

INSTALLATION/CONSTRUCTION STANDARDS
BOOK TWO OF TWO

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INSTALLATION/CONSTRUCTION STANDARDS
BOOK TWO OF TWO

TABLE OF CONTENTS

1. **GENERAL**
2. **CO- ORDINATION WITH OTHER PUBLIC UTILITIES**
3. **DAMAGES AND RESPONSIBILITIES**
4. **INSTALLATION STANDARDS FOR CIVIL**
7. **CABLE INSTALLATION**

**INSTALLATION/CONSTRUCTION STANDARDS
BOOK TWO OF TWO**

TABLE OF CONTENTS

1. GENERAL
2. CO-ORDINATION WITH OTHER PUBLIC UTILITIES
3. DAMAGES AND RESPONSIBILITIES
4. INSTALLATION STANDARDS FOR CIVIL WORKS

- | |
|--|
| <ol style="list-style-type: none">7. CABLE INSTALLATION9. MARKING10. ACCEPTANCE TESTING11. RED LINE DRAWINGS AND PROCEDURES |
|--|

TABLE OF CONTENTS

1. GENERAL
- 1.1. PREFACE
- 1.2. ASSOCIATED DOCUMENTS
- 1.3. ABBREVIATIONS
- 1.4. WORKMANSHIP, MATERIALS, PLANS AND ALTERATIONS
- 1.5. DRAWINGS

1. **GENERAL**

1.1. **PREFACE**

1.1.1. The aim of this document is to give rules and concepts together with guide-lines on how to carry out the work.

1.1.2. In order to cope with the progress in the telecommunications field it is of extreme importance that the standards are revised at appropriate intervals so that they will continuously match the technical developments related to outside plant networks.

1.2. **ASSOCIATED DOCUMENTS**

1.2.1. These foregoing standards are to be applied in conjunction with following sections of the tender documents:

Volume 1:

Tender Conditions and Procedures
Tender Forms
Contractual Forms
Conditions of Contract
Preliminaries

Volume 2.2:

Material Specifications

Volume 3:

Scope of the Work
Method of Measurement
Bills of Quantities
Approved Manufacturers & Restricted Sourcing

1.3. ABBREVIATIONS

1.3.1. THE FOLLOWING ABBREVIATIONS ARE USED IN THE TEXT:

ABD	As-Built Drawings
AC	Alternating Current
ADSL	Asymmetric Digital Subscriber Loop
BSC	Base Station Controller
BSW	Buried Service wire
BTS	Base Transceiver Station
CAT	Contractor's Acceptance Test
CCP	Cross Connection Point
CSA	Carrier Serving Area
ITU-T	International Telecom Union
CTB	Cable Terminal Box
DB	Direct Burial
DBC	Direct Buried Cable
DC	Direct Current
DECT	Digital European Cordless Telecommunications
DFA	Direct Feed Area
DP	Distribution Point
DPL	Distribution Point Location
EFA	Engineering Forecast Area
FAC	Final Acceptance Certificate
FDD	Frequency Division Duplex
FITL	Fibre in the Loop
FTTB	Fibre to the Buildings
GSM	Global System for Mobile Communications
HDSL	High Bit Rate Digital Subscriber Loop
HH	Handhole
ISDN	Integrated Services Digital Network
LC	Line Concentrator
LE	Local Exchange
LJU	Line Jack Unit
LR	Line Regenerator
MDF	Main Distribution Frame
MH	Manhole

MPMP	Microwave Point-to-Multipoint
MoT	Ministry of Telecommunications
MSC	Mobile Switching Centre
MUX	Multiplexer
MW	Microwave
NOSFER	New Fundamental System for Determination of Reference Equivalent
NTS	Not to Scale
OD	Outside Diameter
OF	Optic Fibre
OSP	Outside Plant
PABX	Private Automatic Branch Exchange
PAC	Provisional Acceptance Certificate
PAT	Provisional Acceptance Test
PBX	Private Branch Exchange
PCM	Pulse Code Modulation
PE	Polyethylene
PFAR	Primary Fill at Relief
PGS	Pair Gain System
PMBX	Private Manual Branch Exchange
PVC	Polyvinylchloride
QC	Quality Control
RE	Reference Equivalent
RRE	Receiving Reference Equivalent
RLD	Red Line Drawings
RSU	Remote Subscriber Unit
SAP	Service Access Point
SE	Secondary Exchange
SLJU	Subscriber's Line Jack Unit
SRE	Sending Reference Equivalent
SRS	Subscribers Radio System
STB	Subscribers Terminal Box
SWD	Service Wire Drop
TA	Type Approval
TDD	Time Division Duplex
TDMA	Time Division Multiple Access

TE	Tandem Exchange
TJ	Terminal Joint --
TS	Transmission System
VF	Voice Frequency
WLL	Wireless Local Loop

1.4. WORKMANSHIP, MATERIALS, PLANS AND ALTERATIONS

- 1.4.1. All materials, including manufactured articles, and machinery incorporated in the Works, shall meet all specified quality requirements and be approved by the Engineer.
- 1.4.2. The Contractor shall, before placing any purchase order for any materials intended for incorporation in the Works, submit for approval a complete description of all such materials, names of the firms from whom he proposes to purchase them and copies of all test reports verifying conformity with the provisions of the Specifications. Materials shall not be ordered without the approval of the Engineer. When directed by the Engineer or otherwise specified, the Contractor shall submit suitable samples for approval.
- 1.4.3. The Engineer shall have the right to retest all materials which have been tested and accepted at the source of supply after delivery to the Site and prior to incorporation into the Works and to reject any such materials which are clearly defective or, when retested, do not conform with the Specifications.
- 1.4.4. All construction and installation shall be performed in a thorough and workmanlike manner in accordance with the approved standards and shall be subject to approval by the Engineer.
- 1.4.5. In general, Acceptance Testing shall be witnessed by the Engineer.
- 1.4.6. Appropriate notification times for such acceptance testing will be as specified in Section 10.
- 1.4.7. All materials used shall comply with the Material Specifications unless otherwise instructed by the Engineer.
- 1.4.8. Should any error or ambiguity be discovered in the documentation, the Contractor shall bring the item to the attention of the Engineer.
- 1.4.9. The Contractor will be responsible for maintaining a concise record of all alterations to the Engineers design drawings.
- 1.4.10. All working documentation and detailed plans (Red Line Drawings) required for the permanent installations of the works have to be prepared by the Contractor and submitted to the Engineer to enable the latter to prepare As Built Drawings.

Approval procedures for such submissions by the Contractor shall be strictly followed, in order for the standard of Red Line Drawings to be sufficiently detailed to the required ABD Standards.

1.5. DRAWINGS

1.5.1. The drawings included in this document and issued by the employer give typical installation details to cover the requirements under different conditions and types of network installations.

1.5.2. These drawings follow a proposed numbering system (4 digits) which will be used for further detailed installation/construction guidelines to be issued to the Contractor during the implementation of the project. These are as follows:

1001 - 1200	Coordination with Other Utilities
1201 - 2000	Civil Works Installation Standards
6910 - 6919	Optical Fiber Installation standards.

1.5.3. Drawings are generally self-explanatory, with notes included therein, and may also be grouped where so indicated. Units are typically in 'mm', unless otherwise indicated. These should be considered as sketches, and not suitable for scaling-off, and hence, crucial distances are normally indicated in numbers.

1.5.4. Furthermore, sample drawings are also given for: Final Design Drawings, as would be issued by the Engineer to the Contractor; and, a set of related Final-Design/RLD/ABD, showing the role of Contractor in updating, amending and detailing (off-set and three point measurements) required.

2. CO-ORDINATION WITH OTHER PUBLIC UTILITIES

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TABLE OF CONTENTS

- 2. CO-ORDINATION WITH OTHER PUBLIC UTILITIES
 - 2.1. GENERAL
 - 2.2. SEPARATION FROM ELECTRICAL POWER NETWORKS & OTHERS
 - 2.3. CO-ORDINATION
 - 2.4. DRAWINGS

2. CO-ORDINATION WITH OTHER PUBLIC UTILITIES**2.1. GENERAL**

2.1.1. In order to provide working and maintenance clearances from other utilities, separations shall be maintained in accordance with these guidelines.

2.1.2. As the majority of MoT installations are underground, the requirements for coordination with Lebanon's electrical power installations are described in this general section. Increased use of aerial networks is required and aerial networks are referred to separately in Section 5.



2.2. SEPARATION FROM ELECTRICAL POWER NETWORKS & OTHERS

2.2.1. When crossing and adjacent to electrical installations, the following guidelines shall apply.

2.2.2. Duct and cable installations shall be located to provide reasonable practical clearance from electric lamp standards, traffic signal posts and similar installations. If a minimum clearance of 150 mm is not obtained then a concrete separator of 50 mm thickness or a PVC sleeving is required at the affected location. All applicable regulations from the responsible authorities for such installations shall be adopted.

Utility	Separation Requirement 1		Separation Requirement 2	
	Parallel distance > 10 m	Cross over	Parallel distance < 10 m	Cross over
Water mains sewer pipes manholes joint boxes	300 mm	150 mm	150 mm	100 mm
Lamp standard bases. Traffic signal bases	150 mm	--	100 mm	--
<u>Power cables:</u> ≤ 600 V	300 mm	300 mm	100 mm	100 mm
≤ 13.8 kV	1000 mm	1000 mm	200 mm	100 mm
≤ 33 kV	2000 mm	1000 mm	500 mm	100 mm with reinforcement in the conduit structure for 500 mm beyond power cable
≤ 69 kV	5000 mm	1000 mm	1000 mm	

Table 2.2.2A- MINIMUM SEPARATION FOR CONDUITS INSTALLATIONS

Separation Requirement 1		Separation Requirement 2	
			

Utility	Parallel distance > 10 m	Cross over	Parallel distance < 10 m	Cross over
Water mains sewer pipes manholes joint boxes	300 mm	150 mm	150 mm with PVC	50 mm with PVC sleeving extending 500 mm beyond utility
Lamp standard bases. Traffic signal bases	150 mm	--	50 mm concrete slab or PVC separator, sleeving 500 mm extending beyond utility	
Power cables: ≤ 600 V	300 mm	300 mm	100 mm concrete slab protector	100 mm PVC sleeving extending 500 mm beyond utility
≤ 13.8 kV	1000 mm	1000 mm	200 mm concrete slab separator	100 mm sep. to a 200 mm concrete slab extend. 500 mm beyond the power cable. Slab to include 100 mm PVC maintenance duct
≤ 33 kV	2000 mm	1000 mm	1000 mm	100 mm separation to a 300 mm reinforced concrete slab, extending 500 mm beyond power cable. Slab to include 100 mm PVC maintenance duct.
≤ 69 kV	5000 mm	1000 mm	2000 mm	

Table 2.2.2B: MINIMUM SEPARATION FOR DIRECTLY BURIED
CABLE INSTALLATIONS

- 2.2.3. For parallel installations between telephone and power cables, the minimum separations indicated by Tables 2.2.2A and 2.2.2.B shall be applied.
- 2.2.4. For those cases where the standard separation cannot be achieved, an alternative installation is indicated for parallel runs of less than 10 m (indicated as Requirement 2)

- 2.2.5. These separations are MoT safety requirements, from which all deviations shall be referred to the Engineer
- 2.2.6. At underground crossings with power cables the separations indicated by Tables A+B shall apply.
- 2.2.7. Where voltages of 69 kV and greater are encountered, the Engineer shall be informed of the installations, irrespective of whether the indicated safety separation be achieved.
- 2.2.8. Attention should be given to the requirements for maintenance ducting to be installed under all protection slabs, irrespective of the utility which is below the slab.
- 2.2.9. Electrical cables are not permitted to share duct space or pass through telephone manholes and vice versa.

2.3. CO-ORDINATION

- 2.3.1. Drawing 1110 illustrates a standard for the location of services in roadways.
- 2.3.2. Refer to other Sections for special coordination requirements in respect of different types of networks, such as overhead networks (aerial), etc.

2.4. DRAWINGS

The following drawings are attached:

L9630/1110 INSTALLATIONS IN ROAD/HIGHWAY

3. DAMAGES AND RESPONSIBILITIES

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TABLE OF CONTENTS

- 3. DAMAGES AND RESPONSIBILITIES
- 3.1. DAMAGE CLAIMS
- 3.2. PERMITS AND RELEASE CERTIFICATES

3. DAMAGES AND RESPONSIBILITIES.

3.1. DAMAGE CLAIMS

- 3.1.1. The Contractor shall be solely responsible for settling any claims or damages due to his execution of work, and is required to report such damage to the relevant authority and to the Engineer. This is inclusive of damages to MoT installations.
- 3.1.2. The Employer will not be responsible for any damages by the Contractor in any way whatsoever.
- 3.1.3. In case of damages to MoT plant, resulting to interruption of service to Working Lines, the Contractor shall repair such damage immediately, and shall bear the full cost of providing a "temporary" installation for continuity of such services, or otherwise bear the equivalent in loss of revenue for same. This shall also apply to other installations of MoT, such as trunk cables and the like.

3.2. PERMITS AND RELEASE CERTIFICATES

- 3.2.1. It is incumbent upon the Contractor to seek and obtain all permissions relevant to the works and to have existing facilities located, prior to commencing activities. With regard to existing telephone services, it is also the Contractor's responsibility to trace and expose existing structures, especially those to be used in the new network.
- 3.2.2. Such permissions include a 'permission to work' from the MoT, where the activities involve existing plant (e.g. extensions or rehabilitation).
- 3.2.3. Such permissions shall also include all required 'permission to work' from responsible authorities as applicable to the sites covered in these tender documents (Volume 3), such as but not limited to Roads Authority, Municipalities and the like.
- 3.2.4. Upon completion of installations which involve an approval from Municipalities or private individuals, the Contractor shall obtain a certificate of acceptance of his work, by the concerned authority (e.g., A Reinstatement Certificate, following the completion of conduit or direct buried cable (DBC) installations).

Municipalities clearance certificates are to be provided by the Contractor prior to the issue of Taking Over Certificates in accordance with Sub-Clause 48.1.

4. INSTALLATION STANDARDS FOR CIVIL WORKS

TABLE OF CONTENTS

- 4. INSTALLATION STANDARDS FOR CIVIL WORKS
 - 4.1. GENERAL
 - 4.2. SAFETY ON SITE
 - 4.3. BREAKING OF PAVED SURFACES AND EXCAVATION
 - 4.4. FILLING, BACKFILLING, COMPACTION, SUBGRADE AND SUB-BASE
 - 4.5. REINSTATEMENT CLASSIFICATIONS
 - 4.6. UNDERGROUND DUCTS
 - 4.7. MANHOLES, HANDHOLES, TUNNELS AND EXCHANGE ENTRIES.
 - 4.8. CIVIL WORKS.
 - 4.9. RECONSTRUCTION, REHABILITATION AND EXTENSION ACTIVITIES
 - 4.10. NON-STANDARD DUCT INSTALLATIONS
 - 4.11. CONCRETE WORK
 - 4.12. CABLE SUPPORTS
 - 4.13. TESTING ON COMPLETED PLANT - CIVIL WORKS.
 - 4.14. SAMPLING AND TESTING
 - 4.15. INSTALLATION EXAMPLES
 - 4.16. MANHOLE / HANDHOLES / CABINET BASE DIMENSIONS AND REINFORCEMENT

APPENDIX 1

4. INSTALLATION STANDARDS FOR CIVIL WORKS

4.1. GENERAL

4.1.1 The Contractor shall show evidence that he is aware of the applicable specifications for road construction in Lebanon prior to the execution of any excavation works.

4.1.2 Further, the Contractor is forewarned that there may be superior and controlling specifications appertaining to the particular highways concerned, issued by local Municipalities and City Administrations.

4.1.3 All aggregates, filler material, Portland cement, water and bituminous materials utilized for highway re-construction shall comply with the standards detailed by the documentation obtained under this Section.

4.1.4 For assistance to the Contractor, the remainder of this Section indicates minimum standards and directions which are acceptable to the MoT for the underground installation of its plant. These standards are to include the following items:

Filling, compaction, sub grade, granular sub-base, aggregate base, concrete base, prime coat, tack coat, bituminous base course and wearing course, concrete pavement, paved (tiled) surfaces.

This list is not to be construed as being exclusive of the standards to be found within Lebanon.

4.1.5 Before any road works commence the Contractor shall ensure that all equipment and materials required for the work are on site, that the materials meet the required specifications and the equipment is adequate for the job.

A certificate, signed by the Contractor, stating that he has checked all imported materials should be available for presentation to the Engineer when requested.

4.1.6 All material sources and the quality of materials proposed for use in the Works shall be approved prior to procuring or processing material from such sources. Inspection, sampling, testing and retesting as necessary, shall be at the Contractor's expense.

4.1.7 The Contractor shall have satisfied himself as to the location, suitability and quantity of materials available, extent of work necessary to obtain the material available; the length of haul to the Site, and shall have obtained written permission from the Authorities or Owners concerned for any necessary "quarrying" operation.

- 4.1.8. Sampling and testing procedures shall be approved by the Engineer with the requirements specified hereinafter.
- 4.1.9. The Contractor shall submit to the Engineer, prior to commencement of Works, a statement of origin and composition of aggregates and materials proposed for use in the Works.
- 4.1.10. In order to ascertain the properties of aggregate materials, the Contractor shall submit for testing and approval, representative samples of all materials intended for incorporation in the Works, prior to starting operations. The representative samples shall be taken by the Contractor in the presence of the Engineer.
- 4.1.11. All testing as carried out by the Contractor shall in no way preclude the need for further testing by the Engineer. Approval of specific sources of materials shall not be construed as final approval and acceptance of materials from such sources.
- 4.1.12. Processed materials shall be tested and approved before being stockpiled on Site or incorporated in the Works and may be inspected and tested at any time by the Engineer during their preparation, storage and use. Questionable materials, awaiting testing and approval, shall not be unloaded and mixed with materials previously approved. If the grading and quality of any materials delivered to the Site do not conform to the grading and quality of the established control samples, the Engineer will reject such materials.
- 4.1.13. Samples shall satisfy all specified test requirements. The Contractor shall permit the Engineer to inspect any and all materials used or to be used, at any time during or after their preparation, or while being used during progress of the Works. Unsatisfactory materials, whether in place or not, shall be removed promptly from the Site. The Contractor shall furnish all necessary materials, labour, tools and equipment and transport required by the Engineer for such inspections.

4.2. SAFETY ON SITE

- 4.2.1. Warning signs, fencing, traffic barriers, accesses etc. shall be provided and maintained so as to safeguard and cause minimum inconvenience to the public. Flashing amber warning lights shall be operated at night. Local authority directions shall be followed if so required. Pedestrian accesses shall be provided at 100 m intervals, and cross roads shall have decking provided to permit the passage of vehicular traffic.
- 4.2.2. The Contractor's name, emergency contact address and telephone number shall be prominently posted at the site in both the Arabic and English languages.
- 4.2.3. The minimum disturbance to the surrounding area shall occur. This is with respect to noise, pollution, damage and inconvenience.

- 4.2.4. All debris shall be removed from the site.
- 4.2.5. In general, the minimum requirement is that the site shall be restored to the condition in which it was found. If any specifics are required, the Engineer will give instructions accordingly.
- 4.2.6. The locations in highways and sidewalks shall be in accordance with the latest regulations of the roads and highway authorities.
- Where conflict, obstacles or other unforeseen indications for variations are encountered, the Engineer shall be informed in order that the appropriate instructions may be issued.
- 4.2.7. The Contractor has the responsibility of obtaining the necessary releases and permits to implement the works.
- 4.2.8. Documentary evidence of the lines, levels and grades to be achieved shall be obtained prior to the commencement of works. This evidence shall become the property of the MoT.
- 4.2.9. General site tidiness shall be maintained throughout the work. Clearing of surplus and excess excavated material shall be ongoing.

4.3. **BREAKING OF PAVED SURFACES AND EXCAVATION**

- 4.3.1. In accordance with the design drawings the line of works shall be established. Any obstacles found as unforeseen in the design shall be brought to the attention of the Engineer.
- 4.3.2. The use of Underground Service Detectors, pilot excavations, etc., shall be utilized to minimize the possibilities of damage to existing services.
- 4.3.3. The breaking of surfacing (asphalt, tiles, etc.) shall be performed so as to provide a clean cut edge for restoration purposes.
- 4.3.4. The works shall be excavated as indicated by the design drawings. A minimum initial excavation width is indicated in line with the minimum acceptable working practice. Payment, however, will only be made for works carried out within the dimensions indicated on the drawings. Any over width or over depth excavation shall be made good at the Contractor's expense by use of approved suitable material, in all cases including existence of underground utilities.
- 4.3.5. The excavations shall be provided with all strutting, piling and sheeting necessary to maintain the stability of the surrounding ground and structures.

The design of such works should permit their removal where practical.

- 4.3.6. Excavations shall be left open for the minimum time practical, but in no case, except as agreed with the Engineer, should this exceed 4 days. Where it is not possible to complete the asphaltting within this time, scale then the level of the excavation must be brought flush to the road surface by use of suitable material until final reinstatement can be accomplished.
- 4.3.7. Immediately before the installation of the plant involved, the excavation shall be cleaned and trimmed as necessary.
- 4.3.8. If necessary, by pumping or other approved means, the excavations shall be maintained free from water. Continuous pumping shall not take place without approval from the Engineer.

4.4. **FILLING, BACKFILLING, COMPACTION, SUBGRADE AND SUB-BASE**

4.4.1. INTRODUCTION

In order to comply with increasingly stringent standards of highway reinstatement (following utility installations), 3 gradings of compaction and reinstatement are to be strictly observed.

Class A To cover International roads and requirements for meeting exact standards of reinstatement imposed by city municipalities.

Class B To cover Primary and Secondary type highways.

Class C To cover local roads, asphalted shoulders, residential areas, sidewalks tiles etc.

Other uncovered surfaces such as non asphalted and non concreted surfaces, plantation areas and bare earth do not follow any of the classes above. Reinstatement of such surfaces is detailed in section 4.5.5.

4.4.2. TECHNOLOGY AND ABBREVIATIONS

Sub-grade For the purposes of utility installation the sub-grade comprises all material below the level of the sub-base course (i.e. the original uncompacted ground or scarified and compacted material).

Sub-base Graded mix of crushed rock/gravel, sand, clay silt (including a binder if non is naturally present) comprises the layer between sub-grade and base course.

Base Course	The pavement layer immediately below the wearing course.
Wearing Course	Final asphalt surfacing of highway.
Prime-Coat & Tack Coat	Cut back (i.e. thinned) bitumen suitable for spray application to assist the bond between pavement layers and prevent water penetration to lower layers of construction.
AASHTO(T)	American Association of State Highway and Transportation Officials (Testing)
ASTM(S)	American Society for Testing and Materials (Standards)
Marshall Test	Test to determine density-void ratio and stability - flow value of hot-mix asphalt.
CBR	California Bearing Ratio (for assessing the strength of road construction materials.)
MPD	Modified Proctor Density
MD	Maximum Density
PI	Plasticity Index
RD	Relative Density
MR	Moisture Range.

4.4.3. FILLING

- 4.4.3.1. Natural hollows or over excavation shall be filled with hard-core, excavated material or mass concrete filling to MAT 2011. Compaction shall be in accordance with highway requirements.
- 4.4.3.2. Unauthorized over-excavation and its filling shall be at the Contractor's own expense in all cases encountered.

4.4.4. BACKFILLING - GENERAL REQUIREMENTS

- 4.4.4.1. The Contractor shall obtain approval for his proposed method and rate of placing of backfill, before backfilling commences.
- 4.4.4.2. Material for backfilling shall be uniform in character throughout, free from substances that by decay, erosion or otherwise may cause the formation of cavities, or otherwise affect the stability of the filling and/or damage the

installed plant. Backfill of trenches will be by excavated materials, providing that the material is clean and free from stones larger than 50 mm and is capable of being compacted to the required compaction.

Where excavated material is not suitable then imported materials will be used that will be clean and graded and pass through a 50 mm sieve.

The CBR (California Bearing Ratio) for the backfill material shall be 10% or better. Tests shall be carried out on the backfill material (excavated or imported) and the results made available to the Engineer on request.

- 4.4.4.3. Backfilling shall not commence until the work to be covered has been approved by the Engineer. Exceptions to this ruling must be obtained in writing from the Engineer.
- 4.4.4.4. Water added, if any, during placement of backfill material to achieve required compaction shall be approved by the Engineer.
- 4.4.4.5. The period of time between the placing of structural concrete and the commencement of backfilling shall not be less than 24 hours.
- 4.4.4.6. Fill shall be placed in approximately 20 cm layers and compacted in accordance with highway requirements.
- 4.4.4.7. Compaction tests shall be performed on a regular basis, as specified by the Engineer, and to satisfy the Authority regulating the highway involved. Duplicates of records shall be handed over to the Engineer.
- 4.4.4.8. Care shall be taken to ensure that no damage occurs to the installed plant, or adjacent services.
- 4.4.4.9. Where the specified compaction presents practical difficulties in achievement, the Contractor may propose an alternative backfilling procedure for the approval of the Engineer.
- 4.4.4.10. Compaction equipment shall be supplied to the site for the inspection and approval of the Engineer, prior to the commencement of the work. Unsatisfactory equipment shall be immediately replaced or repaired, as appropriate, to the satisfaction of the Engineer.

4.5. REINSTATEMENT CLASSIFICATIONS

4.5.1. CLASS A (INTERNATIONAL ROADS AND PARTS OF CITY AREAS)

- (a) Minimum width of excavation at asphalt level shall be as shown in the attached sketches.
- (b) For the first 0.4 m of excavation, the sub-base (and sub-grade) shall be removed for the full width of the asphalt cut, after which the required width for the installation alone, need only to be excavated.
- (c) Backfilling (sub-grade) below sub-base: maximum thickness of layers 300 mm compacted to 90% MPD (moisture content (MR) adjusted in accordance with test).
- (d) Sub-base (if present) for 0.3 m depth up to the course; Maximum thickness of layers 150 mm, compacted to 100% MPD.

Asphalt work shall be done according to regulations given by the road authorities and municipal authorities. In any case the minimum requirements shall apply as follows.

Sub-base shall consist of crushed aggregate, sand, clay and silt in accordance with the following ASTM grading:

Sieve size (mm)	ASTM grading (inches)	% Passing (by weight)
50.0	(2")	100
37.5	(1.5")	70-100
25.0	(1")	55-85
20.0	(3/4")	50-80
10.0	(3/8")	40-70
4.75	No.4	30-60
2.0	No.10	20-50
0.3	No.40	10-30
0.075	No.200	5-15

Minimum CBR=60%

- (e) A plasticity index should be determined for the sub-grade material where applicable. The PI shall be less than 6%.

- (f) Prior to asphalt laying, the edges of the old asphalt shall be re-cut to expose a fresh clean surface.

All dust and debris shall be removed from the surface to be asphalted. The edges of cut asphalt shall be sprayed with cut-back rapid curing bitumen RC-2, and the whole of the surface to be asphalted shall be sprayed with a cut-back medium curing bitumen MC-2 prime coat, at the rate of 1.5 l/m².

- (g) The asphalt base course shall be laid not less than 2 hours after the spraying of the prime coat.

The asphalt base course shall consist of mineral aggregate and bituminous material. Aggregates shall have the following grading:

Sieve Size (mm)	ASTM grading (inches)	% Passing (by weight)
37.5	1.5"	100
25.0	1.0"	90-100
20.0	3/4"	70-90
13.0	1/2"	55-60
9.0	3/8"	45-65
4.75	No. 4	34-56
2.0	No. 10	22-42
0.3	No. 40	10-24
0.075	No. 200	2-6

Fine aggregate shall consist of all material passing the No. 4 sieve. Fine aggregate produced by crushing and retained by the No. 10 sieve, shall be examined for the presence of at least one mechanically fractured face. Such fractured material shall comprise at least 85% of the material passing sieve No. 4.

The "Sand Equivalent" of the total aggregate shall be a minimum of 50%, as determined by AASHTO T 176.

Bituminous asphalt cement shall be of Grade 60-70 penetration and the content shall be between 3 and 5%, by weight.

The actual asphalt mix to be used shall be determined by the Marshall Test and shall satisfy the following requirements:

Stability	500 kg minimum
Flow	2-5mm
Voids in total mix	2-7%
Voids filled with asphalt	55-70%
Loss of Marshall Stability	25% maximum

- (h) The thickness of asphalt shall be 150 mm applied in two layers. A tack coat of RC-2 shall be applied between the two layers at the rate of 0.5 liters per square meter.

The compaction density shall be 95% of the maximum density according to mix design.

- (i) The preparation of asphalt cement shall involve heating all materials within a range of 135° to 163°. All material heated more than 42°C above the maximum shall be subject to resetting. Materials delivered to the site for placing shall be at a minimum temperature of 139°C. Below this temperature the material shall be discarded.

- (j) The asphalt wearing course shall consist of mineral aggregates and bituminous material. Aggregate shall have the following grading:

Sieve Size (mm)	ASTM grading (inches)	% Passing (by weight)
13.0	1/2"	100
10.0	3/8"	80
4.75	No. 4	54-76
2.0	No. 10	32-50
1.0	No. 20	20-35
0.3	No. 40	14-26
0.075	No. 200	2-8

The fine aggregate passing sieve No. 4, and retained by No. 10 shall contain not less than 90% with fractured faces.

The "Sand Equivalent" of the total aggregates shall be a minimum of 60%.

Bituminous Asphalt Cement - shall be of grade 60-70 and the content shall be between 4-5.5%, by weight.

The Marshall Test shall be used to determine the mix, which shall satisfy the following requirements:

Stability	750 kg minimum
Flow	2-5mm
Voids in total mix	2-5%
Voids filled with asphalt	70-80%
Loss of Marshall stability	25% maximum

The compaction required shall be not less than 97% of the minimum density according to the Marshall test.

Documented results of Marshall Tests shall be kept on site and made available to the Engineer.

- (k) Should asphaltting be delayed by more than two days, all vertical surfaces shall be re-cut to expose fresh asphalt, and re-coated with RC-2 bitumen.
- (l) All joints and contact surfaces of gutters, manholes, etc., shall receive a thin uniform coating of bituminous material, prior to the placing of the fresh mixture.
- (m) Cores may be requested for the determination of thickness of bituminous layers.
- (n) Adjacent structures and Properties shall be protected from splattering during the application of bituminous material.

Any deposits marring any appurtenances shall be removed by the Contractor.

- (o) Job mixes for asphaltic concrete layers, in general, shall be submitted to the Engineer for his approval. The Marshall test procedure will be used to determine the percentage of liquid asphalt to be incorporated in the mixture. Job-mix formula appropriate to the conditions encountered within Lebanon shall be utilized as the basis for design.

4.5.2. CLASS B (REINSTATEMENT PRIMARY AND SECONDARY ROADS)

- (a) Excavation and reinstatement dimensions to be as indicated in the relative sketches in this document.
- (b) The thickness of asphalt shall be as existing and within the limits 100 mm minimum and 150 mm maximum. It shall be applied in two layers. A tack coat of RC-2 shall be applied between the two layers at the rate of 0.5 lines per square meter.
- (c) In all other respects the reinstatement shall follow that for Class A.

4.5.3. CLASS C (REINSTATEMENT LOCAL ROADS, ASPHALTED SHOULDERS, RESIDENTIAL AREAS AND SIDE WALKS)

- (a) Excavation and reinstatement dimensions to be as indicated in the relative sketches in this document. In situation where installations take place through asphalted road shoulders, the Contractor should seek the Engineer's approval prior to excavation.
- (b) Sub-base thickness is 0.15 m below base course (asphalt) compacted to 100% MPD.
- (c) Thickness of asphalt shall be as existing (but not less than 50 mm). If the thickness of the asphalt is greater than 80 mm then it shall be applied in two layers. A tack coat of thinned bitumen shall be applied between the layers.

- (d) In all other respects the reinstatement shall follow that for Class A.

4.5.4. REINSTATEMENT OF SIDEWALKS

Class C reinstatement also covers the installations required in tiled, concreted or asphalted sidewalks, as per the above.

- 4.5.4.1. Paved (tiled) surfaces shall be restored upon reinstated sub-base, to at least the same condition found prior to the works, unless directed otherwise by the Engineer.

- 4.5.4.2. Broken tiles shall be replaced as necessary, with appropriate cutting tools utilized as required.

4.5.5. OTHER UNCOVERED SURFACES

- (a) In situation where installations take place through plantation areas, non asphalted/non concreted surfaces, or bare earth, the backfill shall be replaced in 300 mm layers, and compacted to meet local standards as may exist. Should no standards exist, a minimum of 90% MPD shall be achieved. Subbase of 0.15 m thickness may be reinstated in the case of existence of subbase, and compacted to 100% MPD. In cases of excavation in non asphalted, non concreted road shoulders, the Contractor should seek the Engineer's approval prior to excavation.

- (b) None of the classes of roads described above shall be applied and no cut backs will be made. The width of the trench shall be equal to the duct formation width up to the surface level.

- (c) Trees, flower beds, lawns etc. shall be replaced/restored to their original standard as far as is reasonable. The Engineer's discretion shall be applied.

- 4.5.6. Refer to the list of roads in Lebanon and their classification.

4.6. UNDERGROUND DUCTS

4.6.1. COVER

- 4.6.1.1. The depth of installation, (or required "cover") shall always be measured to the top of the duct.

4.6.2. GENERAL INSTALLATION DETAILS FOR PVC DUCT

- 4.6.2.1. The line and level of the duct formation shall be kept as straight as possible. Bends will be required for duct formations to be routed around corners at

intersecting roads. (For safety reasons manholes shall usually be planned and located away from intersections)

- 4.6.2.2. The configuration of the duct formation shall be as indicated on drawings 1251 and 1253 or as specified by the Engineer.
- 4.6.2.3. Duct laying shall not be done in the absence of the Engineer unless prior permission has been received. The position of ducts shall be secured (see drawing 1967).
- 4.6.2.4. All ducts shall be located in accordance with applicable roads and municipal Standards. Duct installations in road shoulders shall be avoided. In the absence of relevant Standards, the Engineer must be consulted.
- 4.6.2.5. When routes must be constructed in the vicinity of electrical plant, Section 2: "Coordination with other utilities", shall be consulted.
- 4.6.2.6. Ducts shall be watertight between manholes. Installation methods shall prevent sand and soil from entering the ducts.
- 4.6.2.7. At manhole, handhole and vault walls the bond between the outside surface of the duct and the wall shall be watertight.
- 4.6.2.8. Ducts shall be terminated flush to handhole, manhole and cable vault inside walls. Edges shall be beveled off.
- 4.6.2.9. Ducts entering manholes, handholes and cable vaults shall be plugged and watertight. The plugging mechanism or material shall be readily removable to allow for future cable installation.
- 4.6.2.10. Ducts shall enter manholes, handholes and cable vaults at $90^\circ \pm 10^\circ$ to the structure's walls except where not applicable in existing old MoT structures where ducts shall enter in parallel with the longitudinal structure's wall.
- 4.6.2.11. Ducts shall leave a manhole in a standard formation and enter the subsequent manhole with each duct in the same relative location (See drawing 1957).
- 4.6.2.12. At location between manholes where the duct formation must be modified due to obstructions the formation shall be altered to minimize the movement of each duct. As necessary, duct formation may go below or above existing structures encountered (See drawings 1965 and 1953).
- 4.6.2.13. The duct formation may be curved to approximately 90° . The cold bending radius for PVC duct shall not be less than 12 meters. Preformed bends and/or 5° couplings shall be used where smaller radii are required.
- 4.6.2.14. All ducts shall be mandrel tested according to Section 4.13.

- 4.6.2.15. Where necessary, in conjunction with other duct laying activities, 50 mm PVC (mini-duct) may be added to the duct nest. This is considered as being "laid in open trench". The additional duct should rest directly on top of the 100 mm duct nest, but not between two 100 mm ducts to allow for concrete in the space between the ducts. The depth of cover (80 cm) should then be measured to the top of the mini-duct. See Drawing No. 1902-1908, 1912-1918, and 1922-1928.

Where mini-duct is laid as a single entity similar standards as stipulated in 4.6.3 and 4.6.4 apply. See Drawing No. 1935-1936.

- 4.6.2.16. Only one form of construction shall be utilized between 2 manholes (See drawing 1951).
- 4.6.2.17. Where the required depth of cover cannot be achieved, reinforced concrete slabs (poured in-situ) shall be provided above or integral with the duct structure with a minimum 6 Kg steel/m².
- 4.6.2.18. Ducts from manhole/handhole to cabinet follow the form of construction shown on Drawing No. 1969 (upon vertical formation on MH/HH).

4.6.3. PVC DUCTS IN CONCRETE

- 4.6.3.1. The method of construction shall ensure that the standard spacing is maintained (spacer at 2 m intervals) and that all space between the ducts and a minimum of 75 mm surrounding the ducts is filled with concrete. The formation shall be built up utilizing approved materials and installed according to Section 4.11. Concrete spacers (drawing 1999) should be used for 100 and 50 mm ducts.

The concrete shall be permitted to "key" into the sides of the excavation. Shuttering of ducts shall be made at the Contractor's expense in case of extra width of excavation.

- 4.6.3.2. Concrete immersion vibrators ("pokers") shall be of 30 mm maximum OD, and shall only be used in the 75mm plus space between the ductwork and the sides of the excavation.
- 4.6.3.3. In soft ground, reinforced concrete may be required. The Engineer shall approve such installation.
- 4.6.3.4. In locations where concrete encased PVC ducts are installed with less than a 400 mm depth of cover, as may occur with a road crossing, the concrete formation shall be increased by an additional 100 mm thickness of R/C slab.
- 4.6.3.5. Minimum depth of cover above upper duct layer shall be 80 cm.

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- 4.6.3.6 The method of construction of duct formations when using the trenching machine for excavation does not vary from the standard duct formations specified. Affect.
- 4.6.3.7 One or three sub duct in a pvc duct.
- 4.6.4. PVC DUCTS IN SAND
- 4.6.4.1. The dimensions of the PVC ducts, duct spacers should be in compliance with 4.6.2.
- 4.6.4.2. The separation either longitudinal or perpendicular, to other services, should be 150 mm. Where such is not possible a separating/retaining layer of 50 mm of concrete is required.
- 4.6.4.3. The Engineer shall have the discretionary authority to change the construction method to PVC in concrete or steel ducts, should the circumstances indicate such a requirement.
- 4.6.4.4. Duct formations up to 6-way can be installed in sand as directed by the Engineer. Typical dimensions are shown in the attached drawings. At road crossings the formation will be enclosed in concrete to the approval of the Engineer. If 2 or more ducts are to be laid, they shall be supported by spacers so that the formation will maintain the standard spacing between ducts throughout the length of the installation. Sand, to the appropriate highway specification, shall be placed to fill all spaces between ducts, and compacted.
- 4.6.4.5. The duct formation shall be covered with 100 mm of sand. This is to be followed by suitable backfill to a depth as calculated from the appropriate drawing. A plastic warning tape shall be installed to the approval of the Engineer. As a minimum, warning tape shall be 70 mm wide, yellow PVC, durably marked with the text 'WARNING - TELEPHONE CABLE' and the telephone handset logo at no more than 50 cm intervals. Backfill and compaction shall follow Section 4.4, however, the sand surround shall be composed and consolidated by a method of "Watering in".
- 4.6.4.6. Ducts entering and exiting from cable chambers shall be installed in concrete for a distance of 1.0 meters extending from the outside wall of the chamber. The entire formation shall be enclosed in concrete to a thickness of 75 mm.
- 4.6.4.7. Minimum depth of cover above upper duct layer shall be 80 cm.

4.6.5. STEEL DUCTS.

- 4.6.5.1. Where the installation of steel ducts have been specified as part of the design, or as may be required by the on-site conditions, their installation shall comply with either:

Section 4.6.3 for concrete surround or
Section 4.6.4 for sand surround.

- 4.6.5.2. Steel ducts shall comply with MAT 2221 and, where coupled to PVC ducting, the connecting fittings shall comply with MAT 2202.

- 4.6.5.3. Minimum depth of cover above upper duct layer shall be 80 cm.

4.6.6. GENERAL (PVC DUCTS IN SAND/CONCRETE)

- 4.6.6.1. Duct spacers shall be used to position ducts in formation and to support the ducts while maintaining adequate duct separation in preparation for subsequent sand or concrete embedding. The sand/concrete shall be compressed between each layer and there shall be a covering of minimum 80 mm sand/concrete.

- 4.6.6.2. Following testing of the completed duct nest a nylon draw cord shall be installed in each duct. The cord shall be supplied in lengths of 500 meters and should have a minimum breaking weight of 220 kg subject to the Engineers approval.

4.6.7. ROAD CROSSINGS.

- 4.6.7.1. The crossing of roads and highways with Direct Buried Cables, coupled with the requirements of maintenance, possible future cable additions and the inherent problems of re-excavation across road junctions, implies the use of short sections of conduit at such points.

- 4.6.7.2. Thrust boring shall be used wherever possible in order to avoid disturbance of road traffic.

- 4.6.7.3. 'Road Crossings' shall be constructed in accordance with the installation type (see Drawing 1260)

- 4.6.7.4. Section 2: "Coordination with other utilities" shall be referred to for the installation type to be applied in respect to other underground utilities.

- 4.6.7.5. To be noted for the installation of road crossings, is the requirement for the free passage of longitudinally installed utilities below the crossing. Hence the depth of installation may have a lower limit applied as well as a structural requirement for a minimum depth below the highway surface.

Should particular installations produce a conflict between these requirements, the issue shall be referred to the Engineer.

- 4.6.7.6. All road crossings shall have the duct ends plugged.
- 4.6.7.7. The ends of such 'unterminated' ducts, shall be identified by marker plates as per Section 9.

4.7. MANHOLES, HANDHOLES, TUNNELS AND EXCHANGE ENTRIES.

4.7.1. EXCAVATION AND BACKFILLING FOR MANHOLES.

- 4.7.1.1. Excavation and backfilling for manholes etc. shall be performed in accordance with Section 4.1 to 4.5.
- 4.7.1.2. For the installation of precast structures, the bottom of the excavation shall be leveled with a layer of compacted gravel, hardcore or similar material, as acceptable to the Engineer. The resultant level shall permit the structure to be installed to the required surface level with the minimum adjustment to the frame and cover height (See drawing 1985).
- 4.7.1.3. I-situ work shall have the bottom of the excavation leveled with a minimum of 5 cm blinding mix. The level shall permit the structure to be completed to the required surface level as in Section 4.7.2. Blinding shall not be considered as part of the specified cover to reinforcement.

4.7.2. CONCRETE STRUCTURES

- 4.7.2.1. Manholes and Handholes structures shall not be earthed.
- 4.7.2.2. The completed installation shall comprise a watertight concrete structure, finished with cable supports, cable pulling facilities, ladders etc. as specified by the Engineer, and free from construction materials, debris, water etc. The manhole shall have a marking plate installed in accordance with Section 9.
- 4.7.2.3. Provision shall always be made for the maximum designed numbers of ducts to exit the manhole. Preferably, preformed plastic duct terminators (socket banks) shall be cast into the manhole structure, during its construction.
- 4.7.2.4. Should ductwork be cast directly into the manhole wall, the additional duct capacity shall be stopped approximately 100 cm from the manhole outer wall, and plugged at both ends.
- 4.7.2.5. The bottom ducts shall always be the continued part of the duct runs, to permit easy access to the unused bores.
- 4.7.2.6. Manholes shall be "tanked" to prevent deterioration of the concrete. Material utilized for tanking shall comply with the Engineer's requirements who may give

authorisation to dispense with this requirement where evidence of a lack of adverse ground conditions can be presented.

4.7.2.7. When existing structures have large extension works added, for example in the form of tunnels abutting to an exchange, suitable provision shall be made for relative movement to the satisfaction of the Engineer.

4.7.2.8. Large underground structures adjoining to exchanges (i.e. manholes, tunnels etc.) shall be provided with ventilation facilities to be approved by the Engineer.

4.7.3. EXCHANGE ENTRIES.

4.7.3.1. In order to permit the required entry of cable plant to the exchange, the Engineer shall liaise with the building designers to ensure that adequate provision is made.

4.7.3.2. Exchange entries may consist of:

- Duct banks entering a cable vault end wall.
- Tunnels opening into a cable vault, or for small rural sites, a set of preformed bends to MAT 2202. Such arrangements shall be installed so that the end of the bends exit the exchange floor, or container pad, on the tangent and perpendicular.

4.7.3.3. In the situation that an extension to an existing exchange entry is required or that the task of providing the entry is part of the OSP works the following requirements shall be followed, in conjunction with the design.

4.7.3.4. In all cases ducts shall be sealed with removable plugs or if containing cables, removable sealing compounds. The entrance shall be gastight.

4.7.3.5. Earthing and bonding facilities shall be provided at all the exchanges in accordance with Section 8, with due consideration to the relevant MOT building standards.

4.7.4. DIRECT CONDUIT ENTRANCE - CONTAINER EXCHANGES.

4.7.4.1. Entrance ducts in container exchanges shall be constructed to match the bores in the bottom of the container.

4.7.4.2. The conduit formation shall normally feed from the street line parallel to and approximately 250 cm from the building wall. 90° PVC bends conforming to MAT 2202, shall be used to terminate the ducts under and through the floor of the container. A cable racking facility shall be designed and installed horizontally on the inside wall directly above the duct entrances.



- 4.7.4.3. Horizontal cable support members shall be installed and anchored to the container wall to provide adequate support for vertical cable joints and stubs, consistent with the ultimate capacity of the container.
- 4.7.4.4. Overhead cable ladders (trays) shall be placed to route stub cables to the MDF.
- 4.7.5. CABLE TRENCH ENTRANCE - SMALL EXCHANGE BUILDINGS.
- 4.7.5.1. The cable entrance trench shall normally be perpendicular to the street line with entrance ducts entering at the front end wall. The duct entry shall be centered in the cable trench, spaced on 15 cm centres, at a minimum of 15 cm from the bottom of the trench.
- 4.7.5.2. Cable supports spaced 100 cm apart shall be designed and installed on the exterior side wall of the cable trench. Removable and adjustable cable brackets are to be used. The first cable will always be placed in the first vertical duct row closest to the exterior wall, starting with the bottom layer duct and terminating first and closest, to the duct entrance.
- 4.7.5.3. Two horizontal cable supports shall be installed for the entire length of the cable, above the finished floor of the building. These supports shall be designed to support vertical joints consistent with the ultimate capacity of the building.
- 4.7.5.4. Adequate cable ladders (trays) shall be designed and installed to support cable stubs from the jointing area on the wall to the vertical side of the ODF. To limit cable congestion above the ODF these cable racks shall be separate, and in addition to, those, provided for equipment cabling on the horizontal side of the ODF.
- 4.7.5.5. A removable decking system shall be provided to ensure easy access to the cable trench at floor level. The trench shall be equipped with a pulling iron centrally located at the opposite end to the duct entrance. A line feeding hole (approx. 15 cm diameter.) shall be provided 100 cm above the floor level on the duct entrance wall. The hole shall be aligned with the centre line of the duct structure, and if possible, slanted 30° into the cable trench.
- 4.7.6. CABLE VAULT ENTRANCE - LARGE EXCHANGE BUILDINGS.
- 4.7.6.1. The duct banks shall be located in a manner which allows cables to be easily routed to the ODF without encountering cable congestion in the long term.
- 4.7.6.2. The cable entrance shall be located in the front of the building at the end of the vault. The ducts entering the vault shall be positioned so that the cables can be placed on their respective position with little or no bending.
- 4.7.6.3. Ducts shall preferably enter the vault via pre-fabricated socket banks or plastic terminators. If cast in-situ they shall be perpendicular to the wall, at 15 cm centres. The duct ends shall be beveled so as to remove any sharp edges.

4.7.6.4. The opposite wall to the duct entrance shall have two cast-in pulling-irons centered vertically and horizontally with each duct entrance formation for the pulling of network cables. Pulling-Irons shall be anchored to resist a pulling force of 50 kN.

4.7.6.5. Two line feeding holes (15 cm diameter) equipped with removable covers shall be installed through the basement wall to permit the pulling of network cable into the vault. Holes shall be inclined 30° into the cable vault and located directly above the two duct formations.

Ceiling inserts must be provided by the contractor for suspending cable ladders. These can either be provided during construction or at the time of installing the ladders and uprights.

4.7.6.6. Access to the cable vault or exchange via a tunnel shall be prevented by suitable locking facilities.

4.7.6.7. The exchange manhole cover shall be lockable with a locking bolt according to MAT 2011.

4.8. OUTDOOR CABINET No Need

4.9. RECONSTRUCTION, REHABILITATION AND EXTENSION ACTIVITIES

4.9.1. Existing cable plant shall be fully protected to the satisfaction of the Engineer, before any demolition or rehabilitation work is permitted to commence. Rehabilitation works like cover raising or replacing, existing ducts testing, repair of existing blocked ducts, recovery of installed plant, etc...shall not be executed unless specifically approved by the Engineer.

4.9.2. Conduit additions shall only take place after all options of subducting, re-configuration of existing plant and pair-gain systems have been examined.

4.9.3. Cable Repair Centres of the concerned authorities shall be notified prior to the commencement of work in order that accidental damages may be promptly attended to.

4.9.4. The cutting of existing concrete structures for additions and extensions shall utilize the latest techniques and tools available, so as to cause the minimum damage to the remaining structure.

4.9.5. The entry of 1 or 2 additional ducts into a manhole shall utilize a "core-drill" of appropriate diameter, with the ducts epoxy bonded into the concrete.

4.9.6. Larger numbers of ducts may have the appropriate penetrations cut, and the resultant cavities sealed to comply with Section 4.7.2.

- 4.9.7. The joining of new concrete to old shall result in a structurally integral construction, unless approved otherwise by the Engineer.
- 4.9.8. The final installation shall comply with Section 4.7.2.
- 4.9.9. Where ducts are to be added to existing routes, due care and attention shall be given to the requirements of other utilities.
- 4.9.10. Due to the requirements that other utilities may have for the underground road space, the requirement to increase a manhole's capacity shall preferably be met by demolishing the old structure and rebuilding in the same location. Only where it can be determined that there will not be a future requirement for the road space, may an additional manhole be constructed adjacent to an existing one.
- 4.9.11. A minimum of 4 ducts shall interconnect such installations.
- 4.9.12. Additional ductwork shall be entered into existing manholes so as to result in the minimum cabling problem reconcilable with the expansion requirements.
- 4.9.13. It is recognized that the decision as to the construction techniques necessary may only become apparent after excavation of the works to be extended or rehabilitated. Hence the Engineer shall be present during the decision-making stages of such works to provide instructions as required.
- 4.10. NON-STANDARD DUCT INSTALLATIONS**
- 4.10.1. **BRIDGE CROSSINGS.**
- 4.10.1.1. The Engineer provides the Design Drawings to the Contractor for implementation. It is the Contractor's responsibility then to prepare Shop Drawings following detailed survey of respective areas to be implemented. In particular, it is the Contractor's responsibility amend such design to suit site conditions, and to design special crossings as these are encountered on site, which all shall be submitted to the Engineer for approval.
- 4.10.1.2. The Contractor shall produce a design for the required number of conduit ways, consulting where necessary with the Engineering Authority responsible for the bridge structure, regarding allowable loading, attachment mechanisms etc. Written authorisation shall be obtained, to allow the installation to take place.
- 4.10.1.3. The installations shall, where possible, be self supporting. Supports shall permit the installation to perform as designed by the Contractor with due regard for thermal movement and any necessary restraints.

4.10.1.4. In some instances it may be possible to cast a section of PVC duct in concrete, as an extension/addition to the bridge structure.

4.10.1.5. The Engineers approval for all non standard constructions shall be obtained prior to any commencement of works, in addition to relevant authority approvals.

4.10.2. BURIED RIVER CROSSINGS.

4.10.2.1. Conduit installed alongside bridge structures which cross rivers shall, where possible, be installed on the down stream side of the bridge.

4.10.2.2. Conduit shall always be encased in concrete. The concrete shall be keyed into the sides of the excavation and erosion dams provided as required. Reinforcement may be specified if erosion and exposure of the conduit is a potential risk.

4.10.2.3. The installation procedures utilized shall take all precautions to prevent erosion effects due to the installation of the conduit works.

4.10.3. EROSION DAMS

4.10.3.1. Erosion Dams shall be provided in locations which in the opinion of the Engineer may suffer from the affects of ground and flood water (See drawing 1265).

4.10.3.2. Dams shall be constructed of concrete, with a minimum of 20 cm keyed into the excavation walls and trench bottom. Minimum thickness shall be 10 cm. If the dam is provided on a buried cable route, a spare duct or opening shall be provided for each cable.

4.10.3.3. The opening shall be provided with a removable plug.

4.11. CONCRETE WORK

4.11.1. REINFORCEMENT.

4.11.1.1. Bending shall be by approved means producing a gradual even motion. All bending shall be performed cold.

4.11.1.2. Bends shall comp'y with BS 4466, or as otherwise specified on Drawings and Bending schedules as approved by the Engineer. Bars incorrectly bent shall only be used if the method of rebending does not injure the material. No reinforcement may be bent when in position in the works, without approval.

4.11.1.3. Bond length and splicing of bars shall conform to the requirements of CP 114.

4.11.2. FIXING OF REINFORCEMENT.

- 4.11.2.1. Reinforcement shall be accurately fixed and by approved means maintained in the positions shown on the drawings.
- 4.11.2.2. Bars intended to be in contact shall be wired together with annealed tying wire, minimum gauge No. 16.
- 4.11.2.3. Immediately before concreting, the reinforcement shall be examined for accuracy of placing and cleanliness.

- 4.11.2.4. Cover to reinforcement shall be in accordance with the following, or as described on the drawings. A plus 3 mm tolerance shall apply.

Concrete Grade	Cover (mm)	
	Interior	Exterior
30	30	40
25	30	50

- 4.11.2.5. Chairs or other forms of spacer and/or subsidiary reinforcement shall be employed to maintain the reinforcement in its correct position, which will not normally be shown on drawings.
- 4.11.2.6. Scaffold boards shall be provided to ensure the reinforcement is not displaced by being walked upon during the placing of concrete or other operations.
- 4.11.2.7. Welding of reinforcement shall not take place without the Engineer's approval.
- 4.11.2.8. Mesh reinforcement shall be overlapped by a minimum 300 mm.
- 4.11.3. FORMWORK.
- 4.11.3.1. Forms shall be designed and so constructed that the concrete can be properly placed and thoroughly compacted and that the hardened concrete shall conform accurately to the required shape, position and level, subject to the tolerance and to the standards of finished specified. The deflection of the formwork shall not exceed 30 mm (See drawing 1983).
- 4.11.3.2. When concrete is to be vibrated, special care shall be taken to maintain the stability of the formwork and the tightness of the joints during compaction.
- 4.11.3.3. Faces in contact with concrete shall be free from grout, projecting nails, splits or other defects. Joints shall prevent the leakage of grout and avoid the formation of fins or other blemishes. The resultant finish of the concrete face shall comply with Lebanese building standards and the drawings. Any defective concrete finish will be rejected.
- 4.11.3.4. The Engineer may at his discretion order the defects to be cut out and made good.
- 4.11.3.5. Plastering of defective concrete as a means of making good will not be permitted, except that in the case of minor porosity on the surface, the Engineer may approve a surface treatment of rubbing down with cement and sand mortar of the same richness as in the concrete. This treatment shall be made immediately after removing the formwork.

- 4.11.3.6. Unless otherwise described, 2.5 cm x 2.5 cm chamfers shall be formed on all external corners of concrete members.
- 4.11.3.7. Openings for inspection and escape of washing out water shall be formed so that they can be conveniently closed.
- 4.11.3.8. The construction of the formwork shall ensure easy removal.
- 4.11.3.9. All forms shall be removed without damage to the concrete. The use of mould foil or other material to facilitate this shall be subject to the approval of the Engineer.
- 4.11.3.10. Before placing concrete, all fixings, bolts and cores or similar devices used for forming openings shall be in place.
- 4.11.3.11. The Engineer shall be informed in advance when the contractor intends to strike any formwork.
- 4.11.3.12. The time at which the formwork is struck shall be the Contractor's responsibility. It is recommended that formwork not be struck until the concrete has attained a compressive strength of not less than 10 MPa or twice the stress to which it will then be subjected, whichever is the greater.
- 4.11.3.13. Formwork which is to have high frequency usage, e.g. in precast work, shall be steel fabricated.
- 4.11.3.14. The material and position of any ties passing through the concrete shall be approved by the Engineer. The whole or part of the tie shall be capable of being removed so that no part remaining embedded in the concrete shall be nearer the surface of the concrete than the specified thickness of cover to the reinforcement. Any holes left after the removal of ties shall be filled with concrete or mortar of approved composition, unless directed otherwise by the Engineer.
- 4.11.4. CONSTRUCTION BAYS AND FORMED JOINTS.
- 4.11.4.1. The Contractor shall agree with the Engineer, prior to the commencement of concreting, upon the sequence of placing concrete and the positions of vertical and horizontal joints, whether shown or not on the drawings. When not indicated on the drawings the following general rule shall apply:
- 4.11.4.2. Slabs.
Joints in slabs are to be located at or near the quarter points of the span in slabs, except where otherwise instructed.
- 4.11.4.3. Walls.
Vertical joints away from corners. Horizontal joints above splays or openings.

- 4.11.4.4. Expansion joints shall be formed in the positions indicated and to the details shown on the drawings.
- 4.11.4.5. The expansion joint shall be filled with bitumen impregnated fibreboard to its full depth and width. The infilling will be permitted to be used as permanent formwork only for the second casting. Where the fibreboard is exposed it shall be cut back for a depth of at least 2 cm from the chamfered edge, and filled and pointed with a resilient liquid polysulphide polymer sealant to the manufacturers instructions.
- 4.11.4.6. Concreting shall be carried out continuously up to construction joints.
- 4.11.4.7. Whenever the placing of the concrete is discontinued other than at the exposed faces, this discontinuity shall form a construction joint. Construction joints are to be made only along a horizontal or vertical plane except that in the case of inclined members they shall be at right angles to the principal axis. Care shall be taken to prevent off-setting of the joint and to ensure water-tightness.
- 4.11.4.8. The joints shall in every way satisfy the requirement of the Engineer, and be in accordance with the drawings.
- 4.11.4.9. At construction joints, the laitance film and porous layer of the already set concrete shall be removed and the surface scabbed and then wire-brushed and thoroughly cleaned.
- 4.11.5. JOINING NEW CONCRETE WORK TO EXISTING
- 4.11.5.1. Existing concrete shall be broken out as described or directed and scabbed to form a suitable key for the new concrete. The provisions of Section 4.11.4.6 shall be complied with.
- 4.11.5.2. Where necessary the reinforcement in existing concrete shall be exposed, cleaned and bent to its correct shape.
- 4.11.5.3. Immediately before new concrete is poured the faces of the existing concrete shall be thoroughly wetted or coated with an approved bonding agent.
- 4.11.5.4. New reinforcement shall be securely wired to the existing reinforcement.
- 4.11.6. CONCRETE.
- 4.11.6.1. Materials for the production of plain and reinforced concrete work shall be approved by the Engineer and shall conform to the following:

A. Cement

Cement shall be Portland Cement, originating from manufacturers approved by the Engineer and shall comply with BS 12 or AASHTO M85 Type I in the case of ordinary Portland Cement and with BS 4027 or AASHTO M85 Type II or Type V as directed by the Engineer in the case of Sulphate Resisting Portland Cement.

Only one type or brand of cement shall be used in any one structural member. Mixing of types or brands will not be permitted.

All cement shall be subject to approval and shipments of cement shall be accompanied by a manufacturer's Certificate of Guarantee and/or laboratory test certificate. Approval of any cement sample shall not relieve the Contractor of the responsibility to fabricate concrete of the specified strength.

When tests at the factory or field tests subsequent to the original approval tests show that the cement does not comply with the specifications, the entire consignment from which the sample was taken shall be rejected and the Contractor shall immediately remove the rejected material from the Site and replace it with cement which meets the required specifications.

B. Fine Aggregates

Fine aggregates shall consist of natural sand or crushed rock having hard and durable particles or, if approved by the Engineer, other inert materials having similar characteristics, 100% passing 9.5 mm sieve and 2% to 10% passing 0.15 mm sieve. It shall not contain harmful materials such as iron pyrites, coal, mica, shale or any materials which may attack the reinforcement in such a form or in sufficient quantity as to adversely affect the strength, durability and texture of the concrete.

The Contractor shall, when directed by the Engineer, wash the fine aggregates to remove deleterious substances or for consistency of concrete color. Such washing shall not be carried out using Sea Water.

The total acid soluble sulfate content (BS 812:Part 118 1988) of fine aggregate, expressed as sulphur trioxide (SO_3), shall not exceed 0.40% by dry weight of fine aggregate. The total acid soluble chloride content, expressed as sodium chloride (NaCl), shall not exceed 0.10% by dry weight of fine aggregate.

Total sulfate content (as SO_3) of any mix, excluding that present in the cement but including any present in the other materials, shall not exceed 2.5% by weight of cement in the mix.

Total chloride content (as NaCl) of any mix, including any chloride present in the other materials and in the mix water, shall not exceed 0.35% by weight of cement in the mix.

Fineness modulus, AASHTO M6: $\pm 0.20\%$ of approved value which shall be not greater than 3.1 or less than 2.3. Sieve analysis to AASHTO T27.

Sodium or Magnesium sulfate soundness max 12% , 18% loss respectively. Testing to be in accordance with AASHTO T104.

Content of clay lumps and friable particles, AASHTO T112-82: 3% max.

Sand equivalent AASHTO T176: min 75%.

Coal and lignite, AASHTO T113-82 : 0.5% Max.

Organic impurities AASHTO T21-81 : not darker than standard color.

The amount of hollow shells likely to form voids and present in material retained on a 2.36 mm sieve determined by direct visual separation, shall not exceed 3% by weight of the entire sample.

If the fineness modulus varies by more than 0.2 from the value assumed in the concrete mix design, the use of such fine aggregate shall be discontinued until suitable adjustments can be made in the mix proportions to compensate for the difference in gradation.

C. Coarse Aggregates

Coarse concrete aggregates shall consist of gravel, crushed gravel, or crushed stone free from coating of clay or other deleterious substances. It shall not contain harmful or any other materials which may attack the reinforcement in such a form or in sufficient quantity as to adversely affect the strength and durability of the concrete. If necessary, coarse aggregate shall be washed to remove deleterious substances.

The total acid soluble sulfate content (BS812 : Part 118 , 1988) or coarse aggregate expressed as sulphur trioxide (SO_3), shall not exceed 0.40% by weight (AASHTO T260-82, BS812:part 117). The total acid soluble chloride contents of coarse aggregates, expressed as sodium chloride ($NaCl$), shall not exceed 0.05% by weight. These limits are subject to the following overriding requirements:

The total sulfate content (as SO_3) of any mix, excluding that present in the cement but including any present in the other materials, shall not exceed 2.5% by weight of cement in the mix.

The total chloride content (as $NaCl$) of any mix, including any chloride present in the other materials and the mix water, shall not exceed 0.35% by weight of cement in the mix.

Sodium magnesium sulfate or magnesium sulfate soundness AASHTO T104: 5 cycles: Max 12% , 18% loss respectively.

Abrasion, in accordance with AASHTO T96 requirements .

Content of Clay lumps friable particles AASHTO T112-81: Max 3% by weight.

Soft fragments and shale Max 5% by weight.

Flakiness index , BS812 : 30% Max. Elongation index , BS812 : 30% Max.

D. Water

Water for concrete mix or for curing shall be free of harmful substances such as oil, grease, salts, acids, alkalis, organic matters, fine (dissolved or suspended) and any other substances that reduce the strength or durability of concrete.

Potable Water. Potable water satisfying AASHTO T26 and BS3148 is suitable for mixing and curing. Non-potable water may only be used with the approval of the Engineer upon rigorous testing and analysis.

Mix Design: The water used in the mix design shall be the same as the water approved for site use.

Special Cases: Water used for prestressed concrete structures or for concrete containing or in contact with aluminum fittings or fixtures shall not contain chloride ions.

E. Admixtures

The quantity and method of using admixtures shall be in accordance with the manufacturer's recommendations and in all cases shall be subject to the approval of the Engineer.

In all cases the Contractor shall provide the following information for the Engineer's approval:

- The quantity to be used, in kilograms per kilogram of cement and in kilograms per cubic meter of concrete.
- The detrimental effects caused by adding a greater or lesser quantity in kilograms per cubic meter of concrete.
- The chemical name(s) of the main active ingredient(s).
- Whether or not the admixture leads to the entrainment of air.



The Contractor shall demonstrate the action of an admixture by means of trial mixes.

The use of calcium chloride in any form is prohibited.

Reference may be made to ACI Committee 212 report "Guide for Use of Admixtures in Concrete".

4.11.6.2. The Engineer shall have the right to order that any materials which do not meet with his approval shall not be used in the works. Upon rejection of materials by the Engineer, they shall be immediately removed from the Site by the Contractor.

4.11.6.3. The following minimum requirements shall be applied to various constructions:

(a) Construction of Manholes/Handholes

Reinforced Grade 350 kg.

Cement 350 kg minimum per cubic metre.

Coarse Aggregate to be graded to a maximum of 19 mm.

Site slump tests 9 cm to 12 cm maximum.

Compressive strength after 28 days 275 kg/cm² on cylinder.

Compressive strength after 7 days to be approximately 75% of 28 days strength.

2 Cylinder tests shall be taken for each separate concrete pour, one for the 7 day test and one for the 28 days test.

Precast manholes and handholes should not be brought on site before the 7 day compressive strength is known.

A reference number must be given to each precast unit and compressive strength tests associated with this number. The location of each unit must be identified.

All test results must be submitted to the Engineer.

(b) Encasement of Duct Formations/Construction of concrete spacers

Normal Grade 250 kg.

Cement 250 kg per cubic meter.

Coarse aggregate to be graded to a maximum of 12 mm.

Site slump tests to be 12.5 cm to 15 cm maximum.

Compressive strength after 28 days to be at least 140 kg/cm² on cylinder.

Cylinder tests to be taken at Engineer's discretion. The exact location of the pour must be recorded.

No mechanical vibration of trench concrete allowed as material should be of sufficient plasticity to be worked by hand.

(c) Construction of Cabinet Bases

Materials and strength as in (a) above shall apply.

Cylinder test shall be at Engineer's discretion

4.11.6.4. Aggregates shall be measured by weight.

4.11.6.5. The actual mix ratios of aggregate to cement shall be determined by the Contractor and approved by the Engineer.

4.11.7. REQUIREMENTS IN HOT WEATHER

4.11.7.1. In hot weather the Contractor shall present for the Engineer's approval his proposals for dealing with the following:

- Reduced workability
- Excessive plastic shrinkage
- Rapid strength gain but possible low final strength
- Rapid drying-out of concrete.

4.11.7.2. Initially, the Contractor shall double the number of test cubes made. Half of them shall be cured under site conditions in order to ascertain the relationship between site-cured samples and lab-cured samples.

4.11.7.3. The number of slump tests shall initially be twice that normally required.

4.11.7.4. Air temperatures shall be measured every two hours, and the temperature of every batch of concrete shall be recorded as it is deposited at the work place.

4.11.8. CONCRETE MIXING

4.11.8.1. A materials engineer shall be employed by the Contractor to supervise the work of the concrete laboratory, testing of aggregates, quality control etc.

4.11.8.2. A competent and experienced person shall be employed at the works by the Contractor whose duty shall be to supervise all states in the preparation, placing and curing of concrete.

4.11.9. PLANT.

4.11.9.1. The concreting plant shall be suitable in type, capacity and design for its purpose. The performance of the plant and its disposition shall be to the satisfaction of the Engineer.

- 4.11.9.2. All concrete except where specifically permitted by the engineer in writing shall be mixed in weigh batch mixing machines. Concrete mixing on site shall be subject to the Engineer's approval. The machine shall have a large water storage tank with a gauge so that a predetermined quantity of water can be injected into the mixer drum. The machine shall be in full working order when in use and shall be calibrated at regular intervals and when deemed necessary by the Engineer.
- 4.11.9.3. Aggregate stock piles shall preferably be shielded from the direct rays of the sun or cooled by spraying with water; water tanks and pipes shall be insulated, to ensure that the temperature of concrete when deposited shall not exceed 32°C.
- 4.11.9.4. With the approval of the Engineer, additives may be employed to retard setting time or enhance workability, or induce early bleeding etc.
- 4.11.9.5. The dry concrete ingredients shall be mixed until a uniform color is obtained. After the addition of the water the concrete shall be mixed for a further 2 minutes or until a uniform color is achieved.
- 4.11.9.6. During mixing of the concrete due account must be taken of the water contained in the aggregates. The total water in the mix shall not exceed the amount used in the trial mix.
- 4.11.9.7. The Contractor shall take all precautions to the satisfaction of the Engineer to protect the concrete from the injurious effects of the elements.
- 4.11.9.8. The concrete shall be of such consistency that it can be readily worked into the corners and angles of the formwork and around reinforcement without segregation of the materials or bleeding of free water at the surface. When a suitable amount of water has been determined, the resulting consistency shall be maintained throughout the work and approved tests such as the slump test, shall be conducted as required.
- 4.11.9.9. On striking of formwork it shall present a face which is uniform, free from honey-combing, surface crazing or excessive dusting. In order to satisfy the Engineer that the workability of the proposed mixes is adequate for the specified requirements, the Contractor shall carry out a series of workability tests on the preliminary trial mixes.
- 4.11.9.10. These tests shall be carried out in accordance with B.S. 1881, or such other procedure as may be approved by the Engineer.
- 4.11.9.11. The samples to be tested shall be obtained from the batches used for the preliminary test cubes. In addition, the Contractor shall supply for each of the grades of concrete a section of formwork complete with reinforcement fixed in position and generally representative of the sections commonly to be employed in the Works. The capacity of this trial section of formwork shall be at least half a batch of concrete but in any case not less than 1/4 m³. The formwork shall

comply with the requirements of this Specification for formwork. The mould shall be filled in the presence of the Engineer with concrete of the same mix and batch from which the preliminary test cubes are made and shall be compacted in the same manner and with the same equipment as are proposed for the works. This procedure shall, if necessary, be repeated with modified mixes until the appearance of the concrete after striking the mould is acceptable to the Engineer after which it shall be used as the standard for that grade.

4.11.10. TRANSPORT AND PLACING.

4.11.10.1. The method of transporting concrete shall be to the approval of the Engineer. Concrete shall be so transported that contamination, segregation or loss of the constituent materials does not occur.

4.11.10.2. Concrete batched off-site shall be transported by truck mixer with the mixer rotating slowly until it arrives on site. Alternatively, the aggregates and 80% of the required water may be batched off-site with the cement and remaining water being added on site not more than 15 minutes before the pour commences. Concrete transporters shall be kept as cool as is practical.

4.11.10.3. The concrete shall be compacted and in its final position within 2 hours of the introduction of cement to the aggregates, unless a longer time is agreed by the Engineer. The time of such introduction shall be recorded on the delivery note together with the weight of the constituents of each mix.

4.11.10.4. When truck-mixed concrete is used, water shall be added under supervision, either at the Site or at the central batching plant, as agreed by the Engineer but in no circumstances shall water be added in transit.

4.11.10.5. Unless otherwise agreed by the Engineer, truck mixer units and their mixing and discharge performance shall comply with the requirements of BS. 4251. Mixing shall continue for the number and rate of revolutions recommended in accordance with item 9 in Appendix B of BS. 4251 or, in the absence of the manufacturer's instructions, mixing shall continue for not less than 100 revolutions at a rate of not less than 7 revolutions per minute.

4.11.11. READY- MIXED CONCRETE.

4.11.11.1. Ready-mixed concrete, installed according to Section 4.7, and batched off the Site, may be used only with the agreement of the Engineer.

4.11.12. CONCRETE PLACING.

4.11.12.1. Placing shall not commence until sufficient standby pumps and vibrators are on site to cope with breakdowns.

4.11.12.2. No concrete shall be batched until formwork is ready and all reinforcement is fixed in place.

- 4.11.12.3. All formwork and reinforcement contained in it shall be clean and free from standing water immediately before the placing of the concrete.
- 4.11.12.4. The Engineer shall be given 24 hours notice in the form of a "Request to Concrete" in order that he may check the work. No concrete shall be placed in any part of the structure until the Engineer has counter-signed the submitted "Request to Concrete".
- 4.11.12.5. Upon arrival at the place of deposition, the batch should be accompanied by a document from the concrete batcher station stating (a) the grade of concrete, (b) workability (c) aggregate size (d) type of cement and (e) time of batching of the concrete.
- 4.11.12.6. If concreting is not started within 24 hours of approval being given, approval shall again be obtained from the Engineer.
- 4.11.12.7. Concreting shall then proceed continuously over the area between construction joints. Fresh concrete shall not be placed against in-situ concrete which has been in position for more than 30 minutes unless a construction joint is formed in accordance with Section 4.11.4. When in-situ concrete has been in place for 4 hours or less, as directed by the Engineer, depending upon the mix, type of cement and weather conditions, no further concrete shall be placed against it for a further 20 hours.
- 4.11.12.8. Concrete, when deposited, shall have a temperature of not less than 5°C and not more than 32°C. It shall be compacted in its final position within 30 minutes of discharge from the mixer unless carried in purpose-made agitators, operating continuously, when the time shall be with 2 hours of the introduction of cement to the mix and within 30 minutes of discharge from the agitator.
- 4.11.12.9. Except where otherwise agreed by the Engineer, concrete shall be deposited in horizontal layers to a compacted depth not exceeding 30cm.
- 4.11.12.10. Unless otherwise agreed by the Engineer, concrete shall not be dropped into place from a height exceeding 2 meters. When trunking or chutes are used they shall be kept clean and used in such a way as to avoid segregation.
- 4.11.12.11. No concrete shall be placed in flowing water.
- 4.11.12.12. The area of each concrete pour frontage shall be kept to a minimum and suitable means shall be provided to avoid premature stiffening of concrete placed in contact with hot dry surfaces. Where necessary the surfaces, including reinforcement, against which the concrete is to be placed shall be shielded from the rays of the sun and shall be sprayed with water to prevent excessive absorption by the surfaces of water from the fresh concrete.

4.11.12.13. Due to rapid stiffening in hot weather all clean-up operations such as application of resin cure membranes and dust reducers, and surface finishing, etc. shall follow closely behind final tamping.

4.11.13. COMPACTION OF CONCRETE.

4.11.13.1. All concrete shall be compacted to produce a dense homogeneous mass. Unless otherwise agreed by the Engineer, it shall be compacted with the assistance of vibrators. Sufficient vibrators in serviceable conditions shall be on site so that spare equipment is always available in the event of breakdowns. As a general guide one working vibrator shall be available for each 6 m³/hr of concrete being placed (See drawing 1981).

4.11.13.2. Vibration shall not be applied by way of the reinforcement. Where vibrators of the immersion type are used, contact with reinforcement and all inserts shall be avoided, so far as is practicable.

4.11.13.3. Concrete shall not be subjected to vibration between 4 and 24 hours after compaction.

4.11.13.4. Unless otherwise directed by the Engineer, approved power vibrators of the immersion type shall be used. They shall be inserted at such distances apart or applied in such a manner as will ensure that the concrete is satisfactorily and uniformly compacted.

4.11.13.5. Vibrators shall penetrate the full depth of the layer and where concrete is placed over previously placed concrete not more than 4 hours old the vibrators shall enter and re-vibrate that layer to ensure that successive layers are combined together.

4.11.13.6. Over-vibration, causing segregation, surface laitance or leakage through formwork shall be avoided. Immersion vibrators shall be withdrawn slowly to prevent the formation of voids. Vibrators shall not be used to work the concrete along the forms, or in such a way as to damage formwork or other parts of the structure, or displace the reinforcement or other embedded items.

4.11.13.7. Internal vibrators shall be capable of producing not less than 10,000 cycles per minute and external vibrators not less than 3,000 cycles per minute.

4.11.14. CURING.

4.11.14.1. Concrete shall be protected during the first stage of hardening from the harmful effects of sunshine, drying winds, cold, rain or running water. The protection shall be applied as soon as practicable after completion of placing by one or more of the following methods:

- (A) The concrete shall be covered by a layer of sacking, canvas, hessian, straw mats, or similar absorbent material, or layer of wet sand.

- (B) Alternatively after thorough wetting, the concrete shall be covered with a layer of approved waterproof paper or plastic membrane kept in contact with the concrete.
- (C) Except in the case of surfaces to which concrete has subsequently to be bonded, the concrete may be cured by the application of an approved coloured liquid curing membrane.

4.11.14.2. Application shall be made by low pressure spray in accordance with the manufacturer's instructions. On vertical surfaces, the curing membrane shall be applied immediately after removing the formwork.

4.11.14.3. All concrete shall be covered for at least 14 days after placing and kept continuously wet for the initial 7 days.

4.11.14.4. Concrete placed in ground containing deleterious substances shall be kept free from contact with such ground or water draining for a period of 3 days, or as instructed.

4.12. CABLE SUPPORTS

4.12.1. Each cable shall be provided with adequate supports at approximately 100 cm centres. In Manholes and Vaults joints shall be horizontal. In small exchange buildings joints shall be located vertically. A suitable rack shall support the joint.

4.12.2. Supports shall be installed so as not to hinder the installation of additional cables, allow adequate access for jointing purposes and reasonable working space for maintenance. A working space of 100 cm shall be achieved where possible.

4.12.3. It should be understood that cable vault racking (and the termination joints it supports) is one of the few items of the Outside Plant network which are visibly on display. Consequently craftsmanship of the highest standard is expected with suitable finishes being applied to the installed framework.

4.12.4. Provision for the installation of air feed pipes shall be allowed for in the construction of vault racking.

4.12.5. The cabling running from termination to equipment (ODF, Cabinets, etc.) shall be provided with adequate ladders or trays to allow a neat workmanlike installation to be achieved.

4.12.6. Cable brackets, trays and supports, shall ensure that the cables are supported so as to induce the minimum strain into the materials. Manufacturer installation recommendations shall be followed regarding handling, bending and setting radii. No sharp edges and protruding bolts etc., which may damage cable sheaths shall be permitted.

4.12.7. Earthing facilities shall be provided by the Contractor as required by the design for all cable vault installations. Earthing material shall comply with MAT 3511.

4.12.8. Anchors, bolts and similar fixing devices for concrete shall be installed as per the manufacturers instructions in a neat and workman-like fashion.

4.13. TESTING ON COMPLETED PLANT - CIVIL WORKS.

4.13.1. All new ducts shall be rodded and cleaned before testing. An approved test mandrel, shall be pulled through each new duct in the formation. If any obstruction is encountered, the duct must be cleaned again and, if necessary, repaired before it is tested again. See Drawing 1255, for the test mandrel and bore meter.

4.13.2. Bends of radius 2 m and less, which will not pass the reference mandrel, shall be proven with an approved ball mandrel.

4.13.3. At the discretion of the Engineer, a pressure test may be requested as a test of the water tightness of the completed duct work.

4.13.4. Such testing shall be limited to 50% of the installed section of ducts which are anticipated to be left empty (i.e. 2 ducts out of 3 or 4, 3 ducts out of 5 or 6 etc...). Ducts where cables are to be pulled shall be cleaned and tested prior to cable pulling. Should the chosen test location fail to hold the required pressure for the indicated time, 100% of the ducts within the same section shall be tested.

4.13.5. If the fault is found to exist in one duct only the Engineer shall have the discretion to accept the installation. If further ducts show leakage, the engineer shall instruct the Contractor to repair the affected duct ways. Upon repair, the section shall be given a 100% repeat of the pressure test.

4.13.6. Pressure testing shall consist of pressurising a duct to 25 kPa (0.25 kg/cm²), allowing the pressure to stabilise, after which the pressure shall remain within + 2 kPa (0.02 Kg/cm²) for 30 minutes.

4.13.7. The results of compressive strength testing shall be provided for all structural concrete.

4.14. SAMPLING AND TESTING

4.14.1. Sampling

- 4.14.1.1 Samples of all materials shall be submitted to the Engineer for inspection, testing and acceptance before incorporation in the Works. All materials being used will be subject to inspection, testing, or rejection at any time prior to such incorporation.
- 4.14.1.2 Where untested and unaccepted materials have been used without approval of the Engineer, such use shall be at the Contractor's risk.
- 4.14.2 Source Tests
- 4.14.2.1 All source samples shall be taken by the Contractor in the presence of the Engineer, using approved sampling procedures. All source approval tests shall be performed under the supervision of the Engineer or, when so specified, by an independent laboratory approved by the Engineer and engaged by the Contractor.
- 4.14.2.2 After approval of any source of materials, the Contractor shall produce from such source only to the extent that materials produced are of substantially the same quality as the approved samples.
- 4.14.2.3 The Engineer will periodically order retesting of previously approved sources to verify that they continue to conform to the Specifications and may order retesting at the same or at a different laboratory from the one performing the original source approval tests. If retesting indicates that a previously approved source no longer conforms with the Specifications, the Contractor shall forthwith cease production from such source.
- 4.14.3 Job Control Tests
- 4.14.3.1 Job control tests shall be performed by the Contractor prior to submitting any materials to the Engineer for approval. The Contractor shall submit details to the Engineer of his job control testing program.
- 4.14.3.2 The Engineer may declare the Contractor's job control testing program unacceptable if frequent rejections of submitted materials occur when subjected to the Project Control Tests.
- 4.14.4 Project Control Tests
- 4.14.4.1 All Project Control samples shall be taken jointly by the Engineer and the Contractor. Tests shall be performed in the Site Laboratory, or in situ as appropriate, under the supervision of the Engineer.
- 4.14.4.2 The Engineer may order retesting of any material if there has been a significant delay in the construction operations or if he determines that the material has deteriorated since its original acceptance. Material which does not conform with the Specifications will be rejected and shall be removed from the Works

and replaced or corrected by the Contractor. The Engineer may order additional testing to ascertain the extent of unacceptable material.

4.14.5. Check Tests

4.14.5.1. The Engineer may periodically order check tests to verify the accuracy of Project Control testing and equipment. The Engineer may direct that check tests be performed by qualified persons other than those normally responsible for Project Control testing, or he may direct that the samples be sent to an approved independent laboratory for testing.

4.14.5.2. The Contractor shall provide the Engineer with all necessary Test Report forms and expendable materials required to perform all required tests. Copies of all test results will be issued to the Contractor.

4.14.6 Standards

4.14.6.1. AASHTO Standard Specifications for Transportation Materials and Methods of Sampling and Testing (Part I: Specifications, and Part II: Tests).

4.14.6.2. ASTM Standards for Testing and Materials.

4.14.6.3. British Standards referred to in the Specification

4.14.6.4 Other relevant Standards referred to in the Specifications.

4.14.7. Precedence of Materials and Testing Specifications

4.14.7.1. All references to methods of testing or specifications of AASHTO, ASTM and others will be deemed to refer to the latest methods of testing as specified in the Contract Documents.

4.14.7.2. Unless otherwise specified AASHTO methods of sampling and testing shall be adopted where available. In the case of absence of an appropriate AASHTO specification, the ASTM or BS specification shall govern.

4.14.8. UNACCEPTABLE MATERIALS

4.14.8.1. All materials not conforming to the requirements of the Specifications at the time they are used will be rejected and shall be removed immediately from the Site unless otherwise instructed by the Engineer.

4.14.8.2. No rejected material, the defects of which have been corrected, shall be used until approval has been given.

4.14.9. MEASUREMENT

Unless shown as Pay Items in the Bill of Quantities, all sampling, testing, and retesting, material sources, quality requirements, certificates' inspections, storage and handling requirements, and all other Works prescribed in this Section shall not be measured for direct payment, but shall be considered as subsidiary Works the costs of which will be deemed to be included in the Contract prices for Pay Items.

4.15. INSTALLATION EXAMPLES

Refer to attached drawings of miscellaneous examples of various installation techniques to be strictly followed under the conditions stated therein:

<u>Dwg. No.</u>	<u>Title</u>
L9630/1251	STANDARD CONDUIT CONFIGURATIONS AND DIMENSIONS
L9630/1253	STANDARD CONDUIT CONFIGURATIONS AND DIMENSIONS
L9630/1255	TEST MANDRELS-DUCT WORK
L9630/1260	DIRECT BURIED CABLE INSTALLATION DETAILS
L9630/1265	ILLUSTRATION OF EROSION DAM
L9630/1270	ILLUSTRATION OF CABINET PROTECTION POST
L9630/1901	REINSTATEMENT CLASS A ROAD
L9630/1902	REINSTATEMENT CLASS A ROAD
L9630/1903	REINSTATEMENT CLASS A ROAD
L9630/1904	REINSTATEMENT CLASS A ROAD
L9630/1905	REINSTATEMENT CLASS A ROAD
L9630/1906	REINSTATEMENT CLASS A ROAD
L9630/1907	REINSTATEMENT CLASS A ROAD
L9630/1908	REINSTATEMENT CLASS A ROAD
L9630/1909	REINSTATEMENT CLASS A ROAD
L9630/1910	REINSTATEMENT CLASS A ROAD
L9630/1911	REINSTATEMENT CLASS B ROAD
L9630/1912	REINSTATEMENT CLASS B ROAD
L9630/1913	REINSTATEMENT CLASS B ROAD
L9630/1914	REINSTATEMENT CLASS B ROAD
L9630/1915	REINSTATEMENT CLASS B ROAD
L9630/1916	REINSTATEMENT CLASS B ROAD
L9630/1917	REINSTATEMENT CLASS B ROAD
L9630/1918	REINSTATEMENT CLASS B ROAD
L9630/1919	REINSTATEMENT CLASS B ROAD
<u>Dwg. No.</u>	<u>Title</u>

L9630/1920	REINSTATEMENT CLASS B ROAD
L9630/1921	REINSTATEMENT CLASS C ROAD
L9630/1922	REINSTATEMENT CLASS C ROAD
L9630/1923	REINSTATEMENT CLASS C ROAD
L9630/1924	REINSTATEMENT CLASS C ROAD
L9630/1925	REINSTATEMENT CLASS C ROAD
L9630/1926	REINSTATEMENT CLASS C ROAD
L9630/1927	REINSTATEMENT CLASS C ROAD
L9630/1928	REINSTATEMENT CLASS C ROAD
L9630/1929	REINSTATEMENT CLASS C ROAD
L9630/1930	CABINET BASE CONNECTED WITH 100 MM PVC-BEND
L9630/1931	REINSTATEMENT CLASS C ROAD
L9630/1932	CABINET BASE, ELEVATION
L9630/1933	STANDARD LOCATION WITH AND WITHOUT HANDHOLE
L9630/1935	REINSTATEMENT CLASS C ROAD
L9630/1936	REINSTATEMENT CLASS C ROAD
L9630/1951	DUCT DEVIATIONS
L9630/1953	DUCT DEVIATIONS
L9630/1957	DUCT DEVIATIONS
L9630/1963	DUCT PLUG
L9630/1965	DUCT DEVIATIONS
L9630/1967	DUCT LAYING
L9630/1969	DUCT CONFIGURATION
L9630/1981	VIBRATING
L9630/1983	EXAMPLE OF FORMWORK
L9630/1985	MANHOLE BED
L9630/1999	EXAMPLES OF DUCT SPACER

4.16. MANHOLE / HANDHOLES / CABINET BASE DIMENSIONS AND REINFORCEMENT

Refer to attached Drawings for the dimensions and reinforcement for the main underground structures.

<u>Dwg. No.</u>	<u>Title</u>
L9630/1601	MANHOLE TYPE "A" PRECAST CONCRETE
L9630/1602	MANHOLE TYPE "A" PRECAST CONCRETE
L9630/1605	MANHOLE TYPE "A" CAST IN SITU
L9630/1640	HANDHOLES NO. 1C, DIMENSIONS & REINFORCEMENT
L9630/1645	HANDHOLES NO. 2C, DIMENSIONS & REINFORCEMENT
L9630/1650	HANDHOLES NO. 3C, DIMENSIONS & REINFORCEMENT

HANDHOLES HHAF & HHBF

7. CABLE INSTALLATION

TABLE OF CONTENTS

7. CABLE INSTALLATION

7.1. GENERAL

7.2. DIRECT BURIED CABLES

7.3. CABLE IN DUCT

7.4. AERIAL CABLE

7.5. INTERNAL CABLING

7.6. JOINTING AND TERMINATING OF OPTICAL FIBER CABLE

7.7. DRAWINGS

7. CABLE INSTALLATION

7.1. GENERAL

- 7.1.1. Cable drums shall be rolled in the direction from the exchange/cabinet. Exceptions due to high cable pulling tensions may be allowed provided that the MoT and the Engineer are consulted prior to execution and their approval is obtained. All marking, as required, in manholes/handholes and red line drawings, should then indicate this exceptional cable pulling direction. Cable drums shall be handled only with equipment specifically designed for the purpose (cable trailer, drum jacks, lifting strops and axles etc.). If forklifts are used for lifting of the drums the forks shall be long enough to support both flanges of the drums.
- 7.1.2. Cable shall not be pulled along the ground, and operations shall only commence after the Engineer is satisfied that adequate facilities are available on the site to allow correct installation methods to be followed (roller, winches, tension gauges, lubricants, man power etc.).
- 7.1.3. During installation the cable shall be carefully inspected. Each case of damaged cable discovered before or during installation or by tests or observations after installation shall immediately be brought to the attention of the Engineer. The damaged cable section shall be repaired or replaced promptly. Cable found faulty after being installed shall be replaced by new undamaged cable, and the full cost shall be borne by the Contractor.
- 7.1.4. Cable cores shall be protected at all times. When the cable sheath is opened, the cable core shall be protected to prevent the ingress of moisture and deleterious material. If jointing or other work has to be interrupted, the cable core shall be effectively sealed by an approved method.
- 7.1.5. At all times adequate measures shall be taken to protect existing plant from damage.
- 7.1.6. Plant identification shall be provided by marking plates and tags to be installed as indicated by these standards. Reference should be made to the Engineer for any additional information on designations, which may be required due to on-site alterations to those provided by the design Drawings. Refer to Section 9 for more marking information.

7.2. DIRECT BURIED CABLES.

Not use.

7.3. CABLE IN DUCT

- 7.3.1. All ducts (existing or new) shall be cleaned and mandrel tested before cables are installed. Duct entries should also be prepared.
- 7.3.1.1. Any potentially damaging situations determined during the mandrel operations shall be examined before proceeding with any installation.
- 7.3.2. Cables shall always be allocated so as not to obstruct future placing of other cables, i.e. placing shall always start at the bottom row of the duct assembly, placing the cables row after row, unless otherwise specified by the Engineer.
- 7.3.3. Two or more optical fiber cables may be pulled into the same sub duct provided that the cables are pulled simultaneously (in one haul) and combined cable diameters do not exceed 90% of the duct diameter and the length of the cable section will allow easy placing. An adequate swivel attachment shall be used in order to prevent twisting of the cables. Future possible requirements of the need to remove the cable shall also be considered.
- 7.3.4. Ducts allocated to junction cables shall normally not have any other cable type installed in them.
- 7.3.5. Cables being pulled into duct shall be lubricated with an approved lubricant as required. Suitable Precautions must be taken to ensure the maximum allowed pulling force, according to the cable supplier's directions, is not exceeded.
- 7.3.6. Cables shall be "set" in manholes in such a manner that they do not block vacant ducts or restrict the working space. Suitable cable bearers according to MAT 2021 shall be installed and the cable shall be secured to the bearers.
- 7.3.6.1. The bending radii of the cable shall be kept as large as possible, and under no circumstances be less than that specified either by MAT Specification or by the manufacturer.
- 7.3.6.2. The cable shall not be flattened, kinked nor frequently re-bent about the same point.
- 7.3.6.3. Prior to commencing the "set" of a cable, the sealed end shall be opened, to permit the conductors to move freely, during the operations.
- 7.3.6.4. Should the jointing of the cable not be a follow on procedure, the cable shall be re-capped after its installation, paper insulated and 'dry' plastic insulated cable shall be re-pressurised if the delay is to exceed 36 hours.

- 7.3.7. When the cable has been secured in the manhole the duct shall be sealed with a suitable compound which will allow the removal of the cable at a future date. Creepage of the cable after installation shall be prevented.
- 7.3.8. In every manhole each cable shall be labeled with a metal tag on which cable data, (Size, Type and Cable Number) shall be indelibly inscribed. As detailed in Section 9.
- 7.3.8.1 Cables shall also be supplied with a marker tag on each side of a joint.
- 7.3.9. Cable shall be suitably protected between time of placing and jointing. Sufficient time after placing shall be permitted, to allow for sheath retraction.
- 7.3.10. At the discretion of the Engineer, and as indicated by the site conditions "Cable Protection" may be installed over vulnerable cables (e.g. where significantly exposed under a manhole frame and cover).

7.4. AERIAL CABLE No Need

7.5. INTERNAL CABLING

- 7.5.1. Indoor cables may be installed in ducts, on raceways or attached directly to walls. Before surface mounted trunking or raceways are used type approval must be obtained from the Engineer.
- 7.5.2. Where possible, ducts and other installations into which cable can be conveniently installed shall be chosen.
- 7.5.3. Cables in vertical shafts shall be secured according to the manufacturer's recommendations and at not more than 200 cm intervals.
- 7.5.4. All necessary precautions must be observed when pulling cables through conduits to ensure damage to the cables or conduit does not occur.
- 7.5.5. Holes required for cables or attaching devices shall be made with the minimum possible damage to the wall surface. Any damage or disfigurement shall be restored.
- 7.5.6. Where practical, cables which are surface mounted shall be run in straight lines vertically and/or horizontally, and placed as inconspicuously as possible.
- 7.5.7. Where external cables enter a building for transition to indoor cable, the maximum indoor length of the polyethylene sheathed cable shall be 20 m if not protected by a flame retarding material i.e., sleeve or duct.

- 7.5.8. Suitably aesthetically pleasing channeling or ducting shall be used to protect and mask the indoor installations.
- 7.5.9. Where the running of large numbers of indoor cables occurs, particular care shall be taken to ensure that a neat workmanlike and logical cabling system is the result. The Engineer shall advise as necessary.
- 7.5.10. Holes made for the vertical passage of cable through a building (e.g. ODF access) shall be sealed with fire retarding materials, in accordance with the prevailing building specifications.
- 7.5.11. As required by site conditions, fire protective sealing shall also be applied to horizontal cable access holes, as indicated by the Engineer (e.g. Generator rooms).

7.6. JOINTING AND TERMINATING OF OPTICAL FIBER CABLE

7.6.1. GENERAL

- 7.6.1.1. Before splicing optical fiber of cable shall commence, the Engineer should be assured that all materials, tools, test equipment and provisions for emergency closure of the joint, are available at the location.
- 7.6.1.2. Manufacturer's recommendations regarding the use of material and cable preparation shall be followed.
- 7.6.1.3. Care shall be taken that the work is protected against the entry of deleterious substances.
- 7.6.1.4. Jointing errors: All errors in the jointing of cable pairs, determined by the commissioning tests, shall be corrected to achieve the standards laid down in Section 10.
- 7.6.1.5. The location of the joints, if not specified by the design, shall consider the requirements of future cable placement or reinforcement, access for maintenance etc.
- 7.6.1.6. Under normal conditions, a maximum of 6 cables may converge on one joint enclosure. The maximum configuration may therefore be:

3+3

Economic and engineering considerations may outweigh the general guideline.

7.6.1.7. "Termination" type joints may have more than 4 cables entering a joint e.g.

- Termination joint in a cable vault
- "Looped" DP
- Cabinet stub cables (if required).

7.6.1.8. Enclosures shall be applied according to the manufacturers directions, so as to achieve an air and water tight environment within the joint.

7.6.1.9. Materials shall comply with MAT 4101 and MAT 4111.

7.6.1.10. Joint enclosures shall only be utilised with the cable type for which they are designed.

7.6.2. INSTALLATION JOINT ENCLOSURES IN MANHOLES.

7.6.2.1. The location of a joint enclosure in a manhole will be controlled by the position of the entering and exiting cables, and the number and location of jointing "bays".

Where more than one bay is available the joints enclosures shall alternate between the bays, and also vertically.

In order to facilitate future cable re-arrangements "branch" cables joining a "main" cable shall be looped at least in the manhole, before entering the joint. Loops, subject to the Engineer's approval, shall be left at jointing positions for all optical fiber cables.

7.6.2.2. Cables shall not cross over a duct face.

Branch cables which must cross from one side of the manhole to the other, shall be led preferably above the duct faces, or if necessary, below (for the bottom cables).

7.6.2.3. At the discretion of the Engineer, according to very special site conditions, "Joint Protection" may be installed over vulnerable joint enclosures, or over cables of particular importance.

7.6.4. CABLE TERMINATIONS

7.6.4.1. The location of all cable terminations shall be specified by the Engineer. Should the design require modification on-site the Engineer's approval shall be obtained.

7.6.4.2. Screens and armoring shall be made available for all termination points.

- 7.6.4.3. Within ODF, the termination locations shall be according to the Engineer's drawing with modification only made after consultation with the Engineer. The joint shall be secured in a neat and professional fashion to the racking system provided. No strain shall be transmitted to the cable once the joint is secured.

5470 SPECIALISED TESTS ON OPTICAL FIBRE CABLES.

The work units in this group shall be inclusive of:

Making available as necessary, of test sets of approved performance and the skilled labour to operate them.

5471 OPTICAL TIME DOMAIN REFLECTOMETER (OTDR) TESTS.

The work unit shall include:

Set up, perform and record OTDR. Tests on one optical fibre from an existing termination to any other point as specified. Test may be used as a fault location.

5472 ADDITIONAL OPTICAL TIME DOMAIN REFLECTOMETER (OTDR) TESTS

From the same set up as PU. # 5471 performs tests on additional fibres as required.

5473 OPTICAL ATTENUATION TESTS.

The work unit shall include:

Set up, perform and record optical attenuation measurements on one fibre from an existing termination to any other point as specified.

5474 ADDITIONAL OPTICAL ATTENUATION TESTS.

From the same set up as PU. # 5473 performs tests on additional fibres as required.