2017

Technical Standards Guide for Provision of Communication Services in High Rise Buildings

TRCSL

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CONTENTS

LIST OF TABLES 2

LIST OF FIGURES 3

ABBREVIATIONS 4

1 INTRODUCTION 5

2 COMMON INFRASTRUCTURE REQUIREMENT 6

2.1 Typical Architecture 6

2.2 Common Operator Equipment Room 8

2.3 Building Entry Duct Requirement 9

2.4 Horizontal cable tray 10

2.5 Telecommunication service riser 11

2.6 Fiber cable and patch panel requirements 12

3 SPECIFICATION FOR FIXED BROADBAND COVERAGE IN HIGH RISE BUILDINGS 15

3.1 Infrastructure requirement inside Apartments 17

4 SPECIFICATION FOR MOBILE COMMUNICATION INFRASTRUCTURE IN HIGH RISE BUILDINGS 18

4.1 Connectivity for radio units/antennas in common areas 18

4.2 Connectivity for radio units inside Apartments 19

ANNEXURE A: TECHNICAL SPECIFICATIONS 21

1 Fiber Cable Selection 21

1.1 Fiber Cable Density 21

2 Technical specification for Micro Ducts 25

ANNEXURE B: TESTING PROCEDURE 27

1 Final Testing Standards and Methodologies 27

1.1 Proper Testing Standard for Micro Duct 27

1.2 Proper Testing Standard for Fiber Cable 27

1.3 Proper testing standard for UTP cable 28

LIST OF TABLES

Table 2-1 Space Requirement 9
Table 2-2 Air conditioner capacity 9
Table 2-3 Cable tray specifications 10
Table 2-4 Riser and cable tray dimensions 11
Table 2-5 Patch Panel Requirement 12
Table 2-6 Patch Panel Requirement 13
Table 2-7 Patch panel specifications 13
Table 2-8 Micro Duct Requirement 14
Table 4-1 Remote equipment space requirement 19
Table A1-1 Fiber core requirement for indoor installation 22
Table A2-1 Micro duct recommendation for fiber laying 25
Table A2-2 Proposed micro duct specification 26
Table B1-1 Proposed UAT document for Micro Duct Laying 27
Table B1-2 Proposed UAT document for Fiber cable 28
Table B1-3 Proposed UAT document for UTP Cable 29

LIST OF FIGURES

Figure 2-1 Key infrastructure elements 6
Figure 2-2 Common telecom equipment room and building entry point 10
Figure 2-3 Horizontal cable tray 11
Figure 2-4 Telecommunication riser 11
Figure 2-5 Common telecom equipment room and building entry point 13
Figure 2-6 Floor distributor in the vertical riser in each floor 14
Figure 3-1 Propose architecture for Greenfield Fiber solution 16
Figure 3-2 : Proposed cabling in the apartment 17
Figure 4-1 Example Radio units/antenna placement in a typical floor 18
Figure 4-2 Proposed cabling in common residential area 19
Figure 4-3 : Proposed cabling in the apartment for radio unit 20
Figure 4-4 Horizontal cable tray and termination points for passive DAS 20
Figure A1-1 Maximum bending Radius of candidate fibers 21
Figure A1-2 Fiber 2 core cable specification 22
Figure A1-3 Fiber 8 core cable specification 23
Figure A2-1 Details of Micro duct 26

ABBREVIATIONS

AC	Alternating Current
AP	Access Point
BEP	Building Entry Point
BFPP	Building Fiber Patch Panel
BMDF	Building Main Distribution Frame
BTU	British Thermal Units
CAT6	Category 6
COER	Common Operator Equipment Room
CPE	Customer Premises Equipment
DAS	Distributed Antenna System
FD	Floor Distributor
FTTH	Fiber to the Home
GF	Ground Floor
GPON	Gigabit-capable Passive Optical Network
IBS	In-Building Solution
IEC	International Electro-technical Commission
IPTV	Internet Protocol Television
LSZH	Low Smoke Zero Halogen
OFPP	Operator Fiber Path Panel
OLT	Optical Line Terminal
OMDF	Operator Main Distribution Frame
ONT	Optical Network Terminal
OTO	Optical Telecommunication Outlet
PON	Passive Optical Network
RF	Radio Frequency
STB	Set Top Box
UAT	User Acceptance Test
UE	User Equipment
UPS	Uninterrupted Power Supply
UTP	Unshielded Twisted Pair

1 INTRODUCTION

In the modern world, people seek convenience. In today's hyper-connected world, ubiquitous connectivity is as critical as electricity and water. Developers of High Rise Building Properties usually miss out on prime obligation which is a prime right of the tenants. Authorities are highly concerned about this scenario which has created a negative perception in both foreign and local investors, hampering business growth of the country.

Increased demand by the tenants for continuous coverage, generation of traffic by indoor activities, poor indoor coverage by outside tower sites due to the building structure; whether it is high-rise, basement or even the lift, less signal penetration as a result of the building material and the surrounding buildings

This document details out the specifications for keeping provisions for Fixed and mobile communication related infrastructure that should be developed when constructing high rise buildings. The specifications shall be subjected to the approval of relevant authorities including TRCSL. Actual equipment and design will depend on the structure of the building; however, it is mandatory to liaise with a Mobile and Fixed Operators at the design stage to fulfill the obligations depicted in this document.

For existing buildings, mutually agreeable solutions may be implemented by licensed operators and High-Rise Building management corporations of respective buildings as appropriate, based on the specifications provided in this document.

The developer shall invite all licensed Mobile and fixed Operators at the design stage and assign a duly licensed operator or a certified contractor for passive telecommunication infrastructure building and maintenance of the laid fiber cables. Certification shall be introduced for these specific purposes with the relevant authorities.

If any specific in-building solution to be intended other than the standard infrastructure specified herein, the licensed operators shall furnish necessary infrastructure requirements to the developer formally, which shall be subjected to the approval of the Relevant Authority

Relevant Authority shall establish a technical conformity panel, comprising with professionals through TRCSL.

Developer should provide the infrastructure design to licensed operators who are interested in providing services. Duly licensed operators should be permitted in non-discriminatory manner to provide services to the end customers.

For any Technical clarifications required by the High-Rise Building Developer shall be obtained with the consultation of TRCSL.

2 COMMON INFRASTRUCTURE REQUIREMENT

2.1 Typical Architecture

The following diagram (Figure 2-1) depicts the key elements that are required for providing fixed and mobile services in a High-Rise Building.

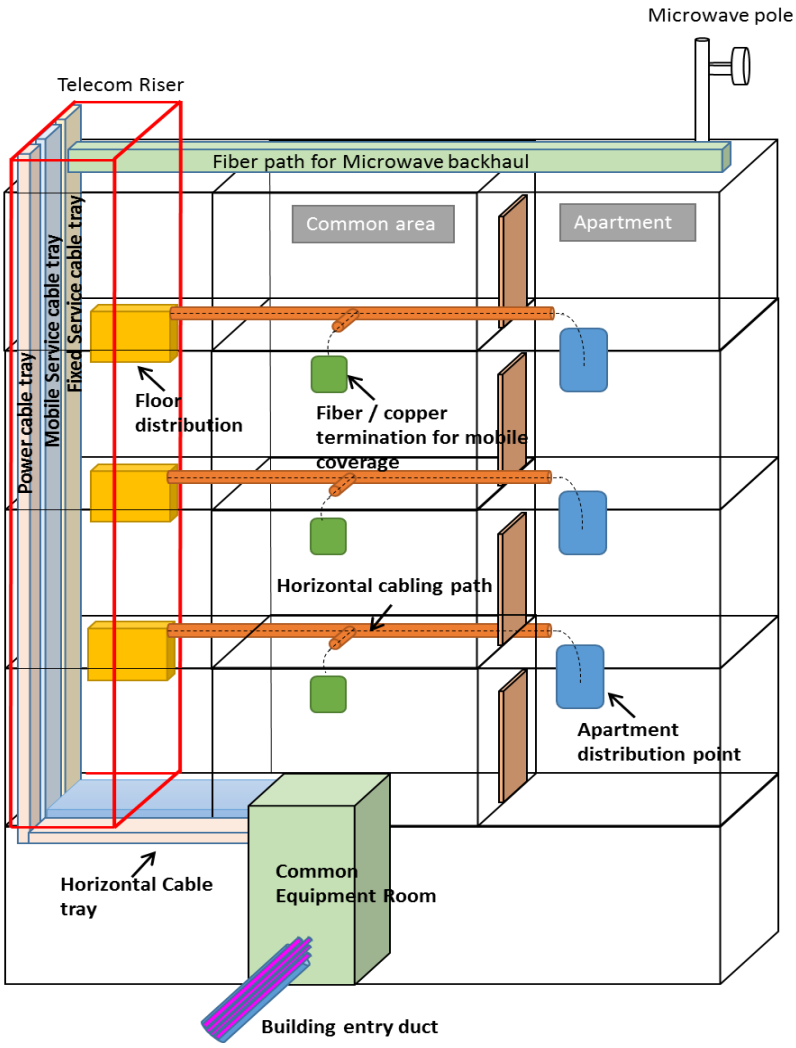
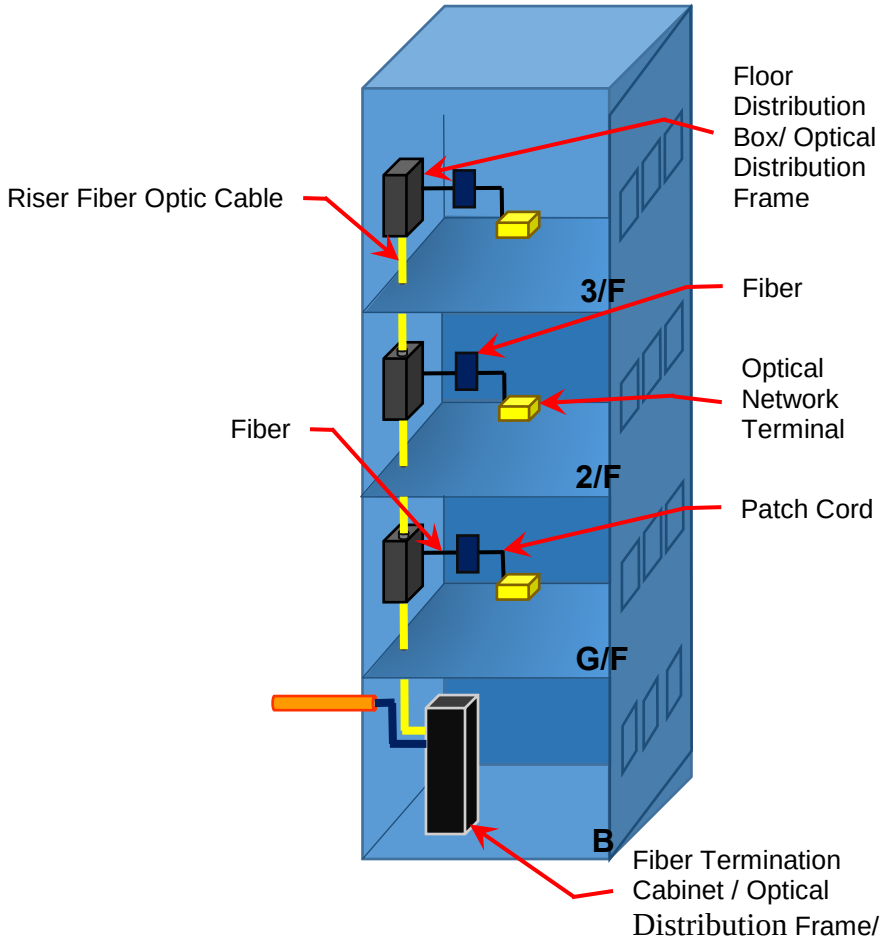


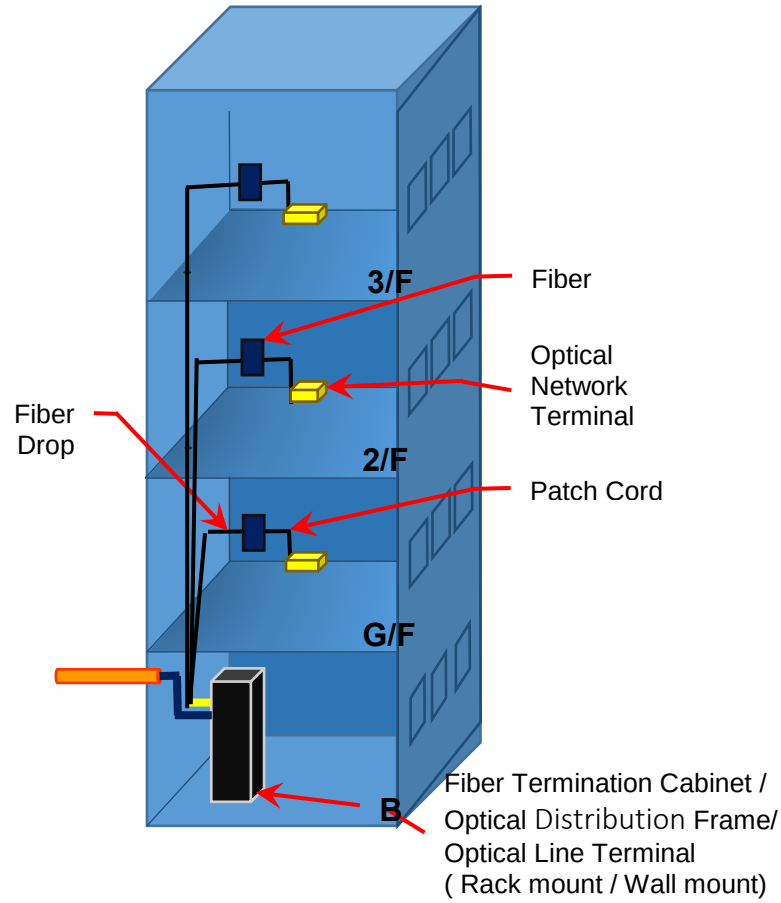
Figure 2-1 Key infrastructure elements

Below types of specific architecture proposed for Fiber solution installation in buildings, suitable architecture will be selected based on the green building or brown building, no of customers and other regulations.

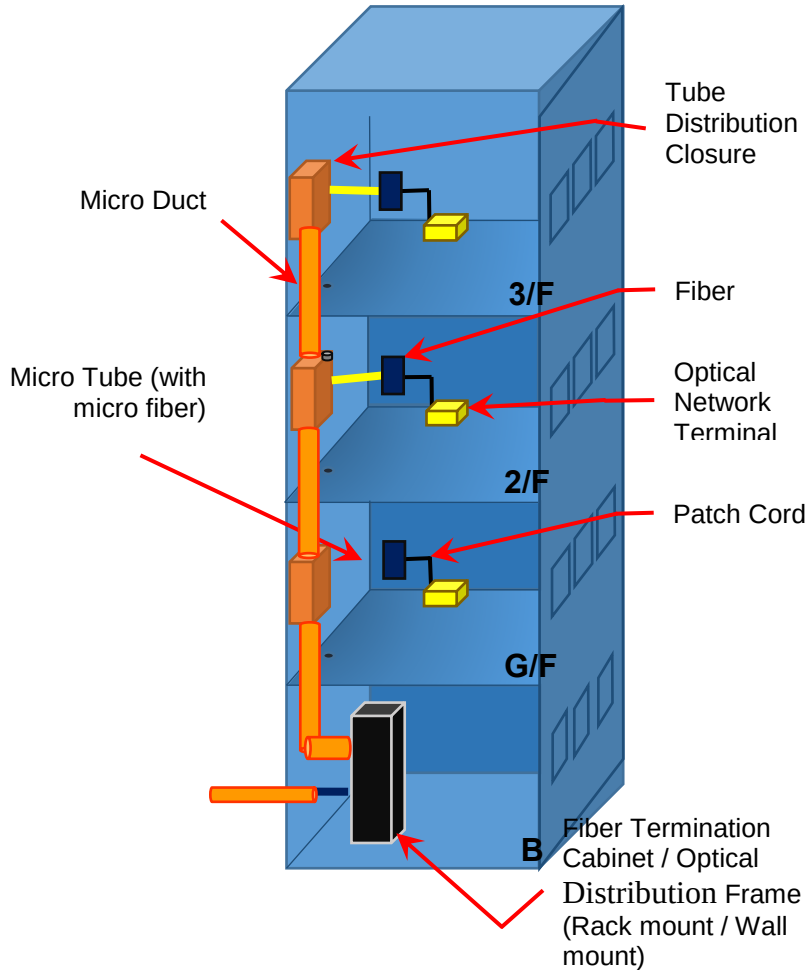
2.1.1 Multi Core Architecture (MCA) for Conventional Deployment Method



2.1.2 Direct Core Architecture (DCA) for Conventional Deployment Method



2.1.3 Direct Core Architecture (DCA) for Air blown method



2.2 Common Operator Equipment Room

1. High Rise Building Developers should reserve a separate and exclusive space for a **Common Operator Equipment Room (COER)** for telecommunication services ideally at the ground or basement floor of the building. This will be shared among both fixed and mobile operators

2. The recommended **space** is stipulated in table 2.1 below and varies based on the number of floors in the building. A minimum height of 3000 mm is required.

Table 2-1 Space Requirement

No. of Floors	Required minimum equipment room size
1-20	3000mm x 3000mm
21 - 40	3000mm x 4500mm
41 -80	4500mm x 4500mm
81 - 120	4500mm x 6000mm

3. The Common room should be equipped with 230VAC 3 Phase power with a backup power supply. Electrical wiring within the common equipment room should include a **minimum of 3 Type-G 13A (square pin) Power sockets per operator with 16A breakers**.

4. The common telecom equipment room should maintain a temperature between 18-27°C (64-80°F) with a humidity level between 40%-60%, since a stable temperature and humidity level is critical for reliability in a communication system. The required Air conditioner capacity is as depicted in table 2.2 below

Table 2-2 Air conditioner capacity

No. of Floors	Required minimum equipment room size	Air Conditioner capacity
1-20	3000mm x 3000mm	36000 BTU
21 - 40	3000mm x 4500mm	48000 BTU
41 -80	4500mm x 4500mm	60000 BTU
81 - 120	4500mm x 6000mm	72000 BTU

5. The Initial cooling capacity given above is for 3 operators and should have a provision for expanding the capacity with the addition of new operators.

2.3 Building Entry Duct Requirement

1. A Building entry duct should be provided by High Rise Building developers connecting the Common operator equipment room to a man hole adjacent to an access roadway for operators to develop backhaul cable infrastructure. Figure 2.2 provides a sample drawing on proposed duct path. Developers manhole shall be kept inside the premises and adjacent to a main access road and operators shall lay their own ducts to this manhole

2. The building entry duct should have a minimum of 4 micro ducts / two 50mm or 100mm rigid PVC pipe as per the case to accommodate more than two operators

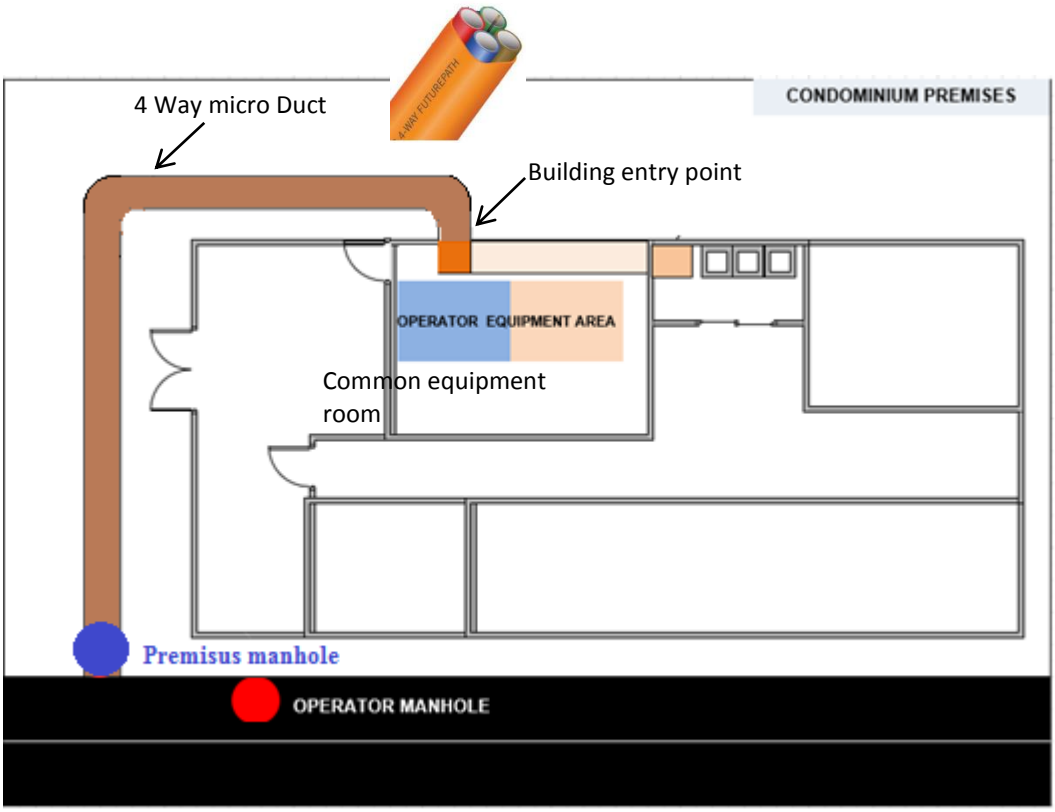


Figure 2-2 Common telecom equipment room and building entry point

2.4 Horizontal Cable Tray

1. The High Rise Building developer should provide a horizontal cable tray between the common equipment room and telecommunication service riser. This is shared with both fixed and mobile telecommunication services.

2. The cable tray should adhere to below standards and should have a minimum width of 600mm to accommodate all service provider requirements

Table 2-3 Cable tray specifications

Item	Specification
Material	Powder coated Zinc Aluminum
Thickness	2mm

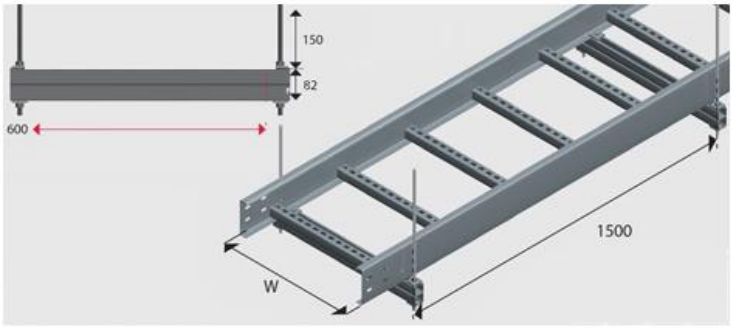


Figure 2-3 Horizontal cable tray

2.5 Telecommunication Service Riser

1. A telecommunication riser connects the common operator equipment room with each floor

2. Three separate cable trays should be made available inside the riser as depicted in figure 2-4 below to accommodate fixed and mobile telecommunication requirements

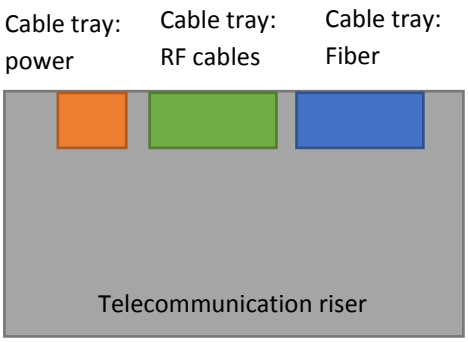


Figure 2-4 Telecommunication riser

3. Minimum dimensions of the telecommunication riser should be as given below

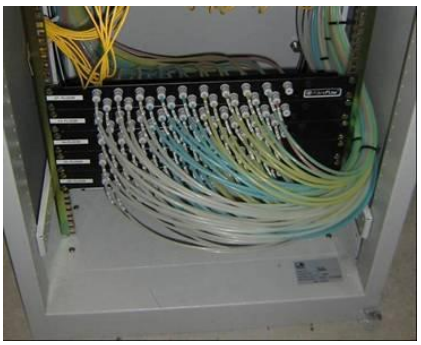
Table 2-4 Riser and cable tray dimensions

No of floors	Minimum Riser dimensions	Cable tray dimensions		
		Fiber cables	RF cables	Power cables
1 - 40	600mm x 600mm	200mm	150mm	100mm
40 - 80	750mm x 600mm	400mm	200mm	150mm
80 - 120	1100mm x 600mm	600mm	250mm	200mm

2.6 Fiber cable and patch panel requirements

1. The High Rise Building developer should provide a fiber patch panel in the Common equipment room to terminate fibers from each apartment unit. The patch panel should facilitate a minimum number of fiber cores per floor as depicted in table 2-5 and 2-6 below. It is recommended to use ***FC connectors or SC connectors*** for the patch panel and to use 144/288 port patch panel(s) considering the current trend of increasing demand in high rising buildings

2. In case of Micro Ducting a Microduct Management panel to be installed based on the number of Micro Tubes.



3. The total port requirement of the patch panel(s) can be derived from below equation, assuming that total no. of apartment in each floor is less than 6.
    a. No. of ports in the patch panel = 8 * No. of Floors
    b. Table 2-5 summarize the No. of patch panel requirement proposed base on total no. of floors

Table 2-5 Patch Panel Requirement

No. of Floors	Patch panel Requirement
1-16	144 port FC/SC Patch Panel
17-32	288 port FC/SC Patch Panel
33-64	2 Nos. of 288 port FC/SC Patch Panel
65-96	3 Nos. of 288 port FC/SC Patch Panel
97-128	4 Nos. of 288 port FC/SC Patch Panel

4. The total port requirement of the patch panel(s) can be derived from below equation, assuming that total no. of apartment in each floor is between 6 and 10.
    a. No. of ports in the patch panel = 12 * No. of Floors
    b. Table 2-6 summarize the No. of patch panel requirement proposed base on total no. of floors

Table 2-6 Patch Panel Requirement

No. of Floors	Patch panel Requirement
1-12	144 port FC/SC Patch Panel
13-24	288 port FC/SC Patch Panel
25-48	2 Nos. of 288 port FC/SC Patch Panel
49 -71	3 Nos. of 288 port FC/SC Patch Panel
72 - 96	4 Nos. of 288 port FC/SC Patch Panel
97 - 120	5 Nos. of 288 port FC/SC Patch Panel

5. Designed The total port requirement of patch panel for the number of apartments per floor greater than 10 , can be designed in consultation with licensed operators.

6. The Fiber patch panel should be labeled as per figure 2-5 below. In order to simplify the diagram only the first row labeling is demonstrated in a 144 port patch panel.

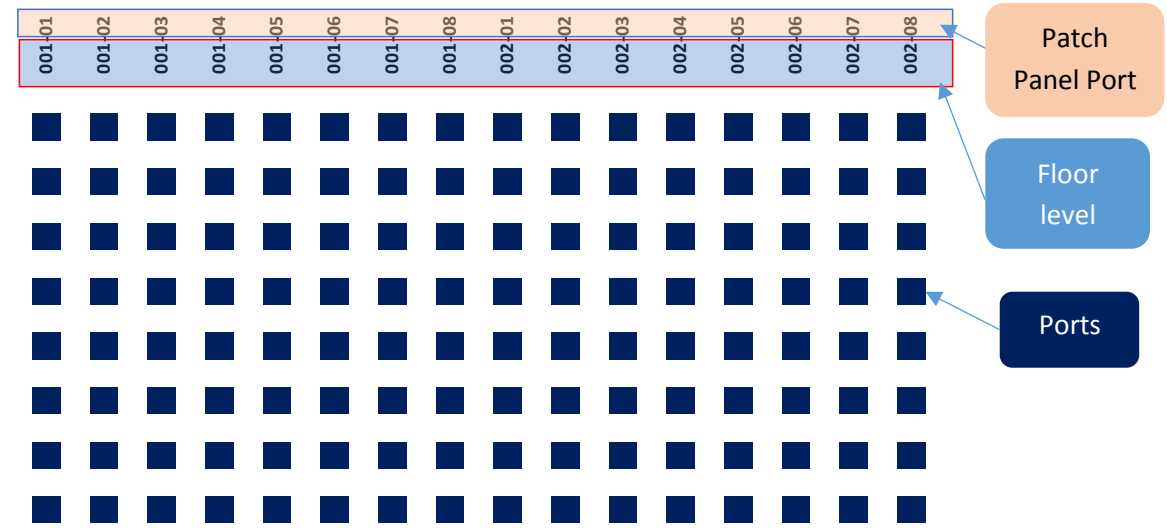


Figure 2-5 Common telecom equipment room and building entry point

7. A floor Distribution Box should be mounted in the vertical riser in each floor. It should be equipped with 2 numbers of FC fiber patch panels as detailed in table 2-7 below.

Table 2-7 Patch panel specifications

No of apartments per floor	Patch panel type
Less than 6	8 port FC/SC patch panel
From 6 to 10	12 port FC/SC patch panel
More than 10	Case by Case Specification

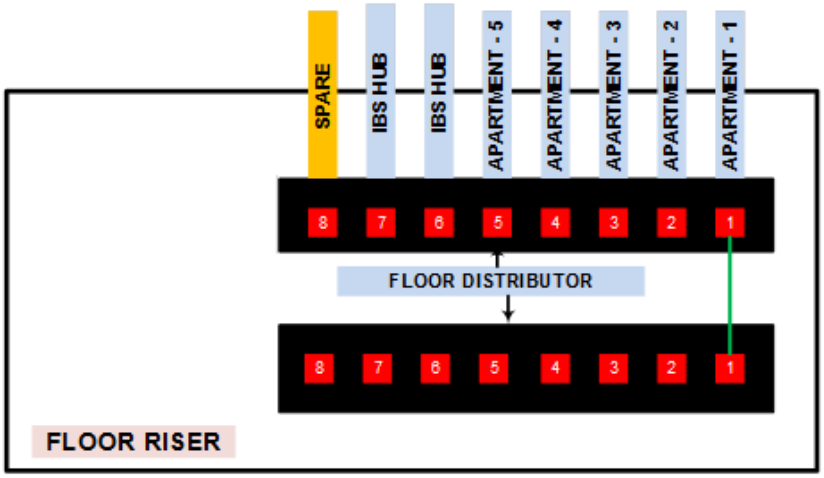


Figure 2-6 Floor distributor in the vertical riser in each floor

8. A 24+1 way micro ducts should be provided in case using the blown fiber by the developer and should be laid in the fiber cable tray connecting the fiber patch panels in the equipment room with floor distribution patch panels.

9. Each sub duct in the micro duct will be used to blow an 8 core micro fiber cable which will be terminated in each floor. One micro duct can serve up to 20 floors. Remaining 5 sub ducts are reserved for future expansion. Table 2-8 depicts micro duct requirement based on the number of floors in the High Rise Building.

Table 2-8 Micro Duct Requirement

No. of Floors	24+1 Way Micro Duct Requirement
1-20	1 micro duct from GF to 19F
21-40	1 micro duct from GF to 19F + 1 micro Duct from GF to 39F
41-60	1 micro duct from GF to 19F + 1 Micro Duct from GF to 39F + 1 Micro Duct from GF to 59F
61-80	1 micro duct from GF to 19F + 1 micro duct from GF to 39F + 1 micro duct from GF to 59F + 1 micro duct from GF to 79F
81-100	1 micro duct from GF to 19F + 1 micro duct from GF to 39F + 1 micro duct from GF to 59F + 1 micro duct from GF to 79F + 1 micro duct from GF to 99F
101-120	1 micro duct from GF to 19F + 1 micro duct from GF to 39F + 1 micro duct from GF to 59F + 1 micro duct from GF to 79F + 1 micro duct from GF to 99F + 1 micro duct from GF to 119F

The maintenance of the in building Fiber Network would be assigned to a licensed operator or a certified contractor on fiber and duct types to be used.

3 SPECIFICATION FOR FIXED BROADBAND COVERAGE IN HIGH RISE BUILDINGS

In order to cater the rapid bandwidth growth due to new application, it is recommended to lay fiber cable up to each apartment. Figure 3-1 provides the detailed architecture of proposed fiber solution aligned to the above high-level plan. Key points of the solution are as given below.

1. High Rise Building developer has to build a micro-duct/ two 50mm or 100mm rigid PVC pipe as per the case path from common room to building entry point outside the perimeter of the building. The micro-duct should contain at least four sub-ducts.
2. COER (Common Operator Equipment Room) will be the meet up location between operators and High-Rise Building developers. Further each operator should be responsible for drawing fiber cable from their closest Fiber point to the COER.
3. It is recommended High Rise Building developer to provide two duct paths to two different outer perimeter locations of the property from the common equipment room to provide redundancy.
4. Operators Should connect & deliver point-to-point Ethernet or PON (Passive Optical Network) technology to provide connections to high rise buildings using Equipment shown in the figure 3-1 below.
5. Passive network development responsibility within the premises (except operator equipment and user equipment highlighted in purple and yellow respectively) is with the High Rise Building developer.
6. High Rise Building developer should provide BFPP (Building Fiber Patch Panel) in the common room which terminates each fiber connection coming from the apartment and common locations and Micro duct Management Panel upon the requirement.
7. There should be enough space close to BFPP (Building Fiber Patch Panel) for installing OFPPs (Operator Fiber Patch Panel) or Optical Splitter Panel around it in a way such that two patch panels can be easily interconnected using patch codes to provide service to each end customer location.
8. Depending on the Architecture selected for particular High Rise Building an 8/12 Core fiber cable shall be drawn between BFPP (Building Fiber Patch Panel) in the COER and FD (Floor Distributor) in each floor using a sub-duct inside the 24+1 way micro-duct laid vertically along the cable riser ladder. Also same micro-duct can be used to draw fiber from COER to the riser area in the building. Only connectivity of a single floor is shown as an example in the Figure 3-1.
9. Depending on the Architecture selected for particular High-Rise Building Two fiber patch panels are used in each floor, one towards BFPP (Building Fiber Patch Panel) and one towards apartments/common corridor areas.
10. Depending on the Architecture selected for particular High Rise Building a 2-core fiber cable is laid from vertical riser to each apartment and each radio unit location in the corridor (explained in chapter 4) using small 2 way micro-duct as shown in the diagram. This 2-core fiber cable is terminated in an OTO (Optical Telecommunication Outlet) at the required location.
11. It is required to build the cable infrastructure (recommended CAT6 cable) to connect end user equipment such as Wi-Fi AP, IPTV, IP phone and residential radio unit at different locations inside the apartment. Only one sample apartment is shown in the figure 3-1.
12. Depending on the Architecture selected for particular High-Rise Building there shall be a cable meet up location close to OTO in each apartment where the operator CPE can be installed inside an enclosure. Copper patch panel also should be located inside the same enclosure. Further there should be a power outlet close to the enclosure for powering up operator CPE.

Detail Technical specification is described in ANNEXURE A and B with relevant justification.

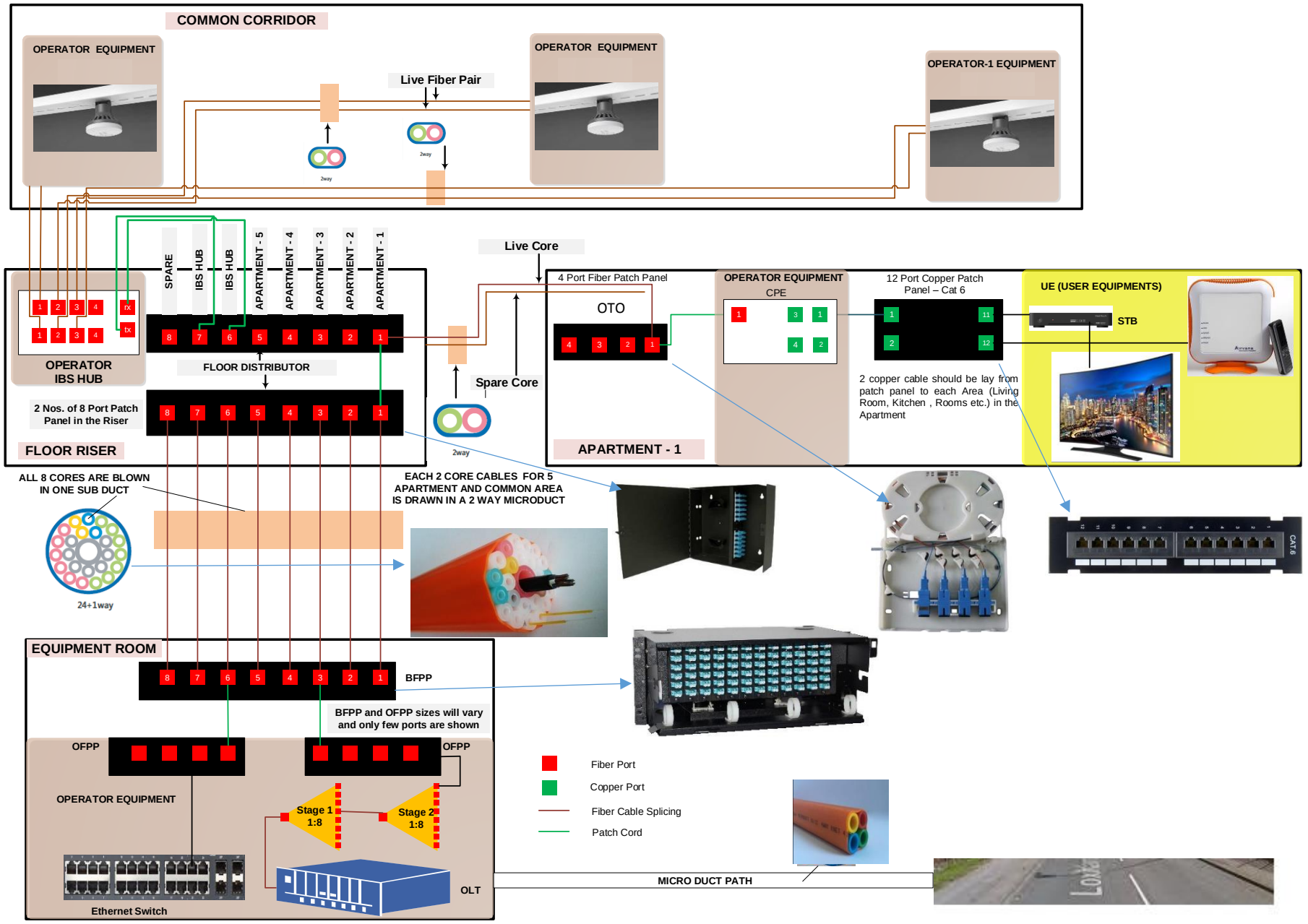


Figure 3-1 Propose architecture for Greenfield Fiber solution

3.1 Infrastructure requirement inside Apartments

1. For Greenfield solutions the 2-core fiber cable for each apartment from the floor distributor is terminated in a 4 port patch panel or Rosette or any Fiber termination Box depending on the Requirement and the architecture selected. This could be located in a fixed wall mount enclosure within the apartment. The enclosure should be equipped with 230V AC power preferably with UPS backup. High level spec of the enclosure is given below
    a. Rack unit size (size U): 6
    b. Usable depth: 21 inches
    c. Door style : glass
    d. Rails adjustable : yes

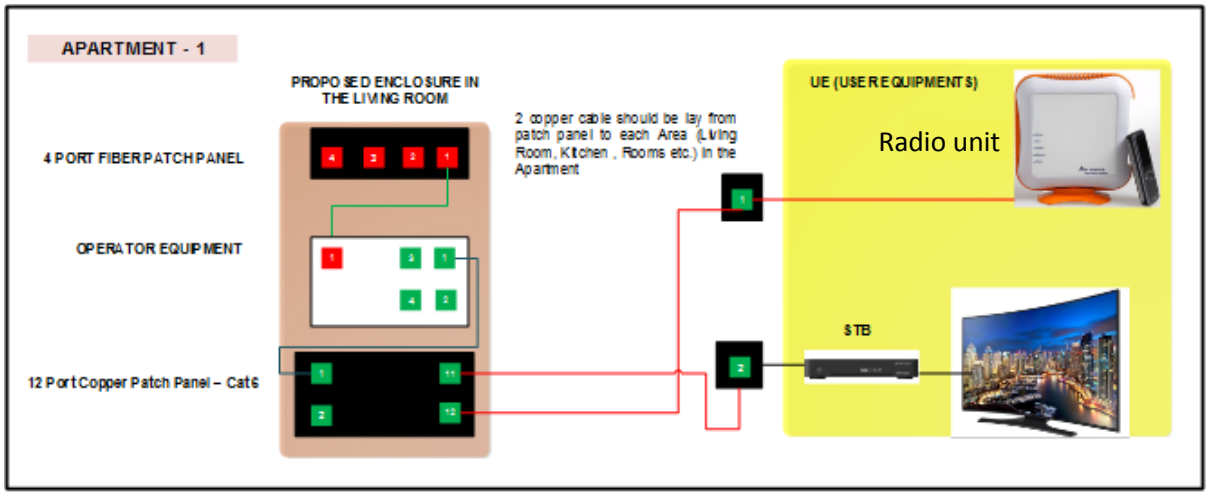


Figure 3-2 : cabling in the apartment

2. Below Accessories are mounted in the proposed enclosure
    a. 4-port fiber patch panel/Rossette/Fiber Termination Box
    b. 12-port CAT6 Unshielded Twisted Pair (UTP) patch panel
    c. Operator CPE
    d. 3-4 13A square pin power socket
    e. Ethernet switch by operator: Required only if total number of user equipment is exceeded 4.

3. A Separate CAT6 cable network should be built from enclosure to each area in the apartment. It is required to terminate 2 number of CAT6 cables in each area to a wall socket. This can be varried according to the number of specific service areas requirement of customer. It is recommended to install UTP wall socket roughly above 300 mm from the floor level.

4. A separate CAT6 cable pair needs to be provided for possible Femto cell connectivity inside each apartment. This wall socket should be placed 2 feet below the ceiling level and the actual location of the Femto cell should be decided on a technical design carried out by an operator or competent radio network engineer. A 230V AC type G power socket should also be located close to the data socket.

4 SPECIFICATION FOR MOBILE COMMUNICATION INFRASTRUCTURE IN HIGH RISE BUILDINGS

4.1 Connectivity for radio units/antennas in common areas

Where an In-building solution for mobile services is proposed for the building, radio units/antennas will be mounted on the ceiling in common areas to provide mobile coverage. The High Rise Building developer is required to obtain a detailed design depicting suitable locations for placing the radio units/antennas during the design phase from the mobile service anchor operator.

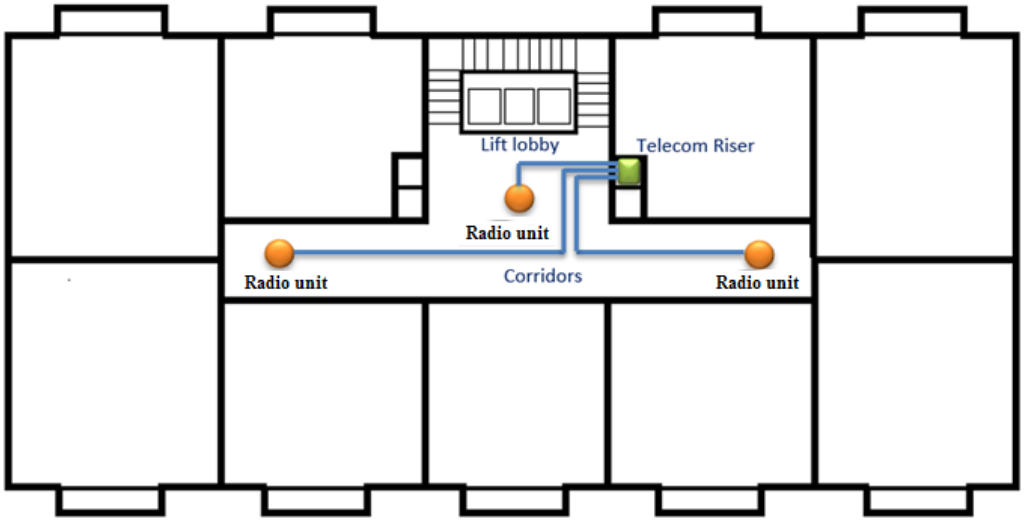


Figure 4-1 Example Radio units/antenna placement in a typical floor

The following infrastructure and cabling is required to facilitate this.

1. It is required to allocate a 2U space in a telecommunication enclosure close to the telecommunication riser to install the IBS hub unit in each floor. A Type G, 230 V AC power socket should be provided at the location.

2. Based on the detailed design a 2 core fiber cable or a CAT6 Ethernet cable needs to be drawn to each Radio unit. Where Ethernet cabling is used the maximum distance from the riser should not exceed 100m.

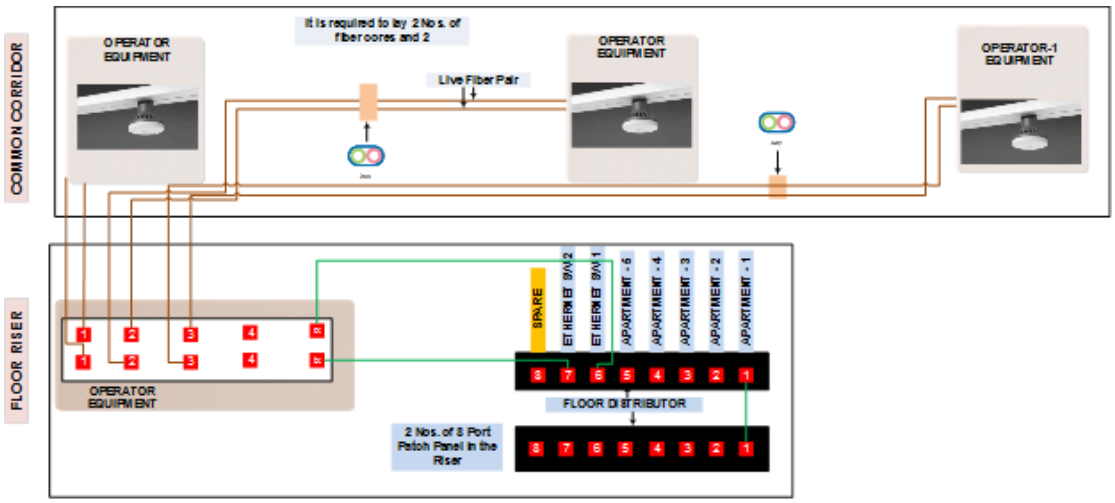


Figure 4-2 Proposed cabling in common residential area

3. Where a passive Distributed antenna system (DAS) is proposed a Horizontal cable tray having 100mm width should be provided by the developer to each antenna location in common areas of each floor for RF Cabling. This cable tray should be connected to the Telecommunication Riser.

4. In addition, for a passive Distributed antenna system (DAS), a 600mm x 600mm Remote equipment space is required on floors to be allocated as given in below table with power **3 Type-G 10A (square pin) Power sockets per operator.**

Table 4-1 Remote equipment space requirement

Floor area of building	Requirement
1000 square meters	Remote equipment space on every 10th floor
2000 square meters	Remote equipment space on every 5th floor
3000 square meters	Remote equipment space on every 3rd floor
5000 square meters	Remote equipment space on every 2nd floor
10000 square meters	Remote equipment space on every floor

4.2 Connectivity for radio units inside Apartments

1. Based on the solution provided placement of radio units/antennas inside apartments will be facilitated by anchor operator if and when other mobile operators request it from the anchor operator.

2. For deploying radio units inside apartments the fiber infrastructure will be utilized.

3. A CAT6/fiber cable from the operator CPE/switch needs to be provided for connecting the radio unit inside each apartment. The Ethernet wall socket should be placed 2 feet below the ceiling level. As with common areas the location of the radio unit should be based on a detailed design carried out by an operator or competent radio network engineer. A 230VAC type G power socket should also be located close to the data socket.

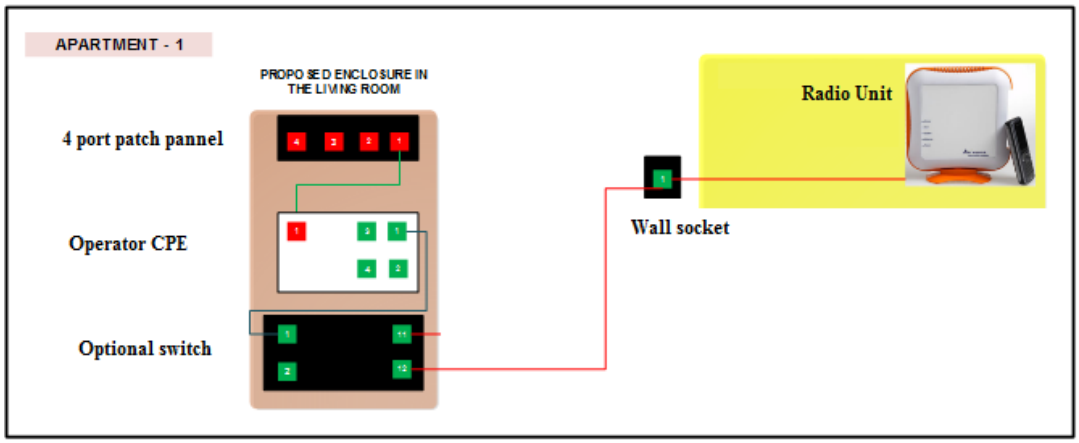


Figure 4-3 : Proposed cabling in the apartment for radio unit

4. For a passive DAS system provisions should be made for placing a duct entry point (2.5cm Diameter) inside each apartment as shown in above Figure 4-4 below

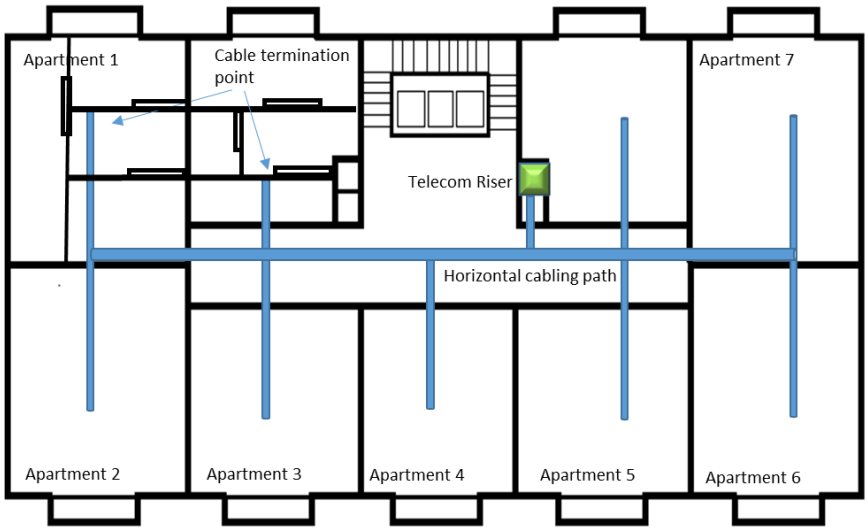


Figure 4-4 Horizontal cable tray and termination points for passive DAS

ANNEXURE A: TECHNICAL SPECIFICATIONS

1 Fiber Cable Selection

Proposed indoor fiber will be laid from common room to the apartment while crossing bending-rich environment with walls, slabs and tight corners. Consequently, It is paramount important to focus on bending radius of the fiber, when selecting the indoor fiber cable to use in the High Rise Building. Figure A1-1 provides detail on bending radius of the several candidate fibers which can be used in indoor installation.

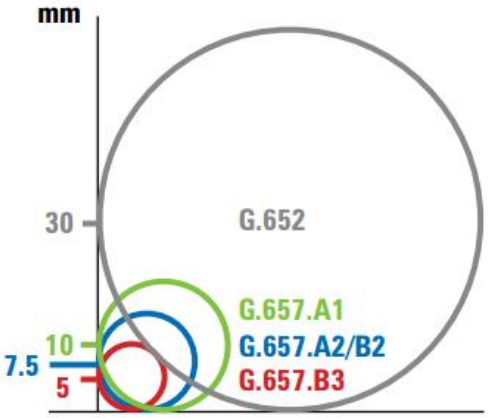


Figure A1-1 Maximum bending Radius of candidate fibers

G. 657 A1 and A2 fibers are fully compliant with G.652 D fiber where most operators are used in OSP (Out Side Plant) development compare to G.657 B2 and B3 counterparts. At the same time, G.657 A2 is shown a superior fiber performance compare to G.657 A1, when it come to the micro bending losses. Consequently, recommended version for fiber cable is G.657 A2.

1.1 Fiber Cable Density

Number of cores in the fiber cable will be a key decision parameter required to optimize the in-building Fiber design. Fiber cable density can be standardized by analyzing apartment distribution in a general High Rise Building. Table A1-1 illustrates the recommendation on core requirement for vertical and horizontal fiber cable laying.

Table A1-1 Fiber core requirement for indoor installation

Description	Core Requirement	Rationally & Justification
Fiber cable laying in the vertical riser - (COER to each floor level and terminate on patch panel in the riser).	8/12 core fiber cable	One floor can be populated up to 10 apartments and each apartment is backhauled by one fiber core. In addition to that it is required to allocate two fiber cores for the common area to backhaul radio unit.
Fiber cable laying in the Floor Distributor – (From patch panel in the riser to patch panel in the apartment and common area).	2 core fiber cable	It is required one fiber core to serve one apartment with either GPON or Ethernet base technology. Remaining fiber cores can be used as spares to increase operational efficiency.

Base on the fiber core type and cable density G. 657 A2 – 8 core blown fiber cable and G. 657 A2 – 2-core blown fiber cable has been selected for fiber cable laying. Technical drawing for proposed micro cables are illustrated in figure A1-2 and A1-3 respectively.

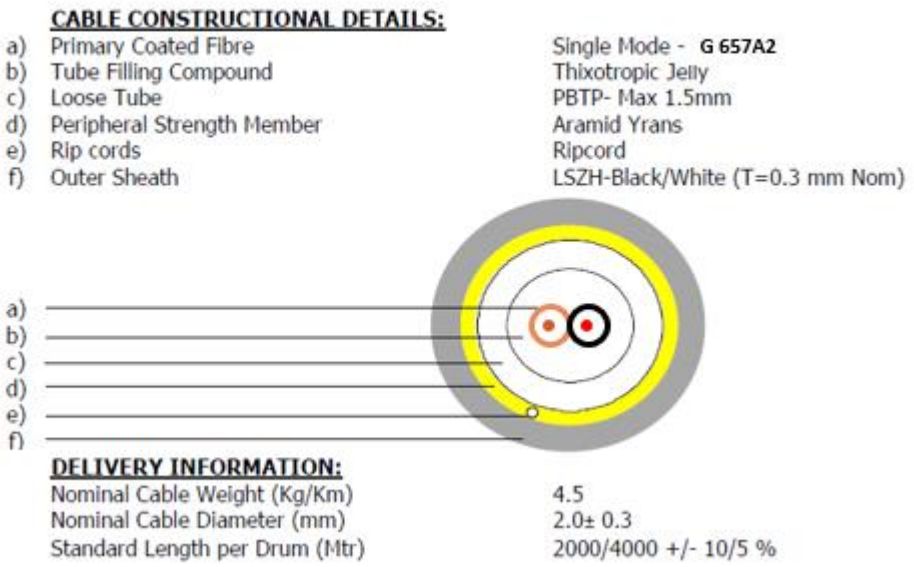


Figure A1-2 Fiber 2 core cable specification

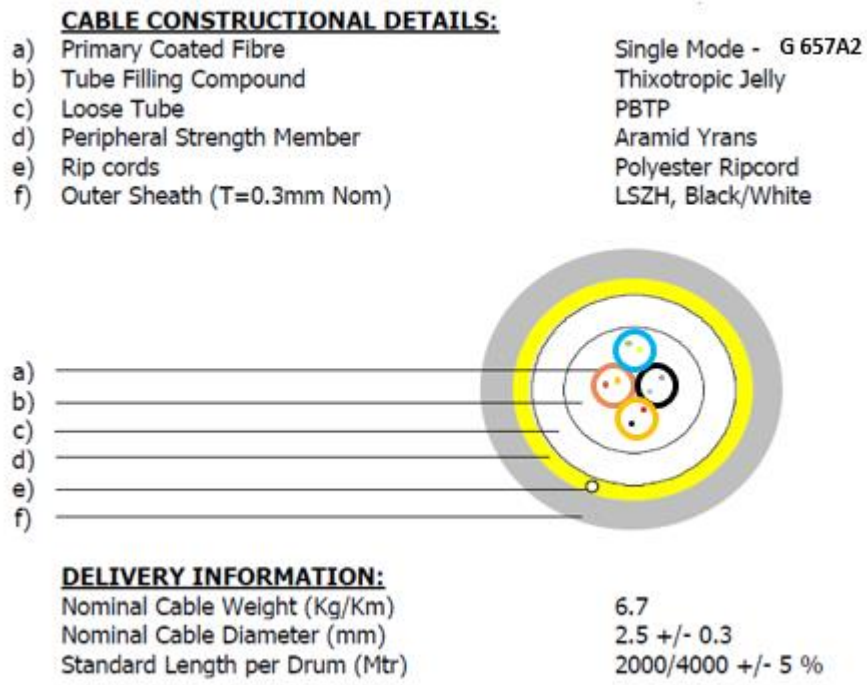


Figure A1-3 Fiber 8 core cable specification

Proposed fiber core should comply with the specification and standards given below.

i. ITU-T Recommendations G.657.A2
ii. IEC International Standard 60793-2-50 type B.1.3 and B.6

Proposed Fiber cable should be supplied by bidders maintaining an ISO 9001 or above quality assurance standard. Fiber cable should have passed the mandatory test highlighted below.

i. Tensile Test – The cables must pass the following tensile test.
   Test method: IEC 60794-1-2-E1
   Test criteria: During Installation (Full Load) 20 x D, D = Cable Diameter
   Installed (No Load) 15 x D, D = Cable Diameter

ii. Impact Test – The cables must pass the following impact test.
   Test method: IEC 60794-1-2-E4
   Test criteria: Impact Load: 4.4 Nm
   No. of Impacts: 20
   Radius of hammer head: 12.5mm
   Rate of Impact: ≤ 2 seconds / cycle
   Test wavelength: 1550 nm
   Pass criteria: Change in attenuation < 0.10dB and no damage to the sheath.

iii. Crush (Compression) Test – The cables must pass the following crush test
   Test method: IEC 60794-1-2-E3
   Test criteria: Crush Load: 3000 N/10cm
   Load time: 5 minutes

Compression plate dimensions: 100 mm long with 6 mm radius at ends
Test wavelength: 1550 nm
Pass criteria: Change in attenuation < 0.10dB and no damage to the sheath.

iv. Twist (Torsion) Test – The cables must pass the following torsion test.
Test method: IEC 60794-1-2-E7
Test criteria: Maximum Twist length: 4 meters
Applied tension load: 50 N
Twist Rate: ± 180O for 10 cycles, with cycle time ≤ 1 minute
Test wavelength: 1550 nm
Pass criteria: Change in attenuation < 0.10dB and no damage to the sheath.

v. Water Penetration Test – The cables must pass the following water penetration test.
Test method: IEC 60794-1-2-F5 Method B
Test criteria: Cable sample length: 3 meters
Applied water head: 1 meter
Test time: 24 hours
Pass criteria: No leakage of water from the opposite end of the cable during, or at the end of the test period.

vi. Temperature Cycling Test – The cables must pass the following environmental test:
Test method: IEC 60794-1-2-F1
Test criteria: Cable sample length: ≥ 1000 meters
Minimum / Maximum Test Temperatures: -10OC and +70OC
No. of Cycles: 2
Minimum Soak time: 8 hours
Pass criteria: Change in attenuation < 0.10dB and no damage to the sheath.

vii. Compound Flow Test – The cable must pass the compound flow test.
Test method: IEC 60794-1-2-E14
Test criteria: Cable samples:As defined in IEC60794-1-2-E14 Clause 17.2
Test Procedure: As defined in IEC60794-1-2-E14 Clause 17.2
Test Temperature: 70OC
Test Time: 24 hours
Pass criteria: At the end of the test period no more than 0.050gms shall have flowed from each of the cable samples. Other requirements as per IEC60794-1-2-E14

viii. Cable Sheath Test – The cable sheath material must pass the following tests:
Carbon Black Content: Shall be 2.6% ± 0.2 when tested in accordance with ASTM 1603
Tensile Strength: Shall be ≥ 15 MPa, based on a sample taken from the cable
Sheath elongation at break: Shall be ≥ 300%, based on a sample taken from the cable sheath. (Please mention any other alternations)

ix. Cable bending radius – (IEC 60794-1-2-E11)
During Installation (Full Load) 20 x D, D = Cable Diameter
Installed (No Load) 15 x D, D = Cable Diameter

x. Cable Kink resistance – (IEC 60794-1-2-E10)
20 x D, D = Cable Diameter

2 Technical specification for Micro Ducts

It is recommended to use Micro duct technology for indoor fiber cable laying, which yield multiple benefit. Micro-ducts are defined in the standard IEC 60794-5-20 as a small, flexible, lightweight tube with an outer diameter typically less than 16 mm. cable. They accommodate micro-cables which place greater reliance on micro-ducts for mechanical protection. Thus a micro-duct must meet the adequate impact, compression and bending requirements necessary for an application while optimizing the space.

Depending on chosen application there are 2 types of micro-ducts

A. Direct buried/thick walled – This does not need to be placed or blown inside another duct or tube. These micro-ducts can be direct buried into the ground as single micro-ducts or in various.
B. Direct installed/thin walled - These are micro-ducts which need extra mechanical protection and are usually installed inside buildings, cable trays or they are blown inside the sub-duct increasing its capacity.

In order to have required protection for the fiber cable it is recommended to use **thick walled micro duct type** and micro cable will be blown inside the micro duct. Optionally to provide better protection **LSZH (Low Smoke Zero Halogen) micro duct** which is surrounded with a sheath of flame retardant low smoke zero halogen material and provide excellent performance under fire hazard can also be recommend for fiber cable blowing.

Table A2-1 Micro duct recommendation for fiber laying

Description	Recommended Micro Duct Type
COER to floor distributor	Thick wall micro duct type (24 + 1 way)
Floor distributor to the apartments	Thick wall micro duct (2 way)

The figure A2-1 provides details on recommended micro ducts.

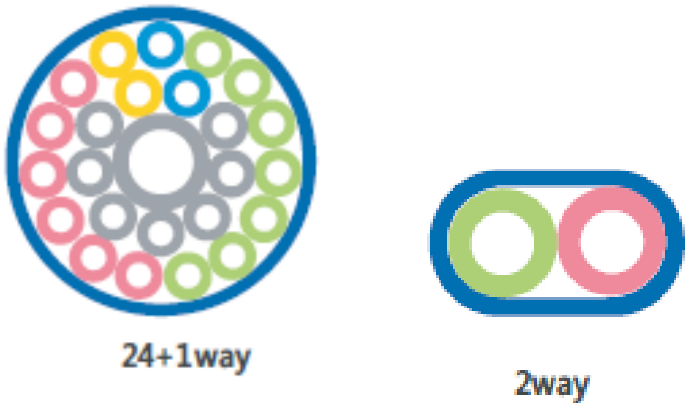


Figure A2-1 Details of Micro duct

Key specification for the proposed micro duct is populated in Table A2-2.

Table A2-2 Proposed micro duct specification

No. of Sub duct	Outer/Inner Diameter of the sub duct (mm)	OD (mm)	Max Tensile (N)	Weight (kg/km)	Bend Radius (mm)	Crush (N)
24 + 1way	**7/4**	**43.6*43.6**	**8440**	**862**	**530**	**2000**
2 Way	**7/4**	**9*16**	**910**	**93**	**110**	**2000**

ANNEXURE B: TESTING PROCEDURE

1 Final Testing Standards and Methodologies

It is essential to maintain proper quality standard on developing fixed and mobile infrastructure for high rising building. This will ensure by accommodating appropriate testing standard to the infrastructure handover process. Proposed standard should cover both passive and active solution pertinent to Greenfield and mobile solution. At the same time, it is crucial to maintain a proper recording process relevant to each testing standard, which will immensely help to increase operational efficiency in the future.

1.1 Proper Testing Standard for Micro Duct

It is required to complete below testing to verify the quality of used Micro duct.

1. Pressure Test
2. Traceability test
3. Visual Test

Table B1-1 demonstrates a UAT (User Acceptance Test) table which can be indorsed to keep the recording of the test.

Table B1-1 Proposed UAT document for Micro Duct Laying

Test Description	From	To	Value					Remarks
			Duct 1	Duct 2	Duct 3	Duct 4	Duct n	
Pressure Test								
Traceability Test								
Visual Test								

1.2 Proper Testing Standard for Fiber Cable

It is required to complete below testing to verify the fiber connectivity.

1. Power Meter Test
2. OTDR Test
3. Visual Test

Table B1-2 demonstrates a UAT (User Acceptance Test) table which can be indorsed to keep the recording of the test.

Table B1-2 Proposed UAT document for Fiber cable

Test Description	From	To	Results							
			Core 1	Core 2	Core 3	Core 4	Core 5	Core 6	Core 7	Core 8
Power Meter Test (Loss dB)										
Visual Test			OK	NOK	OK	OK	OK	OK	OK	OK
OTDR Test										

1.3 Proper testing standard for UTP cable

It is required to complete below testing to verify the quality of UTP infrastructure.

1. Wire-map Test –Simple test that confirms that each wire is hooked up correctly, with no opens or shorts. It is essential to do this, before preceding other test to verify that all connection is correct.
2. Cable Verification Test – This test verifies that the cable will support Gigabit Ethernet.
3. Performance Test – Performance testing should be done to check the attenuation, crosstalk over the full frequency range of the cable.
4. Cable Certification Test – This should be done after complete the end to end UTP installation. The test will guarantee that the cabling meet minimum specification of EIA/TIA standards and should work with any network designed to operate with cat5/6.

Table B1-3 demonstrate a UAT (User Acceptance Test) table which can be indorsed to keep the recording of the test

Table B1-3 Proposed UAT document for UTP Cable

Test Description	From	To	Result							
			Cable 1	***Cable 2***	***Cable 3***	***Cable 4***	***Cable 5***	***Cable 6***	***Cable 7***	***Cable 8***
Wire map test										
Cable Verification Test			OK	NOK	OK	OK	OK	OK	OK	OK
Performance Test										
Cable Certification Test										