 PRODUCTS

3.2.2 Moulded Case Circuit Breakers

Add new paragraph 16 as follows:

16 MCCB'S to be provided as the MCC incoming and outgoing circuits breakers.

3.2.3 Miniature Circuit Breakers

Add new paragraph 6 as follows:

6 MCCB's to be provided as per distribution board final branch outgoing circuit breakers as well as breakers for control circuits within the MCC.

PART 6 Cables and Small Wiring

6.1 GENERAL

6.1.2 References

Add new paragraphs 3 to 5 as follows:

3 Refer to QGEWC up-to-date version of Specification ED 03-40 and ED 03-140 for further reference on XLPE Cables and accessories used on the MV distribution system.

4 Refer to QCS Specification 6 Part 12 for details related to road lighting cabling.

5 Refer to additional Parts 34 & 35 within this Specification for details related to HV & EHV cables.

6.2 PRODUCTS

6.2.4 Jointing 11 kV, L.V. and Pilot Cables

Add new paragraph 5 as follows:

5 EHV Cables. For details on EHV cable jointing, refer to Part 35.

Add new Sub-Clause 6.2.5 as follows:

6.2.5 Operating Conditions for HV Cables

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1 11 kV Cables. The basic technical values shall be as follows, determinded in accordance with the recommendations of IEC 38, IEC 71-1, IEC 71-2 and other relevant IEC Publications:

(a) Nominal system voltage (r.m.s value, phase to phase voltage)		Un = 11 kV
(b) Highest value of system operating voltage (r.m.s. phase to phase voltage)		Um = 12 kV
(c) Highest voltage for equipment (r.m.s. phase to phase voltage)		
(d) Standard rated frequency		50 cycles
(e) Rated short circuit breaking		25 kA r.m.s, 1 second capacity
(f) System configuration		3 phase, non-effectively earthed
(g) Range of highest voltage for equipment (according to IEC 71-1, clause 38)		A
(h) Standard insulation level for equipment (B.I.L.)	(i) rated lighting impulse withstand voltage (peak)	75 kV
	(ii) power frequency short duration withstand voltage (r.m.s)	28 kV
(i) Insulation co-ordination		According to IEC 71-1 and IEC 71-2

Add new Sub-Clause 6.2.6 as follows:

6.2.6 Electrical Criteria for HV Cables

1 Operating Criteria

a) Maximum Power Rating

(i)	Continuous operation	:	as per existing cables and QGEWC's requirements
(ii)	Cyclic operation	:	No special requirements (but the Contractors should advise the proposed cable capacity)
(iii)	Emergency operation	:	No special requirements (but the Tenderers should advise the proposed cable capacity)
(iv)	Short circuit current rating	:	25 kA, 1 sec.

2 Installation Data

(a)	Reference Drawing	:	EHV-01, 02, 03, 11
(b)	Length of cable route	:	Refer to Dwgs
(c)	Laying arrangement	:	
	(i) Type of laying		
	- In PVC ducts at crossings		
	- Directly buried		
	(ii) Type of sheath		
	- earthing	:	Single end bonded
(d)	Maximum air temperature	:	50 °C
(e)	Type of termination and joints	:	Heat shrinkable

3 Construction Data

(a) Conductor

(i) The conductor shall be segmental stranded conductor, size similar to existing one made of annealed uncoated high conductivity copper wires according to IEC No. 228 (1978). The copper wire before shaping shall be smooth, uniform in quality, and free from scale, inequalities, spills, splits and other defects.

(ii) The term "annealed" signifies that the wire can stand elongation of at least 15 per cent without fracturing before stranding, the test piece being not shorter than 150 mm and not longer than 300 mm.

(iii) When made up from shaped wires the conductor shall be clean and uniform in size and shape and its surface shall be free from sharp edges and unless otherwise approved shall be taped with a layer of conductive or semi-conductive material.

(iv) Not more than two joints shall be allowed in any of the single wires forming each length of conductor and no joint shall be allowed within 300 mm of any other joint in the same layer. The jointing of wires shall be made by brazing, silver soldering or electrical welding. No joint shall be made in the wire after it has been formed up into the required length.

(b) Conductor Screen

(i) The conductor screen shall consist of an extruded semi conductive XLPE compound. The screen shall fill the interstices between the individual strand wires forming the conductor and shall provide a smooth, regular finish that shall be firmly bonded to the inner surface of the insulation.

(c) Insulation

(i) The XLPE insulation shall be triple extruded solid di-electric subjected to a dry curing process. The inner semi-conductive layer (conductor screen), solid insulation and outer semi-conductive layer (insulation screen) shall be extruded and cured in a single process.

(ii) All dimensions and tolerances must comply with IEC 502 and the subsequent Amendments.

(iii) MDCV or VCV process only shall be acceptable for the insulation extrusion, curing and cooling.

(d) Insulation Screen

(i) The insulation screen shall be of an extruded layer of semi-conductive compound having a smooth even surface and shall be in close contact with the core insulation.

(e) Metallic Sheath

(i) The sheath of all cables shall consist of new lead of approved origin and purity applied in the form of a seamless tube. The nominal and minimum thickness of the sheath shall be confirmed before each shipment and shall be in accordance with relevant clause of IEC 502 and as per technical schedules. The sheath shall consist of lead alloy type 0.5 °C and shall be free from blowholes and other defects. Special care shall be taken to ensure that dross or other impurities are excluded from the lead press when the press is being charged.

(ii) The metallic sheath thickness and its composition shall be sufficient to ensure adequate mechanical strength and to resist fatigue caused by vibration.

(iii) The sheath shall be capable of carrying, without damage, the fault current for one second under the most severe fault condition, which has to be confirmed by calculations.

(f) Metallic Sheath Bedding

(i) The compounds applied under and over metallic sheaths shall be of such a nature that in the finished cables they do not crack or run at any temperature likely to be attained in transit to the Site, during installation or when the cables are in operation. The compounds used shall have no detrimental effect on the sheath or outer covering.

(ii) The bedding shall ensure the cable longitudinal water tightness, which is to be demonstrated by test.

(g) Anti-Corrosion Outer Protective Covering

(i) The outer covering over the metallic screen and impervious metallic lead sheath shall be extruded black PVC suitable for the operating temperature of the cable.

(ii) The minimum average thickness and minimum thickness at a point shall comply with requirements of IEC 502 and not less than the value stated in technical schedules.

(iii) Means shall be provided to prevent adhesion between turns and layers of the cable on the drum and between the table and the drum or container at such temperatures as may be met with during transit to the Site, at Site, before laying or while stored.

(iv) The design and efficiency of the coverings shall not be affected by clearing or clamping arrangements supporting the cable. Particular care shall be taken to ensure that the outer covering is not damaged in any way.

(v) An outer conductive coating (graphite coating or extruded layer) shall be applied to the covering to serve as an electrode for the voltage test on the outer covering.

(h) Anti-Termite Protection and Flame Resistance

(i) All cables installed in troughs shall have anti-termite protection applied to the outer covering in the form of a chemical additive such as Gamma BHC, anti-termite poison of similar. The manufacturer shall state the chemical to be used, percentage strength and the reduction in electrical and mechanical properties of the outer covering. The flame resistance shall be confirmed for all cables installed in air (according to IEC 332-1).

(i) Sealing of Cable Lengths

(i) Immediately after the completion of the factory acceptance tests, both ends of every length of cable shall be sealed and shall remain sealed until installed in their final position.

(ii) The sealing shall be done by means of a lead cap fitted over each end and plumed to the metal sheath and finally covered by heat shrinkable cap. The cable ends, which left projecting from the drum for the purpose of the test, shall be protected to avoid damage to the sheathing during transport.

(iii) The same type of the sealing shall be applied on installed lengths if there is a time gap between cable laying and jointing activities.

(j) Cable Identification

(i) The outer covering of all cables shall be embossed with the manufacturer's name, year of manufacturer, voltage level, type of insulation, number of cores and size in accordance with BS 6346.

(ii) The embossed letters/figures shall be raised and shall consist of upright block capitals/figures the size of which shall be not less than 15 per cent of the nominal or specified external diameter of the cable except that in no case shall they by greater than 13 mm.

(iii) The maximum gap between the end of one set of embossed lettering and figures as above and the beginning of the next shall be 500 mm.

(iv) Cables shall be identified at each end of the run (including joint bays) with a marker consisting of a label incorporating 4 mm characters. The labels shall be attached to the cables with two PVC straps.

6.3 INSTALLATION

Add new Sub-Clause 6.3.9 as follows:

6.3.9 Testing

The requirements of IEC 502 shall be applicable on this Contract.

PART 7 Conduits and Conduit Boxes

7.2 PRODUCTS

7.2.1 Rigid PVC Conduit and Fittings

Add new paragraph 7 as follows:

7 Rigid PVC conduits shall be provided for embedded and/or exposed installation at regular indoor locations.

7.2.2 Rigid Steel Conduit and Fittings

Add new paragraph 1(h) and 2(g) as follows:

1 Rigid Steel Conduit

(h) Rigid steel conduit shall be provided for exposed installations at all hazardous locations.

2 Metallic Conduit Boxes

(g) All floor boxes to be of watertight construction.

PART 10 Wiring Accessories and General Power

10.2 PRODUCTS

10.2.3 Switches

Add new paragraph 7 as follows:

7 Lighting Switches

Lighting switches are to be provided for local control of all indoor lighting.

10.2.5 Socket Outlets

Delete paragraph 1 and substitute with the following:

1 General Purpose socket outlets

(a) to BS 1363
(b) 3 rectangular pin (2P + E) shuttered with combined switch, rated 13A, 250 V
(c) to be supplied with plug complete with fuse.
(d) to be provided as required for all indoor areas.

PART 13 Telephone Installations

13.1 GENERAL

13.1.1 Scope

Add new paragraphs 3 to 5 as follows:

3 Telecommunication services that fall under the carriageway or within unacceptable proximity to the new limit of the upgraded road shall be relocated at the approval of Q-Tel. The Contractor shall be responsible for liaising with Q-Tel and obtain from them, prior to the completion of the Works, written confirmation that all existing and relocated telecommunications infrastructure is no longer within unacceptable proximity to the new limit of the upgraded road. The Contractor shall be responsible for the relocation of any telecommunications infrastructure unless specified otherwise by Q-Tel of the Engineer.

4 The Contractor is to confirm the exact location of existing telecommunication services with Q-Tel prior to the commencement of the Works.

5 Relocation of fibre optic main lines where relevant, which unless stated to the contrary are anticipated to be almost wholly replaced, generally entails the following:

(a) All necessary infrastructure (ducts, manholes, etc.) for the new system in the new reservation.
(b) Retrieval of existing fibre optic lines and manhole covers and delivery to Q-Tel.
(c) Financial reimbursement to Q-Tel for their supply and installation of the new fibre optic lines.

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13.3 INSTALLATION

Add new Sub-Clauses 13.3.5 and 13.3.6 as follows:

13.3.5 Modification to Q-Tel Specifications

1 The Q-Tel Specification S.006 shall be modified as follows:

(a) The Supervising officer shall mean any accredited official from Q-Tel or a representative as designated by the Engineer.
(b) All cement used shall be sulphate resisting cement as specified in Section 5 of the Qatar Construction Specification.
(c) The concrete quality classes specified in Clause 202 of the Q-Tel specifications shall be as per the following classes specified in QCS Section 5 Part 6.
(d) In clause 105 of Q-Tel Specification “earth, free from stones” is replaced “dune sand, free of salt to a fine grading as approved by the Engineer”

Part 22 Earthing and Bonding

22.3 INSTALLATION

22.3.1 Installation

Part 23 Inspection and Testing

23.3 ELECTRICAL EQUIPMENT TESTING

PART 31 Power Transformers

31.1 GENERAL

31.1.1 Scope

Add new paragraphs 2 to 4 as follows:

2 This Part is additional to QCS and it specifies the general requirements for 11 kV/415 V power transformer.

3 Related Parts and Sections are as follows:

This Section:	Part 6	HV Cables
	Part 22	Earthing and bonding
	Part 32	HV Switchgear

4 Power transformers are required as shown on the Contract Drawings.

Insert new clauses as follows:

31.6 SUBMITTALS

1 The following documents to be submitted to QGEWC for approval:

(a) Product data for each product specified, detailed description of construction, including dimensioned plans, sections, and elevations. Show minimum clearances and installed devices and features, weight and bearing forces, incoming and outgoing terminals and provisions for feeder terminations.
(b) Wiring diagrams of transformers and accessory components, differentiating between manufacturer-installed and field-installed wiring and cabling.
(c) Routine Tests And Special Tests are to include measurement of noise level, winding resistance, voltage ratio, check of polarity/vector group, impedance voltage, load loss, no-load loss, no-load current, induced overvoltage withstand test and separate source voltage withstand test.
(d) Qualification data for firms and persons specified in the "Quality Assurance" Article to demonstrate their capabilities and experience. Include a list of relevant completed projects with project names and addresses, and names and addresses of the respective Engineers and Government.
(e) Shop and construction drawings including foundation details, grouting holes, base frames and installation details. All civil works are to be approved by END, Civil Section (EWD).
(f) Operation and maintenance data for materials and products.

31.7 QUALITY ASSURANCE

1 Installer Qualifications: Engage an experienced Installer (approved by QGEWC) of high voltage electrical distribution equipment to perform the installation specified in this Section.

2 Standards: Comply with IEC 76, 354, 726 - Power Transformers and IEC 296 - Insulating Oil.

31.8 DELIVERY, STORAGE AND HANDLING

1 Spare Parts: provide spare parts as recommended by the manufacturer, for one year maintenance as expected under local conditions, and to allow for emergency replacement due to accidental breakage or failure.

2 Spare Parts for Oil Filled Transformers are to include, but are not limited to, one set of 11 kV bushings, drain plug, fragile parts which are subject to external damage and suitable quantity of make-up insulating oil.

3 Tools and Instruments: provide tools and instruments required for normal routine inspection, testing, operation and maintenance, recommended by the manufacturer.

31.9 PRODUCTS

31.9.1 Oil Filled Transformer

1 Transformer to be 3-phase, two-winding, liquid immersed, sealed type, rated for continuous operation under site ambient conditions at full rated power, naturally cooled (ONAN), with off-load, manual, externally operated tap-changer, lockable in all positions on primary side. Transformer is to comply with IEC 76, 354 and 404-2.

2 Transformer Construction is to be variable volume steel tank, with corrugated wall design forming integral cooling pockets, heavy rolled and welded steel bottom and base frame and hermetically sealed bolted-on cover. Tank is to be completely filled with insulating liquid drawn in under vacuum. Tank cover is to have provision for two thermometers or temperature sensors, lugs for lifting, four lashing lugs and filler- pipe with valve. Tank is to have drain plug at bottom, earthing bolt on cover and earthing pad on base-frame, and a rating plate.

3 Transformer Noise Level in general is to be less than 76 dB at 0.3 m for ratings up to 1600 kVA and 69 dB for ratings up to 630 kVA and in accordance with IEC 551. Windings are to be copper, unless otherwise approved.

4 Transformer Bushings are to be porcelain, tank-cover mounted, or tank-side mounted to manufacturer's standard, and as approved, with plug-in or bolt-on arrangements.

5 Finish for surfaces are to be steel grit blasted, caustic washed and phosphatized, primed with waterproof primer and finished with weather-resistant enamel and final coat of air-drying enamel. Alternative finish may be used subject to approval.

6 Characteristics of Transformer are:

(a)	Rated power (net site rating)	:	1,000 kVA
(b)	Winding connection	:	Dyn 11, neutral insulated and brought out
(c)	Frequency	:	50 Hz
(d)	Type of insulating liquid	:	Oil natural with radiator sealed type ONAN liquid
(e)	Rated voltage:		
	(i) primary	:	11 kV
	(ii) secondary (no load)	:	415 V
(f)	Impedance voltage at rated current	:	6%
(g)	Tap-changer positions at	:	± 25% and ± 5%
(h)	Rated power frequency withstand voltage	:	50 kV
(i)	Rated lightning impulse withstand voltage	:	75 kV

(j)	Short-circuit apparent power of system at location	:	500 MVA
(k)	Duration of short-circuit	:	two seconds
(l)	Terminal connections:		
	(i) HV side	:	fully insulated with cable sealing ends, bolted type.
	(ii) MV side	:	MV busbars or cables to MV compartment.

7 Accessories are to include the following:

(a) magnetic liquid level gauge with N.O. low level alarm contact;
(b) dial type thermometer with N.O. contact and maximum pointer;
(c) pressure relief device with N.O. contact.

31.10 EXECUTION

31.10.1 Installation

1 Comply with QGEWC electrical safety codes and the manufacturer's written installation instructions.

2 Equipment Bases: ensure that concrete bases and foundations provided for installation of equipment are constructed in accordance with approved shop and construction drawings and equipment manufacturer's drawings and that holes for fixings bolts and provisions for passage of cables etc. are provided as required.

3 Cable Trenches: ensure that trench construction and covers provided for installation of power and control cables are in accordance with approved shop and construction drawings.

4 Cabling And Wiring: install cables, wires, raceways, supports, cable ends and termination fittings in accordance with the appropriate sections of the Specification and/or as shown on the Drawings. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values.

31.10.2 Earthing

1 Earth transformers shall be in accordance with Part 22.

31.10.3 Testing and Commissioning

1 Transformer to be tested in accordance with QGEWC requirements.

2 Schedule tests and provide notification at least one week in advance of test commencement.

3 Report: Submit a written report of observations and tests. Report defective materials and workmanship.

4 Tests: Include the following minimum inspections and tests according to the manufacturer's instructions. For test method and data correction factors, conform to applicable Standards.

(a) Inspect accessible components for cleanliness, mechanical, and electrical integrity, for presence of damage or deterioration, and to ensure removal of temporary shipping bracing. Do not proceed with tests until deficiencies are corrected.
(b) Inspect bolted electrical connections for tightness according to manufacturer's published torque values or, where not available, those of applicable Standards.

(c) Insulation Resistance: Perform megohmmeter test of primary and secondary winding-to-winding and winding-to-ground according to the following:

WINDING RATING (VOLTS)	MINIMUM TEST VOLTS (d.c.)	MINIMUM INSULATION RESISTANCE (MEGOHMS) FOR LIQUID FILLED
601 – 5.000	2.500	1.000
5.000 – 35.000	5.000	5.000

(i) Duration of Each Test: 10 minutes.
(ii) Temperature Correction: correct results for test temperature, deviation from 20 C standards.

(d) Turns Ratio: Measure between windings at each tap setting. Measured ratios deviating more than 0.5 per cent from the calculated ratio or the measured ratio for adjacent coil are not acceptable.
(e) Winding Resistance: Measure for winding at nominal tap setting. Measured resistance deviating more than 1 per cent from that of adjacent winding is not acceptable.

5 Test Failures: Compare test results with specified performance or manufacturer's data. Correct deficiencies identified by tests and retest. Verify that transformers meet specified requirements.

31.10.4 Final Adjustments

1 After completing installation and cleaning, touch up scratches and mars on finish to match original finish.

2 Adjust transformer taps to provide optimum voltage conditions at utilization equipment throughout the normal operating cycle of the facility. Record voltages and tap settings to submit with test results.

31.10.5 Demonstration

1 Training: Include a minimum of 2 days of training in operation and maintenance. Provide both classroom training and hands-on equipment operation covering the following:

(a) Safety precautions
(b) Features and construction of project transformers and accessories
(c) Routine inspection, test and maintenance procedures
(d) Routine cleaning
(e) Features, operation, and maintenance of integral disconnect and protective devices
(f) Interpretation of readings of indicating and alarm devices
(g) Protective relay setting considerations
(h) Features, operation and maintenance of separable insulated connector system
(i) Tap-changing procedures.

2 Schedule training with at least 7 days advance notice.

Add new Part 35 as follows:

PART 35 High Voltage Switchgear

35.1 GENERAL

35.1.1 Scope

1 This Part covers the requirements for high voltage switchgear and associated auxiliary equipment. It is based on QGEWC Specification ED/02-60.

2 Related Parts and Sections are as follows:

Part 1	General Provisions for Electrical Installations
Part 31	Power Distribution Transformer
Part 35	HV Cables

3 For the package substations, the HV switchgear is an integral part and should be furnished pre-installed as a complete unit.

35.1.2 Submittals

1 The following documents to be submitted to QGEWC for approval:

(a) Product data for each product specified, including complete manufacturer's catalogues, operating characteristics, provisions for extension or for addition of components, protective relays and characteristics, instrument transformers and metering components, accuracies and curves.
(b) Shop drawings for each switchgear line up and accessory component. Include dimensional plans, sections, and elevations showing minimum clearances, installed devices, major features, and materials lists, weights cable accesses in slabs, grouting holes and installation details.
(c) Wiring diagrams, both elementary and schematic, differentiating between manufacturer-installed and field-installed wiring including detailed identification of relays, control gear and any other components.
(d) Manufacturer's certification, signed by the manufacturer certifying that equipment complies with the requirements specified in Quality Assurance below. Upon request submit evidence of experience.
(e) Product Certification: Signed by manufacturer of equipment certifying that products comply with the specified requirements.
(f) Routine Tests of each complete switchgear unit is to undergo routine tests at the manufacturer's works in accordance with the relevant standards. Submit routine test reports, prior to shipping equipment, indicating ambient test conditions and guaranteed rating of equipment under site conditions.
(g) Installers' certificates signed by the Contractor, certifying that the Installers comply with the requirements specified under Quality Assurance below.
(h) Report of Field Tests: Certified copies of field tests including ground resistance tests.
(i) Maintenance data for materials and products.
(j) Protection coordination scheme with pick-up time-current settings as required to coordinate with upstream and downstream protective devices of the complete system.

35.1.3 Quality Assurance

1 Installer Qualifications: Engage an experienced Installer (approved by QGEWC) of high-voltage electrical distribution equipment to perform the installation specified in this section.

2 Manufacturer Qualifications: Manufacturer shall be regularly engaged in manufacturing switchgear complying with the requirements of these Specifications, experienced with at least 5 projects of similar size and scope.

3 Type Test Certificates are to be submitted to verify compliance of main equipment with the relevant IEC Standards, including, but not limited to, the following: impulse withstand voltage tests, power frequency withstand voltage tests, temperature rise tests, short time current tests, verification of making and breaking capacity, mechanical endurance/operation tests, verification of degrees of protection for persons against contact with live and moving parts, internal arc test, protection degree test.

4. Standards equipment and component parts are to comply with the following Standards:

(a)	common clauses for HV switchgear and control gear standards	:	IEC 694
(b)	a.c. metal-enclosed switchgear and control gear for rated voltages above 1 kV and up to and including 72.5 kV	:	IEC 298
(c)	HV a.c. circuit breakers	:	IEC 56
(d)	insulation coordination	:	IEC 71
(e)	HV a.c. fuse-switch combinations and fuse-circuit-breaker combinations	:	IEC 420
(f)	a.c. disconnectors (isolators) and earthing switches	:	IEC 129
(g)	HV switches	:	IEC 265
(h)	metering and protective current transformers (CTs)	:	IEC 185
(i)	metering and protective voltage transformers (VTs)	:	IEC 186
(j)	relays	:	IEC 225
(k)	reading instruments	:	IEC 51
(l)	watt-hour meters	:	IEC 521
(m)	power transformers	:	IEC 76 (for)
(n)	insulating oil	:	IEC 296
(p)	sulphur hexafluoride	:	IEC 376
(q)	fuses	:	IEC 282-1
(r)	surge arrestors	:	IEC 99

5 Electrical Component Standard: Components and installation shall comply with the local applicable codes and regulations of the Authority having jurisdiction.

6 Manufacturer/Product Selection: The Drawings indicate sizes, profiles, and dimensional requirements of high-voltage switchgear which are based on specific types and models of manufacturers. Switchgear having equal performance characteristics by other manufacturers may be considered provided that deviations in dimensions and profiles do not change the design concept and space requirements or intended performance as judged by the Engineer.

35.1.4 Delivery, Storage, and Handling

1 Deliver Switchgear and components properly packaged and mounted on pallets, or skids to facilitate handling of heavy items. Utilize factory-fabricated type containers or wrappings for Switchgear and components which protect equipment from damage. Inspect equipment to ensure that no damage has occurred during shipment.

2 Store Switchgear in original packaging and protect from weather and construction traffic. Store above grade and enclose with watertight wrapping.

3 Handle Switchgear carefully to prevent physical damage to equipment and components. Remove packaging, including the opening of crates and containers, avoiding the use of excessive hammering and jarring which would damage the electrical equipment contained therein. Do not install damaged equipment; remove from site and replace damaged equipment with new.

35.1.5 Sequencing and Scheduling

1 Schedule delivery of switchgear and accessories equipment that permits ready building ingress for large equipment components to their designated installation spaces. Coordinate delivery of equipment with the installation of other building components.

2 Coordinate the size and location of concrete equipment pads. Cast anchor bolt inserts into pad. Concrete, reinforcement, and formwork requirements are specified in QCS Section 5.

3 Coordinate with other electrical work including raceways, electrical boxes and fittings, and cabling/wiring work, as necessary to interface installation of switchgear with other work.

35.2 PRODUCTS

35.2.1 High voltage Switchgear, General Requirements

1 HV Switchgear Compartment is to include metal-enclosed ring main switchgear unit with SF6 switching and SF6 insulated busbars comprising two incoming switch-disconnectors for ring main network feeders, one transformer protection fuse-switch combination, cable terminal fittings behind dead front panels, and front mounted switchgear operating handles, control, indication and metering devices.

2 HV Switchgear Characteristics

(a)	rated voltage	:	12 kV
(b)	nominal service voltage	:	11 kV
(c)	rated impulse withstand voltage (peak)	:	75 kV
(d)	rated frequency	:	50 Hz
(e)	rated one minute power frequency withstand voltage (r.m.s)	:	28 kV
(f)	rated short-time withstand current for one second	:	25 kA
(g)	busbar current rating	:	630 A (minimum)
(h)	rated peak withstand current	:	63 kA

3 HV switch-disconnector is to be of the general purpose, 3-pole, load-break, short-circuit make, category B to IEC 265.

(a)	rated normal current	:	630 A
(b)	rated short-circuit making		
(c)	capacity (peak)	:	equal to rated peak with-stand current.

4 Switch-disconnector Operation is to be by removable handles at front of unit. Switching mechanism is to be manual, or automatic with remote control, spring charged, quick-make, quick-break, with speed of switching independent of operator. Switch is to be provided with a suitably rated universal motor capable of one complete off-on-off cycle in case of loss of control power. Main switch and earth switch operations are to be separated and safety interlocked with the manual handle inserted in separate access holes for on/off operation of main switch and earth on/earth off operation of earth switch. Handle design is to ensure delay between closing and re-opening of main switch or earthing switch, to provide an anti-reflex operation. It is to be impossible to move earth switch inadvertently into or from earth position except when main switch is in the open position. Indication of switch position is to be mechanical, directly connected to moving contacts. Each switch is to have padlocking device in the open, closed and earth positions.

5 Fuse-Switch Combination is to consist of trip-free, load- break, short-circuit make fuse-switch combination, with operational requirements as for switch-disconnector. Fuse is to be separately located in fuse chamber with interlocked earthing switches providing upstream and downstream earthing of the fuse assembly. Automatic trip switching is to be actuated by fuse striker pins which actuate common trip-bar in switch mechanism. Once operated, striker pins remain in ejected position, preventing reclosure of switch until fuse has been replaced. Single phasing is not to be possible. Fuses are to be totally enclosed, current limiting, cartridge type, high-breaking capacity, with striker pins, and withdrawable from front of unit. Fuse switch combination is to have the following ratings.

(a)	rated normal current	:	200 A
(b)	rated prospective short-circuit breaking current	:	25 kA to IEC 420
(c)	rated prospective short-circuit making current	:	65 kA
(d)	rated current of fuse link	:	100 A

6 Incoming/Outgoing Cables of type and size are to be as shown on the Drawings.

7 Cable Terminal Connectors to stress-relieving, epoxy sealed end, bolted type, complete with all accessories. Alternative arrangement may be proposed by manufacturer.

8 Potential Indicators to be neon type provided at front of each unit, one per phase, using capacitive potential divider to indicate voltage at switch-disconnector cable terminals.

9 Accessories are to include the following:
(a) two N.C. and two N.O. auxiliary contacts on each switch
(b) shunt trip release on fuse-switch combination
(c) earth fault indicator, operated by core-balance type current transformer, located near and outside cable box/termination's with indicator visible from front and with automatic reset.

35.3 EXECUTION

35.3.1 Installation

1 Equipment Bases: ensure that concrete bases and foundations provided for installation of equipment are constructed in accordance with approved shop and construction drawings and equipment manufacturer's drawings and that holes for fixings bolts and provisions for passage of cables, etc. are provided as required.

2 Install switchgear and accessory items in accordance with manufacturer's written installation instructions and the following specifications:

(a) Anchoring: Anchor each switchgear assembly to two 100 mm minimum channel iron sills by tack welding or bolting.
(b) Sills shall suit the switchgear and shall be levelled and grouted flush into the floor.
(c) Platform: Where a membrane-waterproofed floor or pressure slab is indicated under a switchgear location and elsewhere, where indicated, there shall be provided a concrete housekeeping pad. The 100 mm channel sills specified above shall be provided in the pad.

3 Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchgear units and components.

4 Framed Operating Instructions: Printed basic operational instructions for switchgear, including key interlocking sequence, if any, and emergency procedures, framed under clear acrylic plastic on the front of the switchgear are to be provided.

5 Cable Trenches: ensure that trench construction and covers provided for installation of power and control cables are in accordance with approved shop and construction drawings.

35.3.2 Earthing

1 Earthing to be as per paragraph 9.4 of QGEWC Specification ED/02-60.

35.3.4 Connections

1 Install all incoming and outgoing cable supports, cable ends and termination fittings required for HV, MV and control cables.

2 Tighten electrical connectors and terminals in accordance with manufacturer's published torque-tightening values.

35.3.5 Testing and Commissioning

1 General: Comply with applicable IEC standards or the international Electrical Testing Association (INETA) including Standard ATS, "Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems" where no other local standards have precedence.

2 Pre-testing: Upon completing installation of the system, perform the following preparations:

(a) Equipment: inspect equipment upon delivery to site and report any damage to the Engineer.
(b) Switchgear: inspect and check switchgear for completeness and as recommended by the manufacturer and check phasing of buses, contact alignment and clearances.
(c) Components: check component ratings, types, sizes and wiring connections, including current and voltage transformers, fuses, switches, instruments and relays.

(d) Make insulation resistance tests of switchgear buses, components, and connecting supply, feeder, and control circuits.
(e) Make continuity test of circuits.
(f) Provide Manufacturer's installation and testing instructions to test organization.

3 Test Procedure: Conform to the following:

(a) Test objectives: To assure switchgear installation is operational within industry tolerances and is installed in accordance with the specified requirements, and is suitable for energizing.
(b) Procedures: Make field tests in accordance with applicable IEC standards.
(c) Schedule tests and notify Engineer at least one week in advance of test commencement.

4 Protective Relay Settings:

Set in accordance with manufacturer's instructions and the coordinated QGEWC systems requirements. Settings given on drawings shall be verified to be accurate for final system configuration and parameters. Where discrepancies are found, final relay settings shall be recommended to the Engineer, and any revised settings accepted by him shall be used by the test organization to make the final adjustments.

5 Tests: Perform high-potential test of switchgear and accessories and such other tests and examinations as are needed to achieve specified objectives, including the following:

(a) Perform mechanical and electrical operator tests. Check main and auxiliary contact alignment.
(b) Check arc-interrupter operation on load-interrupter switches.
(c) Verify key interlock operation.
(d) Test insulation resistance on each phase to ground and from each phase to each other phase.
(e) Test a.c. overpotential as recommended by IEC standards.
(f) Test contact resistance across each main contact set. Report contact resistance in excess of manufacturer's tolerances.
(g) Test polarity and ratio of CT's.
(h) Test protective relays to determine pickup parameters. Verify accuracy of timing setting for three points on time dial curve.
(i) Trip each circuit breaker by operating each associated protective relay.
(j) Measure minimum pickup voltage of each trip and close coil.
(k) Test arc chutes for losses in accordance with manufacturer's instructions.
(l) Check integrity and insulation of ground and test device.
(m) Check calibration and adjust ammeters and voltmeters.
(n) Verify operation of all auxiliary and emergency equipment.

6 Retesting: Correct deficiencies identified by tests and retest switchgear under such circumstances. Verify by the system test that the total system meets the specified requirements.

35.3.6 Final Adjustments

1 Upon completion of installation, inspect interior and exterior of switchgear. Remove paint splatters and other spots, dirt, and debris. Touch up scratches and mars of finish to match original finish.

35.3.7 Demonstration

1 Training: Conduct a minimum of two days' training in operation and maintenance. Include both classroom training and hands-on equipment operation and maintenance procedures.

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2 Schedule training with at least seven days' advance notice.

Add new Part 36 as follows:

PART 36 Extra High Voltage Cables

36.1 GENERAL

36.1.1 Scope

1 This Part includes single and multiple conductor cables and splices, terminations, and accessories for cables above 11,000 V rating.

2 Related Parts and Sections are as follows:

This Section:	Part 1	General Provisions for Electrical Installations
	Part 6	Cables and Small Wiring
	Part 31	Power Distribution Transformers
	Part 32	11 KV Switchgear

3 General

This section deals with the specific technical requirements related to material, equipment, execution of works and all other activities necessary for the implementation of works related to 132 kV and 66 kV cables.

132 and 66 kV power cables shall be connected to the existing QGEWC transmission system and, after connection, shall form part of the system. The EHV circuits that will be installed and connected shall be as specified by the Engineer. The new lines shall meet the requirements of the existing system.

The 11 kV circuits that require diversion and hence new installation in specific locations are indicated on the Drawings, and they are covered in QCS Section 21, Part 6.

36.1.2 Submittals

1 The following documents to be submitted to QGEWC for approval:

(a) Product data on cables and cable accessories including descriptions and detailed specifications.
(b) Shop drawings of joints and terminations.
(c) Product certificate signed by manufacturer that its products comply with the specified requirements.
(d) Installer certificates signed by manufacturer of cable splicing and terminating products that Installers comply with training requirements specified under "Quality Assurance".
(e) Installer certificates signed by Contractor that Installers of cable splices and terminations meet the experience qualifications specified under "Quality Assurance".
(f) Product Test Reports: Certified reports of manufacturers' factory production and final tests indicating compliance of cable and accessories with referenced standards.
(g) Report of Field Tests: Certified copies of field test records.
(h) Maintenance data for cables and accessories, manufacturer's written instructions for periodic tests of cables in service, operating instructions for fault indicators and separable insulated connectors and their accessories.

36.1.3 Quality Assurance

1 Installer Qualifications: Engage an experienced Installer (approved by QGEWC) of high-voltage electrical cable to perform the installation specified in this section. In addition, for the specific work of cable splicing and terminating, engage Installers who are experienced in cable splices for the specific types of cable and cable accessories specified in this Section.

2 Standards Compliance: Cables and components shall be marked, listed and labelled by Manufacturer in accordance with the approved standards of manufacture (IEC, BS, UL, DIN, UTE, NFC, ICEA, etc.).

3 IEC Compliance: Components and installation shall comply with the relevant IEC Standards and the local Authority specification having jurisdiction.

4 Electrical Component Standard: Components and installation shall comply with NFPA 70 "National Electrical Code".

5 IEEE Compliance: Comply with applicable IEEE standards including C2 "National Electrical Safety Code".

36.1.4 Delivery, Storage and Handling

1 Deliver extra high and high-voltage cable on factory reels conforming to Standard applicable or as otherwise specified.

2 Store cables on reels on elevated platforms in a clean, dry location.

36.1.5 Warranty

1 Special Project Warranty: Submit a written warranty, mutually executed by manufacturer and the principal Installer, agreeing to repair or replace high voltage cables, splices, and terminations that fail in materials or workmanship within the special project warranty period specified below. This warranty shall be in addition to, and not a limitation of, other rights and remedies the PWA may have against the Contractor under the Contract Documents.

2 Special Project Warranty Period: 2 years beginning on the date of Substantial Completion.

36.2 PRODUCTS

36.2.1 Environmental Conditions

1 The following conditions apply:

(a)	Altitude above sea level	:	Below 1000 m
(b)	Distance from sea	:	Less than 10 km
(c)	Wind speed	:	140 km/h Prevailing wind direction NW to NNW
(d)	Ground water level	:	2-70 m
(e)	Pollution level	:	Air heavily laden with dust and salt (vide IEC 8.15, Table 1) with high percentage of salt
(f)	Creepage distance phase to phase	:	35 mm/kV (Vide IEC 815) (based on the highest phase to phase system voltage)
(g)	Isokeraunical level	:	20 thunderstorm days per year

(h)	Lightning current (peak) (for protective earthing)	:	60 kA
(i)	Earthquake factor	:	intensity approx. VI of M.M Scale (Modified Mercalli Scale)
(j)	Design absolute maximum temperature	:	50 °C
(k)	Rainfall Summer	:	13 mm, 1 month
	Winter	:	29 mm, 1 month

36.2.2 Current Carrying Capacity

1 The maximum continuous current capacity, maximum permissible conductor temperature and the factors for determining such rating and temperature shall be based on IEC recommendation No. 287 and subsequent amendments and all actual conditions at site.

2 Cable rating calculations shall be submitted along with the offer based on the data provided under "Design Criteria". The calculations shall be reconfirmed and approved after the Site investigations and before the manufacture.

3 The Contractor shall carry out, at his own expense, moisture content, water table level, and soil thermal resistivity tests along the 132 and 66kV cable route and such other tests as he may consider necessary, sufficiently in advance of the manufacture of any cable, to satisfy himself that, the conditions on-site and his proposed arrangement of cables and method of installation are such that the maximum current carrying capacity can be maintained. If the Contractor considers that the conditions and the proximity to other power cables, spacing and method of installation are likely to reduce the maximum current carrying capacity below the declared value, he shall immediately notify QGEWC as to what the maximum current carrying capacity would be under these conditions and shall not proceed with the work on that portion of the route affected until QGEWC has given its permission.

4 Power cable sizes proposed for this project are based on the sizes of the existing cables to which the new ones will be jointed.

5 The conductor and metallic sheath shall be adequate for carrying the specified short-circuit current when operating under the specified load conditions without deterioration of the di-electric or other component materials of the cable. The overall performance of the new circuit under specified load and short circuit conditions will be equivalent or superior to the original circuit.

36.2.3 Electrical Criteria for EHV Oil Filled Cables

Item No.	Description	132 kV	66 kV
1	Voltage between phases of three phase circuit kV	132	66
2	Number of cores	1	1
3	Sectional area of conductor (2) sq.mm	500	500
4	Conductor details:		
	4.1 Material	Plain Copper	
	4.2 Special features, e.g. plain, tinned, died down, screened shaped, etc.	(Hollow, self-supporting type, screened)	
5	Oil ducts:		
	5.1 Material	Formed by segments	
	5.2 Nominal internal diameter	12.0	12.0
6	Maximum di-electric stress at the conductor, assumed smooth - MV/m	11.2	9.6
7	Minimum radial thickness of insulation between conductor and screen - mm	8.7	4.6
8	Insulating paper:		
	8.1 Type	Kraft Paper Tape	
	8.2 Nominal thickness - mm	0.100	0.150
9	Core screen:		
	9.1 Material		
	9.2 Nominal thickness - mm	*1	*2
10	Materials used for fillers	Paper	
11	Type of Impregnant (º)	Low Viscosity Insulating Oil	
	Viscosity 20ºC - Centipoise	12 ~ 15	
	Viscosity 50ºC“	4 ~ 6	
	Viscosity 85ºC“	2 ~ 3	
12	Binder cover laid-up cores:		
	12.1 Material	Copper Woven Fabric	
	12.2 Nominal thickness - mm	0.3	0.3
13	Minimum radial thickness of metal sheath - mm	2.3	2.1

Note: *1 *One carbon paper tape and one metallized paper tape intercalated with one carbon paper tape: 0,13, 0,14 and 0,13 respectively.*

*2 *Ditto as above, but: 0,15, 0,14 and 0,13 respectively.*

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Item No.	Description	132 kV	66 kV
14	Nominal diameter over metal sheath - mm	54	45
15	Composition of lead Sheath		
	Lead alloy:		
	Tin %	0.175 to 0.225	
	Cadmium %	0.06 to 0.09	
	Antimony %	- - - - - - - - - - - - - - - - -	
	Lead %	The Remainder	
16	Wrappings under reinforcement:		
	Material	Rubber coated fabric tape	
	Nominal Thickness - mm	0.5	
17	Reinforcement material		
	0.1% proof stress - MN/sq.m.	600	600
	Nominal thickness - mm	0.10	0.10
	Number of layers - mm	2	2
	Maximum working stress – MN/sq.m at maximum static pressure of 525 kN/sq.m	71	59
18	Protective outer covering nominal thickness P.V.C. sheath - mm	3.0	2.8
19	Nominal overall diameter of: completed cable - mm	63	54
20	Nominal weight per metre of completed cable - kg	12.5	10.4
21	Minimum radius of bend round which cable can be laid:		
	2 1.1 Laid Direct or in air - m	1.9	1.7
	21.2 In ducts - m	2.2	1.9
22	Minimum internal diameter of pipes or ducts that can be used - mm	100	100
23	Maximum D.C. resistance of conductor per 1.000 m of cable at 20 ºC - ohm	0.0366	0.0366
24.	Maximum A.C. resistance of conductor per 1.000 m of cable at 85 ºC and 50Hz - ohm	0.04715	0.0473

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Item No.	Description	132 kV	66 kV
25	Equivalent star reactance per 1.000 m of three-phase circuit at 50Hz		
	(a) In spaced formation ohm	0.23	0.23
	(b) In trefoil - ohm ohm	0.11	0.10
26	Maximum. electrostatic capacitance per core per 1.000 m of cable at 50Hz - pF	415 x 10^3	707 X 10^3
27	Maximum charging current per conductor per 1.000 m of cable at nominal voltage - amp	9.9	8.5
28	Maximum continuous current carrying capacity per conductor when laid direct in the ground (Net g = 2.5 ºC/m/Watt)		
	1.1 m to top of cable at a ground temperature of 35 ºC	Sheaths bonded at both ends	
	28.1 One Three Phase circuit per trench (a) 132 kV 500 mm²: 3 x single core cables laid in Trefoil	389 A	-
	(b) 66 kV 500 mm²: 3 x single core cables laid in Trefoil	-	417 A
	28.2 Two Three Phase Circuit per trench (a) 132 kV 500 mm²: 6 x single core cables laid in two	328 A	-
	Trefoil groups with 700 mm		
	between circuits		
	(b) 66 kV 500 mm²: 6 x single core cables laid as (a)		361 A
	between circuits.	-	-
	28.3 Assumed maximum conductor temperature	85 ºC	85 ºC

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Item No.	Description	132 kV	66 kV
29	Maximum continuous current carrying capacity per conductor when drawn into pipes (filled with Bentonite Grout) at ground temperature of 35 ºC with Net g = 2.5 ºC/m/Watt with I. 1 m to top of cable.		
	29.1 One three phase circuit (a) 132 kV 500 mm²: 3 x single core cables laid Trefoil.	390 A	-
	(b) 66 kV 500 mm²: 3 x single core cables laid Trefoil	-	415 A
	29.2 Two three phase circuits (a) 132 kV 500 mm²: 6 x single core cables laid. in two Trefoil groups with 700 mm between circuits.	319 A	-
	(b) 66 kV 500 mm²: 6 x single core cables laid as (a)	-	350 A
	29.3 Assumed maximum conductor temperature	85 ºC	85 ºC
30	Maximum continuous current carrying capacity per conductor when laid on rack in air at ambient temperature of 50 ºC (with cable duly clamped)		
	30.1 One three -phase circuit - amp.	708	728
	30.2 Assumed maximum conductor temperature - ºC	85	85
31	Maximum power factor of charging kVA of cable when laid direct in the ground at nominal voltage, normal frequency and operating oil pressure, at a conductor temperature of:		
	15 ºC %	0.35	0.35
	30 ºC %	0.30	0.30
	45 ºC %	0.30	0.30
	65 ºC %	0.28	0.30
	85 ºC %	0.28	0.30

Item No.	Description	132 kV	66 kV
32	Maximum di-electric loss of cable per 1.000 metres of three-phase circuit when laid direct in the ground at nominal voltage, normal frequency and operating oil pressure at maximum conductor temperature - kW	6.36	2.90
33	Maximum power factor of charging kVA of cable at normal frequency and operating oil pressure at a conductor temperature of 20 ºC at		
	50% nominal voltage %	0.30	0.35
	Nominal voltage %	0.30	0.35
	150% nominal voltage %	0.32	0.37
	200% nominal voltage %	0.35	0.40
34	Sheath loss, including reinforcement of cable per 1.000 metres of three phase circuit at nominal voltage, normal frequency and operating oil pressure, at maximum current rating:		
	34.1 Laid direct in the ground with current per conductor as stated in item 28.1 (a) Trefoil - kW	2.1	1.93
	34.2 Drawn into duct cluster with current pet conductor as stated in item 29.1 (a) Trefoil - kW	6.61	7.55
35	Cable thermal resistance nominal design value		
36	Oil pressure, above atmospheric Pressure		
	36.1 Minimum operating pressure kN/sq.m		
	Cable and joints	20	
	Sealing ends	20	

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Item No.	Description	132 kV	66 kV
36 (cont)	Pressure tanks:		
	1 Atmos - kN/sq.m		
	1 ½ Atmos	59	
	2 Atmos		
	3 Atmos		
	36.2 Maximum operating pressure:		
	Static conditions		
	Cable and joints	525	
	Sealing ends	525	
	Pressure tanks:		
	1 Atmos	-	
	1 ½ Atmos	441	
	2 Atmos	-	
	3 Atmos	-	
	Tiansient conditions		
	Cable and joints	784	
	Sealing ends	784	
37	Pressure/Volume characteristics of Pressure tanks: Nominal size : 44 litre 88 litre 135 litre 180 litre 225 litre 300 litre	REFER TO QGEWC DRAWING NO. 7660/26/169	
38	Oil Feed pipes: 38.1 Material and dimensions 38.2 Protective covering EXTRUMED BLACK PUC	Copper inner diameter 12 mm EXTRUDED BLACK PVC	
39	Total oil volume per km of cable approx. litres/km	900	600
40	Maximum length per drum approx. - m	650	700
41	Maximum dimensions and weight of drum arranged for shipping		
	Diameter m	2.42	2.42
	Width m	1.50	1.35
	Weight (Gross weight) kg	9.300	8.100
42	Is the impregnating oil compatible with Butmah Oil Type C6 and Pirelli Volfoil 10	Yes	
43	Electrical resistance of cable sheath: 43.1 Nominal resistance at 20 ºC ohm/Km	0.523	0.677

36.2.4 Site Survey

1 The proposed routes of the cable lines will be established within the way leave accepted and approved by QGEWC.

2 Within a reasonable time after the Contract has come into force, the Contractor shall verify the route through Design Enquiry Letter Procedure survey and agree a final route with QGEWC and confirm the arrangements.

3 Trial pits shall be opened by the Contractor at approved positions proposed by him, to determine the most suitable detailed route and position for the trenches. The width of trial pit shall be sufficient to determine the cable route, but not smaller than that of cable trench.

4 On the basis of the trial pits, detailed survey and the requirements of concerned Government authorities relating to safety clearances, the Contractor shall arrange the necessary drawings to process the necessary RO (Road Opening) forms before the installation commences, as detailed in General Technical Requirements. Obtaining of RO approvals shall be Contractor's responsibility and cost for these works shall be deemed to have been included in his Contract price. However, QGEWC will assist by issue of necessary letters, etc.

5 All routes shall be defined precisely, and shown in drawings at an approved scale (1:500). The stable structures shall be indicated clearly as well as distances. The crossings with roads and underground installation shall be shown. Joint locations shall be identified clearly and sufficient section views shall be shown. Joint locations shall be identified clearly and sufficient section views shall be provided where necessary. The dates of installation of cable joints, cable drum serial No's., name of jointers, shall be included in the "as-built" drawings. Cable section lengths shall also be given.

6 All drawings shall be subject to QGEWC's approval.

7 The quantity of cables, accessories, etc. to be supplied shall be based upon this survey. The programme for route survey works shall be agreed upon with QGEWC prior to commencement of the Works.

36.3 FURTHER REQUIREMENTS FOR EHV CABLES

36.3.1 132 and 66 kV Cable Line

1 WhereEHV circuits that require new sectionsare oil filled, these shall be replaced with oil filled cables.

2 Cable lines shall consist of independent circuits similar to existing requirements, with the minimum spacing to QGEWC's requirements.

3 The minimum following tests are required for the EHV cables:

(a) <u>Conductor Resistance Tests:</u>

The copper resistance of the conductors shall be measured by direct current at room temperature in accordance with IEC publication 141-1 and BSS 6480. The values thus obtained shall not be greater than the guaranteed values as per IEC Publication 141-1 and BSS 6480.

(b) Capacitance Tests:

The electrostatic capacitance of each drum length of completed cable shall be measured at length of completed cable shall be measured at power frequency and shall not be greater than the guaranteed values specified by the Engineer.

(c) High Voltage Tests:

The voltage tests shall be carried out with alternative current in accordance with IEC publications 141-1 for oil filled cables.

(d) Di-electric Power Factor/Voltage Tests:

Each drum length of completed cable shall be tested for power factor at normal frequency and at ambient temperature and at 100 and 200 per cent of normal. The power factor of the charging kVA, after correction to a temperature of 20 °C shall not exceed the guaranteed values stated in the schedules of guarantees. These guaranteed values shall be in accordance with IEC publication 141-1 and BSS 6480.

(e) Voltage Tests on Anti-Corrosion Coverings:

This shall be carried out in accordance with IEC-141 and IEC-229.

Accessories:

(i) Visual dimensional checks on selected samples of each batch of joint boxes (not less than one joint box of each 50 boxes).
(ii) Tests to check inner lead sleeve composition.
(iii) Tests analysis of plumbing and solder to check compliance with B.S 219. Tests should be carried out on samples selected from each batch (but not less than one sample of each 200 sticks)

4 The continuous power rating per circuit under the conditions specified above must be ensured for entire life span of the installation. The Contractor shall submit detailed calculations according to IEC 287, for the proposed equipment to confirm this requirement along with the bids.

5 In order to meet the specified current rating capacity, cross bonding of the metallic sheathes with phase transposition at each joint shall be adopted.

6 The maximum conductor operating temperature shall be limited to 85 °C.

7 The special bonding of the metallic sheathes shall be designed according to Engineer Recommendation C.55/2, issued by Electricity Council – Insulated Sheath Power Cable System.

8 The maximum value of circulating current losses in the metallic sheath and screen shall be 3% of the conductor losses at full rated load current at maximum temperature and shall be taken into account when cable size is determined.

9 The maximum induced voltage at cable sheath at rated load current shall not exceed:

(a) 65 V normal working conditions
(b) 2.5 kV for ground fault conditions (25 kA earth fault current).

10 The metallic sheath (lead alloy) shall be able to carry the complete earth fault current for the specified period. Each component shall be checked to ensure that there is no overloading when they carry fault current together. This shall be confirmed by calculation as per IEC 949.

11 Cyclic and emergency ratings shall be guaranteed by the Contractor. Calculation of these rating shall be carried out according to IEC 853.

12 During installation, when crossing with other heat sources, or laying at depths deeper than 1.1 m at the crossings or such similar conditions, the Contractor shall maintain the specified rating, either by application of the special stabilised backfill or by increasing the phase spacing. For every situation the arrangement with relevant calculations shall be submitted to QGEWC for approval, prior to installation.

13 Specific thermal resistance of 2.5 °C m/W shall be maintained even for completely dry backfilling material. This has to be confirmed before placing the backfill materials in the trench. The ground temperature at depth of laying as well as the thermal resistance of the backfilling material shall be controlled during the cable installation and shall form part of the installation procedure. The Works, material or labour supply necessary to meet this requirement is deemed included in the Contract price.

14 Application of the special backfill in order to achieve cable rating shall be allowed where conditions require so, without additional cost.

36.4 CABLE ACCESSORIES

36.4.1 General

1 All cable accessories (sealing ends, straight joints, link boxes, etc.) must be of an approved and reliable design. The accessories design shall be confirmed by performance of the type test as defined elsewhere. For the EHV cables, the joints should be furnished from the cable supplier or from a supplier with a previous history with the cable supplier.

2 The maintenance requirement shall be brought to minimum, but the design shall be such to enable easy maintenance without disturbing the other items in the system.

3 The voltage stress grading shall be achieved by stress cone device.

4 Design of sealing ends shall comply with IEC 859.
Bonding and earthing system shall comply with IEEE 80 and C55/4 requirements.

5 The earthing resistance of the joint bay earthing system shall not exceed value of 5 ohms.

36.5 TELECOMMUNICATION REQUIREMENTS

36.5.1 General

The following clauses provide information about the existing telecommunication system:

1 The QGEWC Telecommunication System of Qatar Power Transmission System covers transmission of data, tele-protection signals and telephone messages.

The QGEWC telecommunication System consists of 3 networks:

(a) Data communication network
(b) Tele-protection signalling network and
(c) Telephone network

2 Communication lines of newly relocated 132, 66 and 11 kV cables shall be connected to QGEWC Telecommunication System on the same principles of existing system. Each EHV and HV circuit shall be accompanied by a fibre optic cable, which will be connected to the communication equipment in each respective location. The fibre optic cables will be installed and tested to insure that all tele-protection, data communication, and voice communication systems are maintained as the existing system. All signals between substations shall be retested following installation of new circuits.

36.5.2 Fibre Optic Links

1 Two fibre optic pilot cables along the proposed power cables laid on independent way leaves with two appropriate optical line equipment of capacity of 120 telephone channels and one multiplex equipment shall be applied for connection of Existing Substation, to QGEWC Telecommunication System.

2 Error performance and availability objective from ITU-T Recommendation and Reports has been used as criterion in fibre optic links calculations, as well as:

(a)	Guaranteed BER during life time of the system	10-10
(b)	System margin (dB)	3

3 Requirements for fibre optic cable and accessories are given below under the heading entitled “35.16 Fibre Optic Cable and Accessories”.

36.6 CROSSING WITH OTHER UTILITIES AND INTERFERENCE WITH PIPELINES

36.6.1 General

1 In case of crossing with the other installations the following have to be observed:

(a) Clearances between installations shall be according to "Guideline for Planning Works in the Vicinity of EHV Installations", issued by QGEWC (old MEW), May, 91.
(b) The service authorities may imply additional requirements (mechanical protection, etc.) through the work permit procedure. This has to be complied with by the Contractor, and it is considered included in the Contract price.
(c) In case of the crossing with the other heat sources the special attention shall be paid to cable current rating calculations, and additional measures have to be applied.

2 At the crossing with the existing installations the new cable shall be preferably installed beneath, always taking into account the current rating requirements. If necessary, the phase spacing could be increased at the crossing point.

3 After opening of the existing installations and before cable laying, the sketch of the final arrangement shall be approved.

4 Each crossing point shall be clearly marked with the route markers, after backfilling.

5 In case of running parallel with pipelines, the Contractor shall carry out the following checking before starting installation works:

(a) calculation of the induced voltage on the pipeline for the normal working conditions and earth fault conditions
(b) influence due to galvanic coupling between the installations
(c) checking of influence on the pipeline cathodic protection system
(d) possibility of the accelerated corrosion of the metallic structures of the cable line
(e) any requirement arising from these calculations shall be implemented by the Contractor, and are deemed included in the Contract price.

36.7 CIVIL WORKS CRITERIA

36.7.1 General

1 Two circuits in one trench shall be accepted only following QGEWC's approval of the clearance requirements.

2 Method of laying is direct burial in ground with exception of the road crossing where cables are to be laid in ducts. The supply and installation of the supporting structures is part of this Contract.

3 Concrete pits and tunnels/trenches at road crossing and area subject to traffic shall be designed for the maximum wheel load of 6T. (maximum axle load of 12.5T).

4 Concrete structures at and below ground level are to be constructed using sulphate resistant cement only.

5 All foundations and concrete surface at and below ground level are to be isolated from contact with soil in accordance to QGEWC specifications.

The cable route is mainly located parallel with existing or proposed roads, and in principle agreed with the concerned authorities.

36.7.2 Cable Laying Condition

1 The cables shall be laid in flat formation.

2 The material surrounding the cable in its trench must not damage the cable surface and must be suitable for restraining the cable against any thermal expansion or traffic induced movements and, also must be suitable for thermal dissipation from the cable to its surrounding. The material commonly used in Qatar is dune sand. Bedding material must be sufficiently dense to ensure that the value of thermal resistivity of cable environment should not exceed 2.5°K - m/W even if dried out due to cable loading. The compaction of backfill to obtain a low thermal resistivity is usually carried out with vibrating plates and punners. The cables shall be laid on approximately 200 mm of sand fill, which will be placed to form a bed for a cable. Upon completed laying of a cable it shall be covered with additional sand layer 200 mm thick above the top of the uppermost cable.

3 The reinforced concrete slabs are to be used as mechanical protection over the cables. They shall be carefully centred over the cables, and each cover being closely interlocked with the adjacent covers along the entire length of cable.

4 The width of protective covers shall be enough to overlap cable circuits on both sides with 100 mm at least. Cable slabs shall be covered with a 50 mm layer of dune sand followed by 250 mm of backfill over which PVC warning taped shall be laid.
Semi-permeable membrane shall be provided where the water table is found above the cable laying depth.

5 QCS requirements shall be applied where necessary. After installation of the cables, regularly spaced markers will identify the routes. Route markers are required at both ends of joints crossing points, location where route changes direction at both ends of road crossing ducts, locations where site repairs have been carried out to the approval. Different designs of route markers will be required to suit: (a) unmade ground, (b) paved areas, (c) landscaped areas. Route markers shall be installed at specific intervals of about 50 m.

6 Before commencement of excavation works, opening of trial pits shall be carried out at points where obstacles or crossings with other underground installations might be expected and final cable route and method of cable laying shall be determined after this checking. Appropriate sketches/drawings shall be submitted for approval for each crossing before commencement of cable laying.

7 On road crossings cables are to be laid in PVC ducts embedded in concrete 1:3:6 to enable fastest repair of carriageways and easier replacement of cable in case of cable fault. Also on crossings with the proposed roads cable are to be laid in ducts. Continuous ducts length shall not exceed 30 m. Before commencement of excavation works it is necessary to install all ducts under the future streets at cable crossings which shall be extended by at least 1 m on either side of the crossings, to prevent damage to the cables during the construction of the streets. At all crossings one set of spare ducts for each cable circuit shall be provided to avoid future excavation on roads.

To maintain thermal resistance in ducts equal to the adjacent directly buried sections, pumpable filling materials have to be used. Bentonite mixture with a small quantity of cement or similar materials can be used. This material has to be such that it is easily removable. Sample of mixture shall be prepared and tested for thermal resistivity and easy removal before its acceptance for implementation.

8 The procedure of applying for cable route approval shall be as per QGEWC requirements and shall be carried out prior to the commencement of the installation works.

9 The former Ministry of Municipal Affairs and Agriculture specifications shall be used as a guide for the reinstatement of road works, unless specified otherwise by the Engineer.

10 The cable route shall follow the hierarchy specified by QGEWC. Route drawings shall be produced by the Contractor and shall be detailed and accurate in order that they offer easy reference to locate the cables exactly at a later date, by showing the arrangement of cables as laid with complete information regarding their depth, joint locations, services crossed, their location with respect to adjacent permanent structures, etc.

11 Position of each joint bay shall be exactly determined during route identification. This position thus chosen shall be easily accessible for installation works and later for maintenance of the installations.

36.7.3 Cable Joint Bay - Arrangement

1 Joint bay shall be constructed with concrete floor on which the finished joint rest and with width sufficient to allow an increase of spacing between the phases within the joint bay as compared with that in the cable trench.2 This increase of spacing is necessary for the practical reasons to allow adequate access for the jointer to carry out his work but is also necessary for thermal reasons to avoid excessive temperatures within the joint. Joints shall be staggered fully

and segregated, and mounted on concrete supports. The final arrangement shall be submitted for approval.

3 Cables have to be supported in the length between the point where they enter the joint and the floor of the trench. Concrete blocks with clamps may be used under the cable and joint for their support. The joint bays shall be filled with fine dune sand.

Covers of joints, pits, etc., should carry truck load 6T per wheel (and the specified axle load). They shall be of removable type with facility for lifting.

4 Pilot cable joints shall always be located at the main cable joint pit and shall include the laying or re-make loop at each joint.

5 Each joint bay has to be properly marked.

36.7.4 Soil Thermal Condition

1 The soil thermal conditions are assumed as follows:

2 Maximum temperature of soil at 1.2 m depth: 40 °C

3 Maximum thermal resistivity of ground: 2.5°K- m/W

4 In the calculation of current rating, the soil has been assumed to have constant thermal resistivity of 2.5°K - m/W regardless of the heat input from the cables. The Contractor shall maintain this figure even in case of the moisture migration and completely dry soil.

5 The main factors determining thermal resistivity are: composition density, moisture content and degree of saturation, burial depth of cables and soil and cable surface temperature.

6 The Contractor shall check these factors at two stages:

(a) The Contractor shall carry out tests of soil characteristics along the cable route prior to excavation of trenches. These tests shall be carried out at as many points as are dictated by variations in soil material and levels, and in any case at each trial pit.
(b) Upon completed trench excavation, the Contractor shall, if and when required so by QGEWC, test the thermal properties of the soil in an open trench.
(c) The costs of these tests are deemed to be included in the installation costs of the Contract price.
(d) Each test shall comprise the excavation of a trial pit down to 1.3 m depth and the measurement of soil thermal properties and its temperature and moisture content.
(e) A sample of soil shall also be taken from the trial pit for further laboratory analysis if required by QGEWC.

7 After completion of the trial tests specified, the Contractor shall submit his proposals for meeting the requirements for a maximum net thermal resistivity as specified, for approval by in case of crossings with the other installation the following have to be observed.

(a) Clearances between installations shall be according to "Guideline for Planning Works in the Vicinity of EHV Installations", issued by QGEWC (old MEW), May, 91.
(b) The existing installation authority may imply additional requirements (mechanical protection, etc.) through the work permit procedure. This has to be complied with by the Contractor, and it is considered included in the Contract Price.

(c) In case of the crossing with the other heat sources the special attention shall be paid to cable current rating calculations, and additional measures have to be applied.

8 Ministerial Circular No. 6 (with all latest revisions and additions) shall be followed for working in the vicinity of power cables.

9 At the crossing with the existing installations, the new cables shall be preferably installed beneath, always taking into account the current rating requirements. If necessary, the phase spacing could be increased at the crossing point.

10 After opening of the existing installations and before cable laying the sketch of the final arrangement and method statement shall be approved, before cable installation.

11 Each crossing point shall be clearly marked with the route markers, after backfilling.

12 In case of running parallel with pipelines, the Contractor shall carry out the following checking before starting installation works:

(a) calculation of the induced voltage on the pipeline for the normal working conditions and earth fault conditions
(b) influence due to galvanic coupling between the installations
(c) checking of influence on the pipeline cathodic protection system
(d) possibility of the accelerated corrosion of the metallic structures of the cable line
(e) any requirement arising from these calculations shall be implemented by the Contractor, and are deemed included in the Contractor Price
(f) the minimum size of cable trench is specified in the Contract Drawings, but the Contractor may propose and increase this size to meet his obligations with no extra cost.

13 During the construction (backfilling) before placing the material in the trench. This checking could be repeated during the cable laying at the discretion of QGEWC.

14 During the site survey the trial pits shall be opened and the following measurements shall be taken:

(a) ground temperature
(b) moisture content
(c) thermal resistivity

15 The location of the trial pits shall be chosen based on the local soil conditions as well as at the zones where other services are expected to decide exact cable routing.

16 The measurement results shall be provided in the form of chart with the cable length on X-axis and other parameter shown on the Y-axis for each measured location. This will enable identification of the hot spots along the route.

17 Prior to placing in the trench, the backfilling has to be confirmed through the site tests and current rating calculations before it is approved for application.

36.8 TESTING

36.8.1 132 and 66 kV Cables

1 Apart from the testing requirements specified herein, the Contractor shall coordinate with QGEWC for additional testing requirements.

36.9 SEALING ENDS

36.9.1 General Construction

1 The cable termination shall be of an approved and reliable design. Terminating proposals shall be made available by the Contractor before the final approval on the equipment design. Satisfactory type test certificates shall be submitted to the Engineer. The Contractor shall be obliged to carry out one example termination to demonstrate satisfactory performance of the same in gas and oil tight enclosures under all conditions of maximum and operating pressures as well as during testing.

2 The termination shall be designed to restrict the voltage gradients to the safe values both inside and outside the termination and shall be compatible with the SF6 switchgear or transformer cable box.

3 The terminations shall be complete with suitable supporting and lifting arrangements. The design shall be such that stresses due to expansion and contraction in each part of the insulator and fittings shall not lead to the development of defects.

4 The design of all terminations (if any) shall be such as to permit easy cleaning.

5 The termination shall be solid type or filled with oil of an approved type compatible with the main cable insulation. The design shall be such as to prevent the formation of air spaces and air pockets during filling. Means shall be provided to ensure that the filling medium is maintained under pressure if required during the termination procedure. External oil expansion tanks are not permitted.

36.9.2 Accessories

1 Disconnecting link box shall be provided on all sealing ends terminating metallic sheathed cables. Earthing clamps shall be fitted to all boxes.

2 A separated earth terminal of adequate dimensions shall be provided on the main metalwork of all termination points.

3 Supporting structures for all cable terminations shall be provided as part of this Contract. They shall be of an approved design and as appropriate.

4 All steelwork shall be galvanized in accordance with BS 729 and the requirements specified in the QCS and herein.

5 Foundation bolts and plates or steel stubs shall be provided and shall be firmly keyed and grouted into foundation blocks. Complete details of the structures with dimensions and loading shall be provided by the Contractor to enable the foundation design to be checked. Responsibility for final grounding and levelling of the structures and co-operation with the other contractors shall form part of this Contract.

6 All steel structures shall be provided in accordance with the requirements of Section 16 of QCS.

36.9.3 Execution

1 Support structures adjacent to the termination shall be earthed against accidental touch (in accordance with IEEE 80).

2 The Contractor shall liaise with manufacturer of existing switchgear to obtain details of equipment into which the new cables would be terminated in order to clarify the design and manufacture of the cable termination and its enclosure.

36.10 EHV CABLE JOINT

36.10.1 General Construction

1 All cable joints shall be of an approved and reliable design.

2 Complete description and instructions for the jointing method to be used at site shall be submitted before equipment approval. The instructions shall contain information concerning jointing of the cores, copper to copper, insulation, semi-conductive layers, metallic screen or sheath, sheath covering, bedding, etc.

3 The Contractor shall provide joint boxes to protect the joint under all conditions of service and the joint boxes shall be designed to exclude ingress of moisture and all foreign matters.

4 The Contractor shall note that the specially constructed jointing bays are required and shall recommend horizontal distance and staggering to be maintained between joints of adjacent cables. Full details of joint bays shall be submitted by the Contractor.

5 For the 132 kV circuits, the Contractor will lower the existing joints and link boxes in the new underground joint chamber, in coordination with QGEWC. The link boxes will be disconnected and re-connected in the new location. All existing components of the existing link boxes will be safeguarded and protected to insure proper relocation.

36.11 BONDING OF METALLIC SHEATHS

36.11.1 General

1 The metallic sheaths of the 132 and 66 kV cables shall be specially bonded (i.e. sectionalising cross bonding method shall be applied).
The installation shall fully comply with Engineering Recommendation C.55/4 issued by Electricity Association, 1989.

2 The conductors and sheath of single-core 132 and 66 kV cables shall be successively transposed at each joint pit location.

3 The cross-bonding system of the single-core 132 and 66 kV cable sheath circuit as well as design of the relative individual accessories shall be subject to the approval. Insulation flanges at each joint are required to simplify fault locations at the cable sheath.

4 The standard delivered drum length shall include a maximum tolerance of approximately ± 50 metres for achievement of perfect cross bonding and the pertinent calculation shall be submitted with the approved cable route.

36.11.2 Execution

1 The cable sheaths shall be directly earthed through link boxes at every third joint pit and at terminations.

2 At intermediate joints the sheaths shall be earthed through voltage limiters to limit steep-fronted transient over voltages to a value which can be safely withstood by the sheath insulation (i.e. in addition to the cable over-sheath this includes external joint insulation, terminal base insulation, sheath sectionalising insulation if any, as well as the insulation of the bonding leads and link boxes themselves). The specification of surge voltage limiters is given in clause 2.10.

36.11.3 Characteristics

1 The bond connection must be able to carry the normal sheath current as well as the maximum fault current without undue heating. The completed bonding system shall be subject to a test after installation. The cables used for cross-bonding leads shall be of a twin conductor concentric design with an inner insulation of PVC or XLPE and an outer insulation of PVC.

Earthing at each joint location shall comprise of tinned copper wires and insulated copper earth connections of not less than 300 mm² copper cross section, all supplied and installed by the Contractor complete with stainless steel link boxes at each joint and cross-bonding links. All DLBs shall be housed in reinforced underground concrete pits necessary for easy access and disconnection to facilitate periodical serving tests.
Lids of concrete pits shall be made of steel reinforced concrete with two handles sufficiently strong to the weight of lids used. These shall move freely and shall not project after being placed in position. They shall be designed for heavy traffic loading.

2 The size of lead covered copper earth cable shall be adequate to carry the full, expected fault current for the cable system.

3 The individual ground resistance at each earthing point shall not exceed 5,0 ohm and shall comply with requirements of IEEE 80. Where necessary, additional earth rods shall be provided to obtain this value.

36.12 LINK BOXES

36.12.1 General

1 All link boxes shall be designed, manufactured, tested and supplied as per Engineering Recommendation C.55/4 – Insulated Sheath Power Cable Systems.

2 All bonding links and SVL shall be housed in stainless steel boxes, which shall be earthed by connection to the adjacent earth electrode system. Voltage Limiters (SVL) and associated links shall be housed in a common box. Cross bonding link boxes shall be buried, horizontal type with diving bell lids suitable for installation in shallow pits below ground surface. Cross bonding cabinets shall be mounted clear of the bottom of pit.
The highest point of a pit-mounted box shall be not more than 1m below ground level.

36.12.2 Characteristics

1 Link boxes shall be water and dust proof, with protection class IP 65. The lid of each box shall have a label fitted externally bearing the Company's standard message. The label shall also give circuit identification details.

2 Phase identification label shall be provided adjacent to each terminal.

3 Link boxes shall be lockable and supplied complete with padlock and keys to suit master series.

4 The containment of the link box shall be designed so that it can withstand the effects of at least a moderate power arc. The insulation between links must be capable of withstanding the following voltages, with an additional margin of 25%.

(a) DC voltage of 10 kV, used for maintenance testing of the sheath insulation,
(b) Highest 50 Hz voltage arising between sheaths during a system fault,
(c) A 1.2/50 microsecond impulse voltage with a maximum value equal to the protective level as stated in C55/2 Recommendation.

36.12.3 Execution

1 Bonding cable entries at sealing end terminations shall be from bottom only and shall be gantry mounted.

2 Inside the box, cross bonding connection shall be made by links, which shall be removable to allow voltage testing of the cable sheaths. The links shall be able to be removed for testing without distributing the cable leads.

36.13 BONDING LEADS

36.13.1 General

1 All bonding and earthing leads shall have PVC insulated stranded plain copper conductors and shall be of concentric construction.

2 Design of bonding leads shall be based on data given in paragraph 1 above. Electrical criteria,Cross section of copper conductors shall be sufficient to meet the imposed short circuit duty without excessive temperature rise, but not less than 300 mm². Relevant calculations shall be made according to IEC Recommendation Nos. 949 and 986. The electric strength between inner and outer conductors must be consistent with the electric strength of the joint sleeve-sectionalising insulator, both at power and impulse frequency. The insulation level between outer conductor and ground must be half this value.

3 The exterior surface of all bonding leads shall be coated with graphite to serve as an electrode for voltage testing. The outer insulation shall be embossed with words as per Company's Standard.

4 All concentric leads shall be as short as possible, and no bonding lead shall exceed 10 metres in length.

36.14 SHEATH VOLTAGE LIMITERS (SVLS)

36.14.1 General

1 The Sheath Voltage Limiters shall be of gap-less type arrester (zinc oxide type) with the characteristics of the non-linear resistor. SVL shall be star connected with the star point normally earthed.

2 The SVL unit must be capable of continuously withstanding the sheath standing voltage applied to it during full load or emergency overload.

3 The unit selected for service in each and every situation shall be such as not to be endangered by the calculated impressed voltage resulting from the maximum prospective short circuit current in the cable system.

4 When subjected to transient currents up to 10 kA, their residual voltage must not exceed approximate 10 kV. It must be capable of dissipating without damage the energy developed in case of switching associated with faults external to the cables.

36.15 CABLE TILES, WARNING TAPE AND ROUTE MARKERS

36.15.1 General

1 Refer to QCS Section 21, Part 25 or as specified by the Engineer.

36.16 FIBRE OPTIC CABLE AND ACCESSORIES

36.16.1 General

1 This item contains equipment requirements for pilot fibre optic cable and accessories. Design criteria shall be in accordance with IEC (793-1, 2 794-1, 2) and ITU-T (G.652) recommendations as well as Telecommunication system requirements, as given above. Type test certificate for FO cable is required.

36.16.2 Characteristics

1 Fibre Optic Pilot Cable

(a) Operating conditions:

Type of optical cable	metal-free, with single mode fibres	
Number of optical fibres	min. 12	
Refractive index profile	matched	
Cut-off wavelength	at 1.300 nm	at 1.550
	1.100 to 1.280 nm	1.350 to 1.580 nm
Operational wavelength window	1.300 or 1.550 nm	
Attenuation coefficient (dB/km)	at 1.300 nm	at 1.550 nm
	≤ 0.40	≤ 0.25
Dispersion coefficient (ps/(nm-km))	at 1.300 nm	at 1.550 nm
	≤ 3.5	≤ 20
Temperature dependence		
Range 0 °C to 40 °C (dB/km)	< ± 0.05	
Application	trunk or junction networks, for transmission speeds up to 565 Mbit/s	

(b) Installation data:

Laying arrangement	"below in" of cables in HDPE ducts (40 mm) buried in ground along with power cables, under roads in PVC ducts 100 m
Depth of laying	1.0 to 1.5 m
Width of the trench	depending on power cable formation
Maximum soil temperature at 1.2 m depth	40 °C
Maximum pulling force	1.000 N
Minimum bending radius	400 mm

(c) Cable Construction Data:

Type of optical fibre	single mode
Mode field diameter	9.5 ± 0.5 µm
Mode field non-circularity	max. 6%
Mode field concentricity error	1 µm
Cladding diameter	125 µm
Cladding non circularity	max. 2%
Primary coating	acrylate or silicon
Diameter over primary coating	250 ± 10 µm
Type of secondary coating	Loose-buffered
Type of central strength element	fibre-reinforced plastic material
Peripheral tensile strength elements	high-tensile plastic and/or glass yarns
Type or belt insulation	PVC tapes
Type of outer sheath	PVC

Type of anti-termite protection	"rigid" plastic over the cable sheath
Typical delivery length	up to 4.000 m (usually 2.100 ± 100 m)
Fibre optic joint closures	

2 Fibre optic joint closures for fibre optic communication / pilot cables (if any) shall have following characteristics:

Splice capacity	min. 12 fibres with a loose buffered
Installation alternatives	direct buried, in manholes, on portal support
Attenuation	max. 0.1 dB/splice

3 Optical terminal boxes for fibre communication and approach cables shall have the following characteristics:

Splice capacity	min. 12 fibres with a loose buffered
Installations	wall - mounted type
Attenuation	0.5 - 1 dB/per connector
0.1	dB/per splice
Optical connectors	F.C. - P.C. type

36.17 INSTALLATION REQUIREMENTS

36.17.1 General

1 The arrangement of cables and all methods of laying and installation, including any special methods, which may be necessary, shall be subject to approval of QGEWC.

2 Each length of cable and joint bay shall be allotted a distinctive and separate reference number. This number shall appear on the test sheet covering the respective length of cable, shall be clearly marked on the cable drum on which the cable length is delivered to site. It shall be referred to in invoices and Advice Notes and recorded on the route plans.

3 The cables may be laid directly in the ground, installed in cable trenches, shafts, pipes, ducts on concrete troughs or on racks in air in accordance with the route requirements and approved installation practices.

4 Adjacent to terminations and joints the cables shall be laid in a loop or snaked in the ground in order to provide approximately 3 metres spare length on each side to facilitate re-termination and re-jointing at a later date, if necessary. It may not be possible, however, to loop the power cables adjacent to terminations due to the dimensions allocated for the cable route and this requirement will therefore be assessed by QGEWC on a case-by-case basis.

5 The Contractor shall ascertain from the cable manufacturer, the limitations of the PVC over-sheath with respect to exposure to sunlight and the maximum temperature for cable laying governed by the tensile strength of the over-sheath at high ambient to QGEWC in writing and approval of the method of repair must be obtained. The position of the damage must be accurately recorded prior to commencement of repair.

6 Only damages to outer PVC sheath shall be permitted for repairs.

7 The depth of laying cables from the surface of the ground to the top of the cable must satisfy the requirements of the Local Municipality and relevant Statutory Authority. The said depth shall not be less than 1.1 m.

8 It shall be measured from the ground level to the upper surface of the top most cable. This depth may be increased in selected parts of the route or locally to avoid other service installations. On

the Central Reserve and on the foot path the depth shall be measured from the Finished Road Level.

9 Unless it has been agreed that the construction of cables is such as to permit laying at sub-zero temperatures, cable laying shall take place only when the ambient temperature is above 0 °C and has been at this temperature for at least 24 hours, and approved special precautions have been taken to keep the cable above this temperature to avoid risk of damage during handling. Cabling laying shall not be permitted above ambient temperatures recommended by the cable manufacturer.

10 All cables shall be installed with a bending radius not less than that recommended by the cable manufacturer.

11 All combustible outer coverings of cables installed within buildings shall be protected against the spread of fire in an approved manner. Cables passing through floors shall be installed in the manner specified and where required shall be sealed into bushes employing fire resisting material to minimize the risk of spreading fire.

12 Where PVC sheath cables are to have a flame-retardant paint finish applied this shall be applied after completion of cable glanding and termination.

13 All cables specified under this Contract shall be installed in an approved manner. Pilot cables shall be installed in the same trench as power cables.

36.17.2 Provision of Labour and Skilled Supervision

1 The Contractor shall be responsible for providing all labour and skilled supervisors for handling equipment, and laying cable in accordance with this Specification.

2 The Contractor shall also provide the necessary trained staff and tools for terminating and jointing all cables supplied and laid under this Contract.

36.17.3 Responsibility

1 The Contractor shall be responsible for all Site Works associated with the Contract Works, installation and termination of all cables in accordance with this specification.

36.17.4 Trial Pits

1 Trial pits shall be carried out at approved positions proposed by the Contractor, early enough to check the data of the Drawings, to make sure that passage is possible and to determine the most suitable detailed route and position for the trenches and to ascertain the original soil properties. They shall be kept open until QGEWC inspects them and lets the Contractor know it's decision about definitive route adjustment.

36.17.5 Method of Cable Laying

1 The procedure of cable laying shall be subject to QGEWC's approval.

2 Unless instructed to the contrary by QGEWC, the Contractor shall lay cables direct in the ground in the following manner:

The material surrounding the cables, between trench floor, walls and cable titles, shall be at least, 150 mm of sand or other approved material free of stones or any other material likely to damage or penetrate the cable outer sheath. It may be necessary to use an approved semi-permeable membrane to avoid migration of the fill under wet conditions.

The backfill in the reminder of the trench shall be adequate to meet the required thermal resistivity value as specified. A high degree of compaction is required, sufficient to restore and maintain thermal resistivity levels equal or better than undisturbed ground.

At the direction of QGEWC, the Contractor shall remove any material, which is considered harmful, and replace it with an approved backfilling material, if the thermal resistivity of this material can rise above 2.5° Km/W, the Contractor shall provide calculations to ensure that effective external thermal resistivity shall remain below the specified value under all operating conditions.

3 The results of all tests shall be logged and shown on as-laid records of the route.

4 After any cable has been laid and until the whole length of the cables to be laid in the trenches have been covered with protective covers, no sharp metal tools such as spaces or facing stakes shall be used in the trench or placed in such a position that they may fall into the trench. The protective covers shall consist of interlocked slabs of the hydraulically pressed concrete or other approved material of approved dimension and of ample width to protect the cables.

5 If more than one cover is required to cover a group of cables, the width for the covers shall be such that the longitudinal joint between adjacent covers shall be placed above the space between the groups of cables and not immediately above a cable. The position of cables or groups of cables in a trench shall be staked out once the cable has been laid so that covers may be placed in the correct position when the top layer of riddled soil or dune sand has been applied. The width of the cover or covers shall be such that there is a minimum 100 mm overlap on each outside edge of the cable or group of cables.

6 A provisional sheath test shall be carried out for every section before backfilling over the cable tile.

7 The route markers shall be installed as specified by the Engineer. Where, in the opinion of QGEWC, the soil
on-site is unsuitable for ridding or back-filling, the Contractor shall arrange for the importation of suitable material (at Contractor's own expanse), which shall be subject to approval of QGEWC.

8 The Contractor shall take all reasonable steps to ascertain where the cables and associated corrodible materials may be subjected to chemical or electrolytic action and shall submit his recommendations for special precautions to the Engineer for his approval.

9 Where auxiliary cables are laid under the same covers as power cables, there shall be at least 75 mm of riddled earth between the two types of cables.

10 The position of the cables and joints shall be recorded on the route plans. The route shall be identified by means of a grid with at least two reference points for each length of straight cable run.

11 The distance between the centres of power cables and power cable circuits shall be in accordance with the cable manufacturer's specification and recommendation. The Contractor shall be responsible for obtaining the correct spacing parameters from the cable manufacturer and details of installation limitations from QGEWC to ensure cables operation at the pre-determined operation temperatures when installed.

12 The Contractor shall be responsible for obtaining values of the minimum bending radii for all cables required under the Works from the cable manufacturer prior to the commencement of installation.

13 Rollers used during the installation of the cables shall have no sharp projecting metal parts liable to damage the cable.

14 All cables on vertical runs or horizontal runs in the vertical plane shall be cleated.

15 The Contractor shall provide all necessary pulling tools and equipment such as jacks, shafts, rollers, self-driven rollers, pulling cords, etc. including any required power for this equipment. The procedure for unwinding and pulling the cables shall be approved by QGEWC. Pulling by use of stockings is not allowed.

16 The Contractor shall strictly conform to the prescriptions given by QGEWC for all handling of cables and their accessories.

17 The Contractor shall have as many men as necessary for all pulling and supervising operations to be carried out according to the best procedure. The number of men shall be stated in the cable laying procedure and approved by QGEWC.

18 The Contractor shall be solely responsible for any damage due to the carelessness of his staff or workmen. Any cable length so damaged shall be rejected as destroyed.

19 Mechanical pull with a winch solely from one end will be only in special cases because of the cables greater fragility. The self-driven cable rollers shall be used for installation of power cables.

20 Extra snaking 3.0 m length at termination and joints location shall be provided.

21 The Contractor shall allow for installation of permanent thermocouples for sheath temperature test in his Contract Price. At least one set of permanent thermocouples shall be installed at every 3 000 m. The locations, number and arrangement of testing (the number of thermocouples at each location shall be at least seven) shall be submitted to QGEWC for review and approval, prior to installation.

36.17.6 Excavation of Trenches

1 The Contractor's attention is drawn to the procedures and requirements detailed in the Contract Documents and Specifications.

2 The exact location of each trench shall be approved on-site. Trenches shall be kept as tight as possible and each trench shall be excavated to the approved formation and dimensions and shall have vertical sides which shall be timbered or otherwise secured where necessary so as to avoid subsidence and damage to all walls, roads, sewers, drains, pipes, cables and other structures. Timber and other material for this purpose shall be supplied by the Contractor.

3 The depth of all excavations for trenches shall be measured from the surface of the ground and the width of the trench shall be measured between the vertical sides of the trench or between the inside faces of the sheeting (if any).

4 The bottom of each trench shall be firm and of smooth contour. The Contractor shall take reasonable precautions to prevent damage to the road or highway or ground surface from a slip of breaking away of the sides of the trench. Where trenches pass from a footway to a roadway or at other positions where a change of level is necessary, the bottom of the trench shall rise or fall gradually. The rate of rise or fall shall be approved.

5 It is the Contractor's responsibility to ensure that he is acquainted with the nature of the ground conditions prevailing along the cable route and the installation rates of the cables shall include for any and all types of excavation and backfill on the "as found" basis.

6 The Contractor shall deal with and dispose of water to prevent any risk of cables and other materials to be laid in the trenches being adversely affected. He shall provide all pumps and appliances required and shall carry out necessary pumping and baling.

7 Unless otherwise agreed, provision shall be made during excavation and until interim restoration has been completed for reasonable access of persons and vehicles to property or places adjacent to the route.

8 When the excavation for trenches has been accurately executed, the relevant notice shall be given by the Contractor to QGEWC. Laying of cables, shall not be started until the Contractor has obtained the QGEWC's approval to proceed with the work.

9 The maximum length of trench open at any time shall be as per Traffic Police and PWA regulations. It should not cover more than one drum length.

10 The Contractor shall not work in any area where other underground services are still covered. QGEWC shall have the right to stop the work or part of the Works where the Contractor fails to take the necessary measures to uncover these utilities and the Contractor shall not claim for additional compensation in time or money.

11 The Contractor shall perform all hand excavations, protection and other work as specified herein or as required to locate existing utilities and services within the limits of this Contract, or at off-site locations as designed by QGEWC and in accordance with the requirements of all Contract Documents. The existing utilities and services referred to herein shall include, but shall not be limited to all sewers, water mains and lines, gas mains, electric (both power and lighting), telephone and such others as may be encountered under this Contract.

12 The Contractor shall notify the concerned Municipality and other relevant authorities in good time of his intention to excavate sections of road, which include plantation and shall not start digging before getting approval from PWA. All works shall be done according to the rules and regulations from the relevant department of the PWA.

13 During the execution of works related to laying of cable lines within gardens and road landscaping areas, the Contractor shall comply with the following rules and regulations:

(a) Power cable lines shall not be closer than a horizontal distance of 1.50 m to the nearest tree trunk axis.
(b) The details of the irrigation lines shall be obtained from the PWA.
(c) The approval to the excavation works shall be obtained from the PWA.
(d) Branch irrigation lines are usually laid at a depth of 60 cm from ground level.
(e) The Contractor shall bear the full expenses of reinstating the disturbed irrigation lines network to its original shape existing before the start of the excavation works. Approval from the relevant authority of the quality of the agricultural clay soil to be reinstated and its levelling procedures shall be provided by the Contractor.
(f) The Contractor shall bear the full expenses incurred in the process of removal of the plantations, their subsequent reinstatement as well as the cost of the plantations within the excavation zone.
(g) The Contractor shall include the cost of relocating the path of the irrigation lines or the cost of irrigation of the plantations, if necessary.
(h) QGEWC shall withhold payment of the dues of the Contractor until a confirmation from the relevant authority to the effect that the Contractor has abided by the above-mentioned rules and regulations is obtained. Such confirmation shall be given either in writing it through a site meeting.

Section 21: Electrical Works

14 The Contractor's attention is drawn to the following:

(a) He must use all necessary precautions and protective measures to maintain existing utilities, services and appurtenances that must be kept in operation. In particular, the Contractor shall take adequate measures to prevent undermining of utilities and services, which are presently in service.

(b) He must protect existing or new utilities and services when considered necessary and as directed by QGEWC. The Contractor shall be responsible for bracing and supporting utilities and services to prevent settlement, displacement of drainage. The protection of utilities and services as specified herein, will not be paid for separately but shall be considered as subsidiary obligation to the work under this Contract unless specified otherwise by the Engineer.

(c) The Contractor shall not remove any utility or service line, conduit or any structure, above or below the ground, within the limits of the works before receiving written permission from QGEWC.

(d) The Contractor prepares appropriate drawings for protection work of other utility services and shall obtain the approval of the appropriate utility authorities before commencing the construction.

(e) The Contractor shall not interfere with supplies and services of whatsoever nature such as but not limited to water, electric power and light, telephone, buried cables and sewerage. If any such supply or service is damaged as a result of the Contractor's actions, the Contractor shall report it to the owner of the supply or service immediately.

(f) The Contractor shall be responsible for any damage caused to such supplies or services as the result of his operations and shall fully indemnity and keep indemnified the PWA, the Engineer, QGEWC and the owner of such supplies and services for all consequences of the damage of whatsoever nature.

(g) The method of execution of repairs shall be decided by the owner of the supply or service and shall be carried out by the Contractor at no extra cost.

15 In cases where the excavation is to be made on asphalt, paved or concrete roads and/or pavements, the asphalt or concrete surfacing shall be cut using a suitable disk cutter at a depth of not less than 120 mm. The Contractor shall take all necessary measures to minimise damage of the asphalt beyond the width of the excavated trench. Reinstatement of roads is to be as per the requirements of the latest issue of the "Code of Practice and Specification of Road openings in the Highway" or as specified by the Engineer.

16 The method of cutting of road surfacing is essential and shall be strictly adhered to.

17 The use of an air compressor and associated cutting tools will not be allowed.

18 There shall not be any soil classification for excavating either in soft or in hard material. The Contractor is responsible for obtaining information he considers necessary regarding the possibility of encountering soil with varying degree of hardness, and shall be deemed to have allowed for it in his Contract price.

17 The excavation of hard material, if any, shall be carried out by pneumatic tools. Blasting shall not be allowed under any circumstances.

20 All trenches shall be excavated with vertical sides to the width, lines, grades and depths as shown on the Drawings or as specified in writing by QGEWC.

21 All excavations shall be adequately supported and kept free from water from any source at the Contractor's expense and to the satisfaction of QGEWC.

22 Any over-excavation shall be backfilled with suitable fill material and completed in accordance with the specifications. Where directed by the Company such over excavations shall be backfilled with mass concrete at the Contractor's expense.

23 The unsuitable or surplus excavated material shall be removed, to an area approved by the PWA, by the Contractor and at his expense.

24 The Contractor shall take all necessary security measures, such as signs, lights, supports, etc. and generally comply with the recommendations and requirements of the relevant authorities and/or Police in order to avoid accidents, landslides and other damages.

25 The closing of roads should be avoided. Where this is unavoidable the Contractor shall obtain the approval of the relevant authorities.

26 Prior to commencement of excavation the Contractor shall survey and submit the existing ground levels.

36.17.7 Excavated Material

1 The material excavated from each trench shall be placed so as to prevent nuisance or damage to adjacent hedges, trees, ditches, drains, gateways and other property, objects or things. Excavated material shall be stacked so as to avoid undue interference with traffic. Where, owing to traffic or other considerations, this is not permissible, the excavated material shall be removed from the Site and returned for refilling the trench on completion of laying. Surplus materials shall be disposed of by and at the cost of the Contractor as specified by the Engineer. Surplus material shall never be left on-site for more than one week.

2 Excavated material shall be stacked at a minimum distance of 300 mm from the edge of the trench to provide a walkway and eliminate risk of stones falling in the trench.

36.17.8 Galvanised Support Built In

1 Where required for security of the Works and adjacent buildings or structures, the galvanized support shall be placed in trenches and built in as QGEWC may instruct or approve and shall form part of the Works.

36.17.9 Obstructions

1 When, in the course of the Contract Works, obstructions are encountered which necessitate the diversion or alteration to gas, electric, hydraulic, water of sewage mains, or other works, or alterations to buildings, foundations and tunnels, or when conditions necessitate adoption of a special construction of trench, the Contractor shall immediately notify QGEWC.

36.17.10 Filling In and Reinstatement

1 Filling in of trenches shall not commence until QGEWC has inspected and approved the cables and accessories in situ. Such inspection shall not be unreasonably delayed.

2 Where the cable route passes along public roads or pavements or areas designed for future roads or pavement the backfilling shall comply with PWA requirements.

3 All excavations made (whether for the purpose of cable laying or trial holes) shall be backfilled in 150 mm layers. Each layer shall be adequately sprayed with water in such manner that, in conjunction with the means of compaction that are to be used, a density of at least 95% of the dry density at the optimum moisture content shall be achieved. The backfilling and the interim restoration of the upper levels shall be completed to the satisfaction of QGEWC.

4 If the Contractor is required by QGEWC to carry out permanent reinstatement of any portion of the route, the refilled trench shall be temporarily reinstated and left and maintained in a thoroughly safe condition until the work of permanent reinstatement is carried out. On any portion of the route where the Contractor is not required by QGEWC to carry out the permanent reinstatement, the refilled trench shall be temporarily reinstated and left and maintained in a thoroughly safe condition and be in suitable state for permanent reinstatement.

5 The work of permanent reinstatement shall include all necessary keying into the existing surface and shall be carried out to the approval of QGEWC.

6 If at any time road traffic is required to cross the cable trench or route, the part of the trench or route affected by the road crossing shall be permanently reinstated. It shall remain in place until permission is granted by QGEWC to proceed with the road crossing.

36.17.11 Excavation of Tunnels

1 Where required by QGEWC, a tunnel shall be driven, such as will allow ducts, pipes or cables to be laid as specified. The cross section and levels of each tunnel shall be approved, and the Works shall be carried out in accordance with the provisions of the relevant clauses of these specifications.

36.17.12 Cables Drawn Into Ducts and Pipes

1 Cable ducts are required at all road crossings, regardless of whether they are minor or major.

2 Where existing road crossing ducts are indicated on Drawings, their existence or their adequacy for the cable sizes cannot be guaranteed. The Contractor shall clearly understand that the information provided shall be used as a guideline and they shall be responsible for providing necessary ducts and ensure they are adequately sized.

3 On the crossings with the marked future roads, the Contractor shall install the standard ducts arrangement, extending them minimum 1 m beyond the proposed kerb lines into each verge or verge and centre reservation.

4 On the roads less than two years old, open cutting is not permitted. If it becomes necessary, "Thrust Boring" method is acceptable.

5 At all road crossings 50% spare duct arrangement for double circuit and 100% spare ducts for single circuit are required.

6 The Contractor shall provide the ducts and pipes. The Contractor shall remove any loose material from the ducts, and prove them by drawing through a mandrel of slightly less diameter than the duct, immediately before pulling in the cables. A suitable draw line shall be used to facilitate cable pulling. If the pipe or ducts form a tortuous path with friction a suitable lubrication may be used to ease the stress on the cables when pulled. Any lubricant used shall have no detrimental effect on the cables.

7 The Contractor shall reapply graphite coating if it is scraped off while pulling or after the application of a lubricant. Where specified by QGEWC, two split pipes shall fit around the cable. The splits shall be positioned on opposite sides of the cable after its installation.

8 All ducts or pipes, whether in use for cables or not, shall be sealed against entry of water, oil and vermin with a suitable semi-plastic compound supplied and installed by the Contractor after the approval of QGEWC. Cable ducts on the existing road shall be extended 500 mm beyond verge.

9 All ducts, floor bushings, etc. shall be completely filled and sealed at either end. The filling material shall be bentonite mixture with addition of a small quantity of cement to stabilize the gell

and sand to improve load bearing. The material shall be pumped into suitably prepared ducts with a cement pump and must be able of being removed by the application of high-pressure water jets. The content of bentonite mix shall be subject to QGEWC's approval.

10 It is preferable that cable ducts are not longer than 12 m, but the maximum allowed length is 30 m.

11 When the cable route is such that changes in direction of pipes do not facilitate a continuous pipe or where a pipe is too long to allow a continuous cable run, facilities shall be made for cable draw pits in which the cables shall be supported and routed in accordance with these specifications.

36.17.13 Concrete Structures

1 Concrete structures for joint-pits, etc. shall be provided and the concrete shall be in accordance with Section 5 (Concrete). Grade of concrete shall be SRC 25. Concrete structures at and below ground level are to be constructed using sulphate resistant cement. All foundations and concrete surfaces at and below ground level are to be isolated from contact with soil in accordance with concrete protection details as specified by the Engineer.

2 Complete designs of joint bays and draw-pits shall be submitted with by the Contractor. Cover slabs for joint-bays and draws-pits and the joint-bays and draw-pits themselves shall be designed by the Contractor and shall allow for a 36 tonne truck to pass over it and axle load of 12.5 tons. The point load under such a condition shall be indicated accordingly.

36.17.14 Guards

1 Where cables are exposed to mechanical damage, sheet steel guards shall be provided to protect them. Detailed drawings of all cable guards produced by the Contractor shall be approved by QGEWC before fabrication has commenced.

36.17.15 Cable Markers and Records

1 Cable markers and other approved means shall be provided to mark the position of each joint and shall also be used in approved positions to show the positions of all cables, pipes and ducts, particularly where they cross a road, or are laid along a road or where there is an abrupt deviation on the route, and such cable markers shall be erected as reinstatement is being carried out. At road crossings permanent markers shall be provided on both sides of the crossings in the event of damage to or removal of one of the markers.

2 The Contractor shall supply as soon as possible after installation two copies of the route plan showing the certified depth and position of all buried cables including these laid to the specified instructions of QGEWC. An up-to-date copy must be available at site at all times.

36.17.16 Tests During Cable Laying

1 During the procress of laying, the Contractor shall subject the cable and other accessories to the provisional sheath test for every section, before backfilling over cable tile.

36.17.17 Cable Routes

1 The Contractor shall verify all the cable routes through Design Enquiry Letter Procedure with the QGEWC.

2 The Contractor shall apply for access to all cable routes, prior to commencement of works.

3 The procedure of applying for cable routes shall be the responsibility of the Contractor. Based on trial holes and information obtained during site surveys and from concerned Government

authorities the Contractor shall arrange the necessary drawings and circulate RO (Road Openings) forms as necessary. The Contractors responsibility shall be to provide all road-crossing ducts, which are necessary and/or replace existing ducts which are found not suitable under the existing system.

36.17.18 Route Plan

1 Where cable routes are shown on Drawings, these shall be verified with the concerned authorities. Within a reasonable time after the contract has come into force, the Contractor shall survey the route and agree a final route with QGEWC. He shall confirm the arrangements and submit required drawings for processing the necessary RO forms before the installation commences. The quantity of cables, accessories, etc. to be supplied shall be based upon this survey. The programme for route survey works shall be agreed with QGEWC prior to commencement of works.

2 The Contractor shall, during the progress of the work, record on a set of route plans at 1:500 scale or other approved scale, such particulars as will allow an accurate reference to be made afterwards in case of any fault of projected modifications. The plans shall show exact position of every joint termination and oil feeding point, location of oil pressure tanks, gauges and terminal boxes.

3 The Contractor shall also record on approved cross-section plans particulars of the depth of the trench, the arrangement of the cables, the positions of all obstructions beneath or above which the cables are laid and such other particulars as may be required. These plans shall be made as reproducible drawings of approved dimensions and shall be the property of QGEWC. They shall be submitted to QGEWC within one month of completion of each section of the Works together with such prints as may be required.

4 Suitable binders shall be provided for the route plans.

36.17.19 Cable Termination

1 The Contractor is to terminate and connect up the cables in accordance with details approved by QGEWC.

2 Necessary sunshields shall be provided and installed for cables exposed to direct solar radiation.

3 The Contractor is to be responsible for the correct phase rotation and connections in accordance with information supplied by QGEWC. Particular care is to be taken in case of these cables, where subsequent correction may be difficult. Phase tests will be carried out by the Contractor to the satisfaction of QGEWC. All equipment required to carry out these tests shall be provided under this contact.

4 Where insulated glands are provided, the Contractor is to ensure that the insulations are maintained after jointing the cable, and shall demonstrate this to the satisfaction of QGEWC.