भारतीय मानक ब्यूरो
(उपभोक्ता मामले, खाद्य एवं सार्वजनिक वितरण मंत्रालय, भारत सरकार)
BUREAU OF INDIAN STANDARDS
(Ministry of Consumer Affairs, Food & Public Distribution, Govt. of India)

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व्यापक परिचालन मसौदा

हमारा संदर्भ: सीईडी 46 /टी-26 **12 मार्च 2025**

तकनीकी समिति: भारत की राष्ट्रीय भवन निर्माण विषय समिति, सीईडी 46

प्राप्तकर्ता :

1. सिविल अभियांत्रिकी विभाग परिषद, सीईडीसी के सभी सदस्य
2. राष्ट्रीय भवन निर्माण संहिता विषय समिति, सीईडी 46 के सभी सदस्य
3. सीईडी 46 की उपसीमितयों और अन्य कार्यदल के सभी सदस्य
4. रुचि रखने वाले अन्य निकाय।

महोदय/महोदया,

निम्नलिखित मानक का मसौदा संलग्न हैं:

प्रलेख संख्या	शीर्षक
सीईडी 46 (26914) WC	**भारत की राष्ट्रीय भवन निर्माण संहिता भाग 8 भवन निर्माण सेवाएँ अनुभाग 6 सूचना तथा संचार को समर्थ बनाने वाले संस्थापन** [SP7(भाग 8 अनुभाग 6) का चौथा पुनरीक्षण] (आई सी एस नंबर: 01.120: 91.040.01)

कृपया इस मसौदे का अवलोकन करें और अपनी सम्मतियाँ यह बताते हुए भेजे कि यह मसौदा प्रकाशित हो तो इस पर अमल करने में आपको व्यवसाय अथवा कारोबार में क्या कठिनाइयां आ सकती हैं।

सम्मतियाँ भेजने की अंतिम तिथि: 11 अप्रैल 2025

सम्मति यदि कोई हो तो कृपया अधोहस्ताक्षरी को ई-मेल द्वारा ced46@bis.gov.in पर या उपरलिखित पते पर, संलग्न फोर्मेट में भेजें। सम्मतियाँ बीआईएस ई-गवर्नेंस पोर्टल, www.manakonline.in के माध्यम से ऑनलाइन भी भेजी जा सकती हैं।

यदि कोई सम्मति प्राप्त नहीं होती है अथवा सम्मति में केवल भाषा संबंधी त्रुटि हुई तो उपरोक्त प्रलेख को यथावत अंतिम रूप दे दिया जाएगा। यदि सम्मति तकनीकी प्रकृति की हुई तो विषय समिति के अध्यक्ष के परामर्श से अथवा उनकी इच्छा पर आगे की कार्यवाही के लिए विषय समिति को भेजे जाने के बाद प्रलेख को अंतिम रूप दे दिया जाएगा।

यह प्रलेख भारतीय मानक ब्यूरो की वैबसाइट www.bis.gov.in पर भी उपलब्ध हैं।
धन्यवाद।

भवदीय

ह/-
(द्वैपायन भद्र)
वैज्ञानिक 'ई' एवं प्रमुख (सिविल अभियांत्रिकी विभाग)

सलंग्न: उपरिलिखि

भारतीय मानक ब्यूरो
(उपभोक्ता मामले, खाद्य एवं सार्वजनिक वितरण मंत्रालय, भारत सरकार)
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Website: www.bis.org.in , www.bis.gov.in

WIDE CIRCULATION DRAFT

Our Reference: CED 46/T-26 **12 March 2025**

National Building Code of India Sectional Committee, CED 46

ADDRESSED TO:

1. All Members of Civil Engineering Division Council, CEDC
2. All Members of the National Building Code Sectional Committee, CED 46
3. All Members of Subcommittees, Panels and Working Groups under CED 46
4. All other interests

Dear Sir/Madam,

Please find enclosed the following draft:

Doc No.	Title
CED 46 (26914) WC	**National Building Code of India Part 8 Building Services Section 6 Information and Communication Enabled Installations** [Fourth Revision of SP 7 (Part 8 Section 6)] (ICS No. 01.120: 91.040.01)

Kindly examine the attached draft and forward your views stating any difficulties which you are likely to experience in your business or profession, if this is finally adopted as National Standard.

Last Date for comments: 11 April 2025

Comments if any, may please be made in the enclosed format and emailed at **ced46@bis.gov.in** or sent at the above address. Additionally, comments may be sent online through the BIS e-governance portal, **www.manakonline.in**.

In case no comments are received or comments received are of editorial nature, kindly permit us to presume your approval for the above document as finalized. However, in case comments, technical in nature are received, then it may be finalized either in consultation with the Chairman, Sectional Committee or referred to the Sectional Committee for further necessary action if so desired by the Chairman, Sectional Committee.

The document is also hosted on BIS website **www.bis.gov.in**.

Thanking you,

Yours faithfully,

Sd/-
(Dwaipayan Bhadra)
Scientist 'E' / Director and Head
(Civil Engineering Department)

Encl: As above

FORMAT FOR SENDING COMMENTS ON THE DOCUMENT

[Please use A4 size sheet of paper only and type within fields indicated. Comments on each clause/sub-clause/ table/figure, etc, be stated on a fresh row. Information/comments should include reasons for comments, technical references and suggestions for modified wordings of the clause. **Comments through e-mail to ced12@bis.gov.in shall be appreciated**.

Doc. No.: CED 46 (26914) WC   **BIS Letter Ref**: CED 46/T-26

Title: National Building Code of India Part 8 Building Services Section 6 Information and Communication Enabled Installations [Fourth Revision of SP 7 (Part 8 Section 6)] (ICS No.01.120:91.040.01)

Last date of comments: **11 April 2025**

Name of the Commentator/ Organization: ______________________________

Clause/ Para/ Table/ Figure No. commented	Comments/Modified Wordings	Justification of Proposed Change

NOTE- Kindly insert more rows as necessary for each clause/table, etc

BUREAU OF INDIAN STANDARDS

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Draft Indian Standard

National Building Code of India

Part 8 Building Services

Section 6 Information and Communication Enabled Installations

[Fourth Revision of SP 7 (Part 8 Section 6)]

(ICS No. 01.120: 91.040.01)

National Building Code Sectional Committee, CED 46	Last Date for Comments: 11 April 2025

C O N T E N T S

National Building Code Sectional Committee, CED 46

FOREWORD

This Code (Part 8/Section 6) covers the essential requirements for information and communication enabled installations, technology systems and cabling installations in a building. It also covers the basic design and integration requirements for telecommunication spaces within building/buildings along with their cabling infrastructure, their pathway components and passive connectivity hardware. It also includes general requirements relating to installation of different wireless and wireline communication equipment, cable terminations, power connections and general guidelines required for planning and providing information and communication technology (ICT) services in the building at the planning and execution stages. The provisions given herein are basic requirements applicable to all residential and other buildings. These can be used at the time of upgradation of existing buildings for properly accommodating telecom systems/services. Buildings meant for data centres and those for housing telecom exchanges/facilities for offering public services may have various other considerations. For such buildings, provisions of this Section are indicative and may be a subject of actual requirements.

Telecommunication plays a vital role in modern society similar to electricity, water, gas, and transport systems. It is difficult to imagine a life without telecommunication technologies. In a building, a broad variety of telecommunication systems are expected to be installed. Buildings have provision for installation of various utilities. However, unlike traditional utilities, telecommunication systems are constantly evolving at a rapid pace.

Telecommunications connectivity can be delivered through cable, wire, optical fibre, fixed wireless and mobile wireless technologies. Each of these technologies when considered for use inside buildings, especially when the buildings are either commercial or multi-dwelling units or complexes, places its own requirement in terms of building space, power supply, internal extensions to various work areas/dwelling units. For example, for wire line services, broadband cable television, etc, the entry to the buildings/complexes will be through underground cables and the distribution of services further into the complexes will be from the bottom of the building to the upper stories. On the contrary, any wireless technologies, where antennas are to be installed at terrace along with a system which can distribute the signals through cables or in building solutions, the flow of cables will be from top storeys of the building to the bottom. Keeping in view that there are multiple telecom service providers (TSPs), there is growing need for provision of seamless wireless services to the users at public buildings such as airport, malls, hospitals, railway stations by sharing infrastructure without any discrimination.

The telecom facilities can be chosen by the user from the gamut of technologies and associated features as options are available based on the requirement, cost, service and maintenance convenience, future upgradation requirements, user preference, quality of service /experience etc. While providing telecom enabling infrastructure in the building, the provisions are to be made for making the infrastructure supportive for multiple technologies/ products and the requirements of telecom service providers. Use of building management system (BMS), access control, surveillance, and creation of 'Smart' building will require significant telecom infrastructure to be created within the buildings which may be supported by M2M communication technologies. Individual/tenant users of the building may also have their own M2M/IoT systems with wireline or wireless (Cellular, Satcom, WiFi, LoRa, Zigbee, and other wireless protocols) gateways. The telecom support infrastructure in the buildings/campuses needs to be responsive and accommodative of these requirements.

In order to facilitate installation/upgradation of telecom systems, proper planning and understanding of enabling provisions for telecom technologies and physical infrastructure are necessary. Modern telecommunication technologies such as distributed antenna system, In-building solutions (using technologies for example WiFi 6/6E or higher versions, cellular 4G/5G and beyond) are also to be considered during the building planning stage itself and providing shared access to multiple telecom service providers as per demand by end users. The enabling infrastructure may include cable riser systems, conduits, cable trays, Fiber management systems, passive and active infrastructure DAS etc. Appropriate space need to be earmarked for installation of equipment at the entry point of service and running the cables, etc, through shafts and horizontal conduits inside the walls, centre of the corridors and centre of the work space, etc. Thus, cabling pathways infrastructure should be designed to be of general nature but flexible enough to accommodate a variety of current and future telecom systems and emerging technologies.

Choice of service to be provided inside the complexes/buildings will depend on the users. As already mentioned above, the delivery of service can be spread across technologies and across various service providers. Therefore, the arrangement for telecommunication infrastructure needs to be made in such a manner that the requirements and the challenges of at least near future (say 10 years) can be met without disturbing or retrofitting the building infrastructure. This Section has been formulated to cover these aspects.

In the formulation of this Section, due weightage has been given to international coordination among the standards and practices prevailing in different countries, in addition to relating it to the practices in this field in this country. This has been done by deriving assistance from the publications of ISO, IEC, ITU, TEC, TRAI regulations and DOT orders/guidelines etc.

Considering all the above, this new Section was introduced in 2016 to address the essential requirements for information and communication enabled installations and the related.

In line with technological advancements and evolving connectivity requirements, significant modifications have been made to the section on ICT installations in buildings, in this version of the Code. These updates aim to address current demands for faster data transfer rates, advanced wireless standards, and improved maintenance protocols to ensure robust and reliable ICT infrastructure. The significant changes incorporated in this revision include:

a) The table on balanced twisted-pair cabling channel performance is updated to reflect maximum data transfer rates, aligning with present-day bandwidth demands and ensuring future readiness.

b) A new provision on meshed bonded networks, which provide enhanced immunity to electromagnetic interference (EMI) and are recommended for environments with high-density ICT equipment, in **4.1.1**.

c) A new informative **A-6** includes an overview of In-building solutions (IBS), including distributed antenna systems (DAS), leaky feeder cables, and small cells, to enhance indoor wireless connectivity in areas with weak signals. It also includes key considerations such as coverage requirements, interference management, capacity planning, and aesthetic integration to ensure seamless indoor mobile connectivity.

d) A new informative Annex B on street furniture that highlights the use of streetlights, utility poles, bus stops, traffic signals, etc to support ICT infrastructure, in Annex B.

For the purpose of deciding whether a particular requirement of this Section is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 2022 'Rules for rounding off numerical values (*second revision*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this Section.

Code Users are requested to share their inputs/comments on the draft particularly based on the changes listed above in the foreword; and especially on those text highlighted in yellow in this draft.

Important Explanatory Note for Users of the Code

In any Part/Section of this Code, where reference is made to **'good practice'** in relation to design, constructional procedures or other related information, and where reference is made to **"accepted standard"** in relation to material specification, testing, or other related information, the Indian Standards listed at the end of the Part/Section shall be used as a guide to the interpretation.

At the time of publication, the editions indicated in the standards were valid. All standards are subject to revision and parties to agreements based on any Part/ Section are encouraged to investigate the possibility of applying the most recent editions of the standards.

In the list of standards given at the end of a Part/Section, the number appearing within parentheses in the first column indicates the number of the reference of the standard in the Part/Section. For example:

a) Good practices [8-6(1)] refers to the Indian Standard(s) give at serial number (1) of the list of standards given at the end of this Part/Section, that is, IS 9537 (Part 2):1983 'Specification for conduits for electrical installations: Part 2 Rigid steel conduits'

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Draft Indian Standard

National Building Code of India

Part 8 Building Services

Section 6 Information and Communication Enabled Installations

[Fourth Revision of SP 7 (Part 8 Section 6)]

(ICS No. 01.120: 91.040.01)

National Building Code Sectional Committee, CED 46	**Last Date for Comments: 11 April 2025**

1 SCOPE

1.1 This Code (Part 8/Section 6) covers the essential requirements for information and communication enabled installations, technology systems, cabling installations, and other passive & active equipment in a building. It also covers the basic design and integration requirements for telecommunication spaces within building/buildings along with their cabling infrastructure, their pathway components and passive connectivity hardware considering future requirements including flexibility requirement for installation of active infrastructure by the service providers.

1.2 It also includes general requirements relating to installation of different communication equipment, cable terminations, power connections and general guidelines required for planning and providing information and communication technology (ICT) services in the building at the planning and execution stages. The provisions given herein are basic requirements applicable to all residential and other buildings. These can be used at the time of upgradation of existing buildings for properly accommodating telecom systems/services. Buildings meant for data centres and those for housing telecom exchanges/facilities for offering public services may have various other considerations. For such buildings, provisions of this Section are indicative and may be a subject of actual requirements. Introduction of street furniture as a crucial enabler of ICT infrastructure, leveraging existing structures like streetlights, utility poles, and bus stops to support small cells and air fiber for enhanced connectivity has been made.

NOTE – In this Section, 'Telecom' has been used interchangeably with 'ICT', as most of the time there may be only telecommunication hardware present. Apart from the provision of telecommunication systems, Information Technology (IT) system in the building may be either common for the building or separate for the individual users. In case the entire building is used by the same user, the IT system may be common and thus IT space for Building Management System (BMS), CCTV, etc, can be shared with telecom facilities. In case where individual IT systems owned by several users are provided, separate spaces may be earmarked inside telecom spaces for individual IT infrastructure. Sometimes, individual users may also use the common IT facilities. However, the cabling, wiring, etc, for IT systems should use the same pathways, which are used for telecommunication hardware.

2 TERMINOLOGY

For the purpose of this Section, the following definitions shall apply.

2.1 Access Point — A hardware device or a computer's software that acts as a communication hub or as an interconnection port for users of wireless devices to connect them to a wired or wireless local area network (LAN).

2.2 Antenna – An electrical device designed to transmit or receive radio waves or more generally, electromagnetic waves for the purpose of radio frequency communication such as Wi-Fi, radio, television, satellite communication, radar communication and mobile communication. This is also called an aerial.

2.3 Attenuation – A general term that refers to any reduction in the strength of an electrical/electromagnetic signal.

2.4 Backbone — A high-capacity facility (for example, pathway, cable or conductors) which acts as a major pathway within a network from which further smaller capacity facilities get distributed.

2.5 Backbone Cabling Media Distribution and Building Pathway — A part of a building premises telecom cable distribution system that provides connection between telecommunications spaces. It typically provides building connections between floors in multi-storeyed buildings as well as campus connections in multi-building environments.

2.6 Building Management System — It is a low voltage automation or remote control system installed for managing different building sub-systems like, heating, ventilation, lighting, air conditioning, fire protection, access control, etc.

2.7 Bus Bar — It refers to thick strips of copper or aluminium, in electrical power distribution that conduct electricity within a switchboard, distribution board, substation, or other electrical apparatus.

2.8 Coaxial Cable — A type of wire that consists of a centre wire surrounded by insulation and then a grounded shield of braided wire. The shield minimizes electrical and radio frequency interference.

2.9 Consolidation Point (CP) – A location for interconnection between horizontal cables extending from building pathways and horizontal cables extending into furniture pathways.

2.10 Cross-Connect — A facility enabling the termination of cable elements and their interconnection or cross-connection.

2.11 Distributed Antenna System (DAS) – It is a system that uses network of physically or spatially separated antennas to extend radio coverage of any technology inside a building.

2.12 Direct to Home (DTH) — The direct reception of satellite programs using small dish antennae (personal dish) placed on a roof or window of a house.

2.13 Frequency – The measurement of the number of times that a repeated event occurs per unit of time.

2.14 Horizontal Cabling — It includes, (a) the cabling between and including the telecommunications outlet/connector and the horizontal cross-connect, and (b) the cabling between and including the building management system outlet or the first mechanical termination of the horizontal connection point and the horizontal cross-connect.

2.15 Horizontal Cabling Media Distribution and Building Pathway — It consists of the horizontal cabling in the building, the horizontal pathways supporting the horizontal cabling, and the telecommunications spaces that support the horizontal pathways. The use of the term horizontal in the name of the element does not require that the elements be placed or installed parallel to the ground or floor.

2.16 Horizontal Cross-Connect (HC) – A cross-connect of horizontal cabling to other cabling, for example, horizontal, backbone, and equipment.

2.17 In Building Solution (IBS) – It is a telecom infrastructure solution designed to enhance indoor network coverage for mobile or fixed wireless or Wi-Fi network for seamless indoor connectivity. DAS can be a part of IBS.

2.18 Inside Plant (ISP) — Telecommunications infrastructure designed for installation, interior to the buildings.

2.19 Intermediate Cross-Connect (IC) — A cross-connect between first level and second level backbone cabling. First level backbone is a cable between a main cross-connect (MC) and intermediate cross-connect (IC) or horizontal cross-connect (HC). Second level backbone exists between an intermediate cross-connect (IC) and horizontal cross-connect (HC).

2.20 Internet of Things (IoT) — A network of all physical objects connected to internet primarily using M2M communication technologies.

2.21 Local Multipoint Distribution System (LMDS) — A broadband radio service designed to provide two-way transmission of voice, high-speed data and video (wireless cable TV) digitally through microwave.

2.22 Local Area Network (LAN) — A computer network covering a local area, like a home, office or small group of buildings.

2.23 Machine to Machine (M2M) Communication – It is a set of wired/wireless communication technologies which enable machine/device (for example sensor, meter, etc) to capture an event (for example temperature, motion, meter reading, etc) and relay through communication network to an application that translates the data from device to a meaningful information.

2.24 Main Cross-connect (MC) – A cross-connect for first level backbone cables, entrance cables, and equipment cables.

2.25 Main Distribution Frame (MDF) — A structure where all the copper wires, fibre or coaxial cables for a network terminates for patching/cross-connection on separate or composite frames.

2.26 Metropolitan Area Network (MAN) — A network designed to carry data over an area larger than a campus, such as an entire city and its outlying area.

2.27 Multichannel Multipoint Distribution System (MMDS) — A method of delivering multiple voice/data/television signals digitally by microwave transmissionto subscriber households.

2.28 Multi-user Telecommunications Outlet Assembly (MUTOA) – A grouping in one location of several telecommunications outlet/connectors.

2.29 Optical Fibre — It refers to the medium and the technology associated with the transmission of signals/information as light pulses along a glass fibre.

2.30 Optical Distribution Frame (ODF) — Optical fibre distribution frame where ends of optical fibre terminates for further patching/cross-connection.

2.31 Outside Plant (OSP) — Telecommunications infrastructure designed for installation, exterior to the buildings.

2.32 Propagation Delay — In a communications system, it refers to the time lag between the departure of a signal from the source and the arrival of the signal at thedestination.

2.33 Public Mobile Network — A network that is established and operated by a telecom service provider for the specific purpose of providing mobile telecommunications services to the public using technologies such as GSM, CDMA and LTE.

2.34 Radio Frequency — A frequency range from 20 kHz and above, used for transmitting/receiving text, data, audio, or video signals.

2.35 Server — Any computer on a network that contains data or applications shared by users of the network on their client terminals.

2.36 Splicing – The process of permanent joining of bare fibre end to another fibre by means of splicing tools.

2.37 Smart City/Building/Home — An innovative city/building/home that uses information and communication technologies, and other means to improve quality of life, efficiency of operation and services and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social and environmental aspects.

2.38 Telecommunication Spaces — The rooms and areas where telecommunications cabling systems are terminated, cross-connected and interconnected to installed telecommunications equipment. Various examples of these based on the function and areas, are equipment room (ER), telecommunications room (TR), entrance facilities (EF) and telecommunication enclosures (TE).

NOTE – The definitions of telecommunication spaces and workspace (*see* **2.44**) are used for calculation of infrastructure requirements, facilities, etc. This does not inhibit the utilization of space for any other purpose. Depending upon the requirements, number of telecommunicationspaces in a given building may vary for the same area.

2.39 Telecom Service Provider (TSP) — A service provider who is duly authorized by Government of India or its designated entity to operate telecom services. Here the term TSP shall include access service providers, telecom InfrastructureProviders (IP1s), Internet Service Providers (ISP), virtual network operators (VNOs), satellite communication service providers, Public Data Offices (PDO) and Public Data Office Aggregators (PDOA), or any other wireline, wireless, Direct to Home (DTH) or cable service providers.

2.40 Telecom Tower/Mast/Pole — A vertical structure for installation of antenna(e) that provide radio frequency air interface for telecommunications services. It can also bein the form of mast or multiple poles of varying height. Poles may be located at different points typically on the roof.

2.41 Telecommunication Media and Connecting Hardware – It consists of cables, equipment cords, patch cords, and connecting hardware components. All balanced twisted-pair, optical fibre, coaxial cabling and wireless systems are made up of such components. These cabling components and resulting cabling systems are used in outside plant (OSP) and premises cabling [also known as inside plant (ISP)] environments of the building telecommunication infrastructure.

2.42 Underground Cable Vault (UCV) — An underground cable vault (part of an underground duct system) used to facilitate placing, connecting, and maintaining telecommunications cables and associated equipment. It collectively refers to manholes, hand holes, and pull holes.

2.43 Very Small Aperture Terminal (VSAT) — It usually refers to satellite terminal used to transmit and receive signal from satellites with an antenna installed in user premises.

2.44 Wide Area Network (WAN) — It is a network that is capable of spanning a geographical area larger than a city.

2.45 Workstation — An electronic device that performs some information processing or display function and connects to the communications network. Typically, this may be a desktop computer with keyboard and display or laptop computer, but might also be a telephone, a printer, an access control terminal, orsome data-gathering device.

2.46 Workspace – Any location and the space around where a workstation may belocated. Typically, there can be several workspaces in a room.

3 GENERAL REQUIREMENTS FOR TELECOMMUICATION SPACES AND CONNECTING HARDWARE

3.1 Telecommunication Spaces

3.1.1 *General Considerations*

The following shall be the considerations for telecommunication spaces:

a) *Accessibility* — Telecom spaces that are intended to serve multiple users should be located in common spaces that should be accessible through a common corridor or outside door. The space for each telecom service providers may be separated to the extent feasible by partitions for security reason and controlled access to their equipment. The telecommunication spaces should be accessible, but the access should be controlled against the unauthorized access (for example, with a lock and key arrangement or by an electronic access system).

b) *Acoustic noise levels* – Acoustic noise levels in telecom spaces should be kept to a minimum by not collocating noise-generating equipment (for example, photocopy equipment, high-speed printers, and mechanical equipment).

c) *Administration* – All pertinent documentation of deployment of telecom equipment and cables should be maintained by owner or agent when the installation is completed. All telecom spaces shall have appropriate signs to identify the space and should be included within the security plan of the building. There must be sufficient space between the equipment of different service providers for maintenance and better workmanship.

d) *Cable separation* – Telecom cables should be separated from possible sources of electromagnetic interference (EMI) and from possible radio frequency interference (RFI). For safety purposes, power cables should be separated from telecom cables.

e) *Ceilings* – The general requirements for ceilings in telecom spaces should include the following:

1) Generally, the minimum ceiling height shall be 2.4 m above finished floor. However, consideration may be given for having a 3 m ceiling height.
2) If suspended ceilings are provided, necessary rodent protection may be provided.
3) The ceiling finish should minimize dust and be light coloured to enhance the room lighting.

f) *Conduits, trays, slots, sleeves and ducts* – Slot/sleeve systems should be located in places where pulling and termination of cables is easy to achieve. Bend radius requirements and service loop guidelines shall be considered. Sleeves and slots shall not be left open after cable installation. All sleeves and slots shall be fire-stopped in accordance with Part 4 'Fire and Life Safety' of the Code.

The size and number of conduits or sleeves used for backbone pathways depends on the usable floor space served by the backbone distribution system. However, sleeves in multiple of 100 mm are recommended to serve a TR, ER or EF. Multiple telecom spaces on the same floor shall be interconnected with a minimum of one 75 mm conduit or a pathway that provides equivalent capacity.

g) *Dust and static electricity* – Dust and static electricity should be avoided by,

1) Placing active printers outside of telecom spaces, and
2) Treating floors, walls, and ceiling to minimize dust.

h) *Electrical power* — When active equipment of TSPs or the building equipment (for example, PABX) are installed in TR/ER, etc, the telecom spaces shall be equipped to provide adequate electrical power with redundancy and sub-meters to each of the service providers at TRs and ERs. The recommendations are as under:

1) A power generator set should be considered if longer power interruptions are expected for which the battery backup is not adequate. Further, as telecom services are required on 24x7 basis, uninterrupted electrical power for telecom services shall be provided from local or central uninterrupted power supply (UPS) with adequate battery backup. Further, UPS arrangement may be extended to equipment in TE/corridors also.
2) Separate socket outlets for equipment, tools, test instruments, etc.
3) Separate electrical distribution panels that serve telecom equipment/spaces from those that serve other purposes are recommended. These should be clearly identified with proper sign writing.

j) *Prevention from flooding* – Telecom spaces should be located above any threat of flooding. When locating telecom spaces where a threat of flooding is unavoidable, rack elevations may be designed so that active equipment and telecom components are placed above the threat level. Sometimes locating the ER/TR on a floor above ground floor may be safer. The locations that are below or adjacent to areas of potential water hazard (for example, restrooms, kitchens) should be avoided. Liquid carrying pipes (for example, water, waste, steam) should not be routed through, above, or in the walls encompassing the ICTs space. If due to unavoidable circumstances, liquid carrying pipes are passing through telecom spaces then these spaces may be preferably monitored for water seepage by deploying suitable water seepage detection system. Otherwise, regular watch may be kept to detect seepage.

When air conditioning ducts are installed in telecom spaces, water dripping/leaking from AC vent should be controlled and, if required, monitored by water leaking system. Instructions for prevention from liquid cleaning agents, air purifying liquids, pest repellants and sprays usage should be indicated by proper sign writing.

k) *Lighting* – Following are the important considerations for lighting of telecom spaces:

1) Locating light switches near the entrance(s) to the telecom space.
2) Coordinating the lighting layout with the planned equipment layout (especially overhead cable trays) to ensure that lighting is not obstructed.
3) Providing electrical power for the lighting and ICT equipment from different circuits.
4) Placing at least one light or set of lights on normal power and one light or set of lights on emergency/UPS power.
5) Using a light coloured finish on walls, floors, and cabinets to enhance room lighting.
6) Providing task lighting illumination at the point of cable termination.
7) Providing adequate lighting of spaces, which may be controlled by automated controllers such as Building Management System (BMS),if required, or ensured otherwise. Use of dimmers and occupancy sensors is not recommended.

m) *Location* – All telecom spaces shall be located in areas that are best suited (preferably centrally located to reduce the cable length) to serve the occupants of a floor or building. The following shall be observed when locating the spaces:

1) Telecom spaces in multi-floor buildings should be aligned vertically.
2) Telecom spaces should be located in areas that are dedicated to telecom use. Equipment that is not related to the support of telecom spaces (for example, piping, duct work, distribution of building power)

shall not be located in or pass through a telecom space.

n) *Environmental control* – When active devices which are heat producing equipment are present, original equipment manufacturer (OEM) recommended temperature and humidity range should be maintained by adequate arrangement for heat dissipation. If environmental parameters are exceeded, an alarm should be activated. A positive pressure is required to be maintained with a minimum of one air change per hour in the telecom space. More stringent requirements may apply based on the equipment needs in the telecom space. It is recommended to have sufficient arrangements of air conditioners for cooling of telecommunication equipment housed or to be housed in Telecom room and equipment room.

p) *Fire protection* – The telecom spaces shall be equipped with adequate fire detection, alarm and suppression systems as per Part 4 'Fire and Life Safety' of the Code. Fire retardant cables are recommended to be used inside the building to reduce incidences of fire.

q) *Bonding and grounding* – All equipment and cable shields shall be properly bonded to the telecom bonding and grounding infrastructure of the space (*see* 4.1 for details).

3.1.2 *Equipment Room (ER)*

3.1.2.1 An equipment room is an environmentally controlled centralized space for telecom equipment that usually house equipment of higher complexity than telecommunication rooms and also usually houses a main or intermediate cross-connect. Any or all of the functions of a telecommunications room may be provided in an equipment room. ERs differ from TRs in the way, that, ERs are generally considered to serve a building, campus, tenant, or SP, whereas TRs serve a floor area of a building. In some cases, an ER may also contain the EF or it may serve as TR. ERs may be connected to backbone pathways that run both within and between buildings. Although an ER usually serves an entire building, many building designs may use more than one ER in order to provide separate facilities for different types of equipment and services or redundant facilities and disaster recovery strategies.

The initial assessment for design and specifications for an ER shall be based ondetailed information about the site, including,

a) User requirements;
b) Telecom pathway locations;
c) Service providers' requirements;
d) Environment/facility conditions; and
e) Building requirements

3.1.2.2 *Space allocation and layout*

The space allocation and layout may be determined by following methods:

a) *Determining size based on area served* – When the telecom designer does not know what specific equipment will be used in an ER, the designer can use the amount of floor space that the room will serve, to determine the minimum size of the ER. If the usable floor space is also unknown, the usable floor space may be estimated by deducting 20 percent from the total floor area.

   Generally, an area of 9.3 m^2 may be considered for calculating the work areas. If work areas are smaller leading to possible increase in number of work areas in building, the size of the ER should be increased accordingly. The minimum recommended size for ER is 14 m^2. The general practice is to provide 0.07 m^2 of ER space for every 10 m^2 of usable floor space. For special use buildings, such as, hospitals and hotels, ER size requirements may vary.

b) *Telecom service provider space requirements* – If equipment or cable terminations that are owned or maintained by a TSP are to be located inthe ER, then location and amount of space required shall be determined as per the space requirement of TSP.

c) *Telecom equipment locations* — As equipment for communication systems are located in the various equipment rooms throughout the building, these rooms shall be physically secure, aesthetically provisioned and conveniently located. The communication equipment may be located with due consideration of the modular provision of building design and criteria for expansion joints matching to electrical distribution and maximum fire safety distance requirements. The other considerations for telecom equipment location include the following aspects:

   1) Types of cables, their uses, bending radius, turning radius, conduit radius, etc.
   2) *Provision for future expansion* – In view of the evolving nature of the communication technologies, provision for future expansion shouldbe ensured by way of stand-by arrangements. The distribution infrastructure should also be as flexible as possible. Small conduits will quickly fill up and may not accommodate some technologies, for example, low loss broadband or high capacity fibre optic cables. The most flexible distribution design involves cable trays for horizontal (floor level) distribution with large conduit sleeves for wall penetration, where necessary. Vertical trunk distribution should also be achieved with conduit sleeves.
   3) *Maintainability* – As it is difficult to remove or shift just a few cables from a crowded or convoluted conduit system for operational or maintenance requirements, steps should be taken to ensure easy access and maintainability of cable system right in the initialarchitectural design stage.

3.1.3 *Telecommunications Room (TR)*

3.1.3.1 A telecommunications room is the area within a building that houses the telecommunications cabling system and associated equipment. This includes the mechanical terminators and/or cross-connects for floor-serving distribution facility for horizontal cabling and backbone cabling system. There should be at least one TR or TE per floor. TR or TE can also house active equipment, like LAN switches, routers, OLT, DAS, Cable TV or DTH systems etc, or passive equipment, like optical splitters, FDMS. Most of these equipment are available in wall mount units. The switches/routers can also be shared between telecom equipment and other low voltage in-building systems. This reduces the demand on floor space requirements for TR/TE. Sometimes, a TSP with the consent of the building owner may require to provide additional equipment, such as for mobile signal booster, at a later stage, in TR/TE. Therefore, it is recommended to have additional space in advance, especially in tall buildings of five storeys or higher, preferably on top floor.

3.1.3.2 Multiple rooms TEs are required if the cable length between the horizontal cabling (floor distribution) [HC (FD)] and the work area outlet location, including slack, exceeds 90 m (or more in case of optical fibre depending upon its type and application as indicated in **3.2.4.2**). If the usable floor space to be served exceeds 930 m^2, additional TRs should be considered. Following are the guidelines for TR size:

Area Served	*Dimension of TR*
465 m^2 or less	3 m x 2.4 m
More than 465 m^2 and less than equal to 930 m^2	3 m x 3.4 m

NOTE – The size of 3 m x 2.4 m has been specified to allow a centre rack, cabinet, or enclosure configuration.

In smaller buildings, less space is required to serve the telecom distribution needs of the occupants. The size guidelines for smaller buildings should be as below:

Building Smaller Than	*Served as*
465 m^2	Shallow/Walk-in rooms (Walk-in rooms shallbe at least 1.3 m x 1.3 m. Shallow rooms shall be at least 0.6 m deep by 2.6 m wide.)
93 m^2	Wall cabinets, self-contained cabinets, enclosed cabinets

NOTE – Installation of active equipment in shallow or walk-in rooms is not recommended because many types of equipment require environmental controls and a depth of at least 1 m.

3.1.4 *Entrance Facilities (EF)*

Building entrance facilities (EF) provide the point at which outdoor cabling of the telecom service provider interfaces with the intra-building/intra-campus backbone cabling. In cases, where the functions of the EF are combined with the functions of the ER in the same space, the room may house equipment that is owned and maintained by service providers. In these cases, requirements specified by the service providers shall be considered when designing the ER.

If a separate space is required for service providers, it should be in or adjacent to the EF and may require a mesh partition or locked cabinet. A space of at least 1.2 m x 1.83 m shall be considered for each service provider. An entrance facility necessarily be an enclosed space. However, having an enclosed area or access protected area is suggested at all occasions, considering safety requirements.

The duct from the cable vault (CV) of the telecom service provider generally consists of 100 mm conduits encased in reinforced concrete. The exact number of conduits will depend upon the size and use of the building. These conduits may be used forall communication systems serving the building including additional capacity and access cables and pathways capacity. To maintain the safety of the TSP cable, itmay preferably enter the building above the ground and then feed the equipment room.

A separate 230 V .-16/6 A circuit with double outlets should be provided (for plugging in temporary test equipment or to power the tools) every 2.4 m along the EF and ER combined wall. All wall outlets are to be located approximately 300 mm above the finished floor levels with the breaker and clearly labelled. In addition, two dedicated 230 V, 16/6 A sockets should be provided for each (permanently installed) communication service rack. If the sockets of racks are fed from UPS power, appropriate levelling may be provided to distinguish between main power sockets and UPS power sockets.

3.1.5 *Telecommunication Enclosures (TE)*

A TE is simply a case or housing for telecom equipment, cable terminations, and cross-connect cabling for distribution of telecom services on a floor. The TE may also contain access points for wireless services. Although, TEs serve much in the same way as that of a TR, a minimum of one TE should be located on each floor, if no TRis considered on the floor. The TE door(s) may be hinged or removable. If the enclosure consists of metallic components, it shall be earthed.

3.2 Telecom Media and Connecting Hardware

3.2.1 A cabling system consists of cables, equipment cords, patch cords, and connecting hardware components like cable patch panel, MDF and FDMS. All balanced twisted-pair, optical fibre, and coaxial cabling systems are made up of such components. There can be different topologies for cabling used in a building like star, tree, bus bar, ring, etc, or a combination of these to suit different technological requirements. Within a building, most of the wiring is between the work spaces and the equipment room. Wireless systems can also be part of the telecom media. However, connectivity to the network, which delivers telecom service, is generally provided using cables at the back end.

The selection of appropriate style of cabling is important and accordingly, some of the user requirements to be considered before selecting the specifications and style of cabling and connectors for a telecom enabled building may include the following:

a) Number of user work areas and telecom spaces used to serve the building occupants;
b) Types of services and technology used for delivery of services;
c) Number of telecom outlets/connectors desired at each user work area;
d) Number and styles of user equipment (for example, telephony, LAN, building automation);
e) Cabling system transmission performance expectations;
f) Backbone distances and horizontal cable lengths involved in the building orcampus;
g) Future growth expectations (for example, 15 to 20 percent recommended minimum growth factor);
h) Environmental conditions including electromagnetic interference; and
j) Other types of low voltage systems and their network requirements.

3.2.2 The cables should have ferrule marking at the terminations as well as along the length of the cable at suitable interval. Similarly, copper pair/fibre pair should be identifiable at terminating end for easy identification and convenience during maintenance. For the purpose, a suitable chart should be available at locations, like inside cross-connect box. Further, all the documentation of pathways and cables should be properly maintained.

3.2.3 While designing the cabling system for large multi-tenant building, it should be kept in mind that the tenants may prefer subscribing to the services of multiple service providers. Thus, enough space should be available in ducts, pathways, etc, for laying additional conduits/trays, keeping in view the present and future demands. Capacity for pathways (that is, conduit, raceways, trays, baskets) may be planned so that initial installation achieves a fill of 40 percent and at final installation, fill of 60 percent, taking into account the expected future requirements.

3.2.4 Various cabling systems are described under **3.2.4.1** to **3.2.4.3**. For the purpose of reference, details about connecting hardware components and classification of cables by fire safety properties are given in Annex A.

3.2.4.1 *Copper twisted-pair*

The transmission performance of balanced twisted-pair cabling and telecom associated components are based on a number of factors within the cabling or component design. These performance levels use the terms category and class. Standards developed internationally utilize both class and category, depending on the specific cabling element, as described in Table 1.

Table 1 Balanced Twisted-Pair Cabling Channel Performance
(*Clause* 3.2.4.1)

Sl No.	ISO Category/Class	TIA Category	Frequency MHz	Maximum Data Transfer Rate
(1)	(2)	(3)	(4)	(5)
i)	Category 3/Class C	Category 3	16	10 Mbps
ii)	Category 5/Class D	Category 5e	100	1 Gbps
iii)	Category 6/Class E	Category 6	250	1 Gbps
iv)	Category 6A/Class EA	Category 6A	500	10 Gbps
v)	Category 7/Class F	NA	600	10 Gbps
vi)	Category 7A/Class FA	NA	1 000	10 Gbps
vii)	Category 8/Class G	Category 8	1 500 to 2 000	25/40Gbps

NOTE – For Category 8/Class G balanced twisted-pair cabling, the maximum permissible distance is restricted to 30 m.

A large number of cable designs are used in the ICT industry, resulting in various names and acronyms for their identification. Special publication gives balanced twisted-pair cable designations using *x*/*y* designation, where *x* is the overall screen type and *y* is the individual pair screen type, which may be used. Details of various nomenclature based on this, using various categories of cables, are given in Annex A.

NOTE – Special publication may be ISO/IEC 11801:2002 'Information technology — Generic cabling for customer premises'.

3.2.4.2 *Optical fibre*

Optical fibre cables are used in backbone and horizontal cabling applications, when the service is delivered on fibre to the user or inter/intra building communication is to be carried on fibre. Example of former is GPON (Gigabit Passive Optical Network), which require Fibre to Home (FTTH) and the example of latter is LAN implementation using optical network. Transmission of information through optical fibre cables is not degraded by crosstalk, ambient noise, lightning, and most electromagnetic interference (EMI). It has better loss characteristics compared to copper pair. Thus, it permits high data rate communication to be carried out to much larger distances than copper pair.

Optical fibres are classified as either single-mode or multi-mode. Single-mode optical fibres have a relatively small diameter featuring a core of 8 to 11 µm and a cladding diameter of approximately 125 µm. Multi-mode optical fibre has a larger core diameter (for example 50 µm or 62.5 µm) with the cladding of approximately 125 µm. Multi-mode fibre has higher loss compared to single-mode fibre. However, it is generally recommended for in building/intra campus use as it cost less than the single fibre. The latter has low loss characteristics and can carry higher speed to longer distances due to which it is mainly used in long haul applications. However, depending upon the size of the building/campus or availability of various types of cables, combination of both types of cables or only single-mode cable may need to be used. Use of single-mode fibre has the advantage that future upgradation requirements are taken care of right in the beginning.

Optical fibre cables are available in various capacities in terms of number of fibres like 6 fibre, 12 fibre, 24 fibre, 48 fibre, 96 fibre, etc. Each fibre has a different colour which helps in easier identification during installation and operations. The colour scheme is repeated for every group of 12 fibres for higher fibre count cables.

Selection of optical fibre cable size for different segments of cabling depends upon various factors.

The colour code chart for fibre optic cable is as under:

Fibre/Tube No.	*Color*
1	Blue
2	Orange
3	Green
4	Brown
5	Gray
6	White
7	Red
8	Black
9	Yellow
10	Purple
11	Rose
12	Aqua

NOTE – The specifications of the certain types of optical fibre cables are available in Department of Telecommunications, Telecom Engineering Centre (TEC), Govt of India, the details of which can be seen from TEC website, www.tec.gov.in

When it is decided to use optical fibre cable, choice is to be made from among variety of standard cables. There are two broad categories of cables namely OM (multi-mode optical fibre) and OS (single-mode optical fibre). The former is suitable for much shorter distances compared to the later as, data rate supported by cable is a function of cable length used. OM cables are preferred cables for campus applications as they are economical for short distances. OM cables are further sub-categorized into OM1, OM2, OM3 and OM4, which are differentiated based on data speed and distance combinations. Once the data speed and distance to be covered is decided, choice of cable category becomes simpler. When used inside the buildings, attenuation of signals is caused due to cable fibres facing sharp bends. Multi-mode cables show larger attenuation than single-mode cables on bends inside the building. Thus, bend insensitive and fire retardant optical fiber cable as per relevant TEC specification are recommended for use in the buildings.

Considering that backbone cable carries the combined traffic of all work areas andthe growth of data use with time, provision for future expansion should be provided. It is recommended that planning should be done for 10 Gbps to 1 Tbps or above speeds depending upon anticipated requirements of the users. Therefore, when using multi-mode cable, choice may need to be made typically from among OM3 and OM4 cables.

A chart showing typical length and data rate support characteristics of various cables is given below:

Subsystem Backbone	*Lengths Up to*	*Data Rates Up to*
Campus backbones (OM1 fibre)	2 000 m	155 Mb/s
Campus backbones (OM2 fibre)	550 m	1 Gb/s
Building backbones (OM2 fibre)	300 m	1 Gb/s
Building backbones (OM3 fibre)	300 m 100 m	10 Gb/s 100 Gb/s
Campus/building backbones (OM4 fibre)	550 m 150 m	10 Gb/s 100 Gb/s
Campus/building backbones (OS fibre)	10 000 m	100 Gb/s

Enhanced versions of OM3/OM4 cables can also be examined for use. Once the cable category is selected, care should be taken that active equipment which feeds the fibre is equipped with the corresponding interface, to take care of, for example requirement of different optical power source and optical wavelengths for different types of cables. Further, from each TR drop fiber or cable of 2 to 4 fibers are also recommended.

3.2.4.3 *Coaxial cable*

The predominant coaxial cables are Series-6, Series-11, and radio grade (RG) 59. These coaxial cables have a characteristic impedance of 75 Ω. While the termination procedures may be similar, special attention shall be paid to the manufacturer's specific instructions for termination and connectors. The cables/passive components used for DAS/IBS system should cover frequency range from 400 MHz to 4 000 MHz. Coaxial RF telecom cables of various sizes (for example, 12.70 mm, 22.23 mm, 31.75 mm) or as required for efficient RF signal transmission be deployed to ensure comprehensive mobile signal coverage within the building.

Coaxial cable is used for computer networks, CATV and video systems. Historically, coaxial cable was designated as RG cable. Coaxial cables used in broadband applications are available in the market with following constructional variations:

a) Centre conductor diameter;
b) Centre conductor being solid or stranded;
c) Dielectric composition;
d) Outer braid's percent of coverage; and

e) Impedance.

3.2.5 *Wireless Systems*

Wireless connectivity is also provided inside the building for enabling access to public mobile network or for enabling internet/intranet connectivity with flexibility of user terminal movement. Various wireless systems are described below:

a) *Wireless LAN (WLAN) access point (AP)* – A wireless LAN (WLAN) access point (AP) is a network device located in areas of a building or campus and placed in relatively close proximity to where users interact with their wireless enabled network devices. APs allow wireless enabled devices (for example, computer, printer, mobile, tablets, laptop, IoT devices or any other device) to connect through Wi-Fi or related standards. Wireless networks here can even include the networks of low voltage automation system in the building as well as M2M/IoT smart buildings/smart homes/smart offices. There are various wireless standards for M2M/IoT device connectivity. AP network devices are typically mounted on walls or ceilings with structured cabling that provides a physical connection to a HC (FD), which provides further connectivity to private/public network through the facility installed in TR/TE.

b) *Wi-Fi access points (WAP) with centralized controller* – Access point shall support at least IEEE 802.11 ax/be or any higher versions/ more modern standards. There may be numbers of WAPs to cover area/building and in such situation user may prefer centralized controller. Centralized controller can be hardware or software based and depending upon number of WAPs may be provided at each ER/TR/TE. These access points can also be used for connecting the low voltage automation systems (building management system and other in-building system). The access points are connected to the network as described in (a).

NOTE – However the secure access to Wi-Fi network and authorisation of users is critical will need to be ensured by owner.

c) *Distributed antenna systems (DAS)/In-building solutions (IBS)* – DAS/IBS are signal distribution systems for strengthening the public mobile wireless signal inside the buildings or installations. They require cable and passive antenna to be installed in corridors/rooms, normally along the centre line. The active equipment, wherever required can be installed in ER/TR/TE, on which cables to/from DAS/IBS are connected.

d) *Wireless repeater* – It takes an existing signal from a wireless router or wireless access point and rebroadcast it with amplified signal. It is also called wireless range extender. This is used to mitigate low signal issues.

While planning and installing wireless devices, it is required to maintain enough spacing between them to avoid frequency overlap and interference by their own signal. The wireless coverage area radius is impacted by a number of factors including the following,and these factors like penetration losses, signal to noise ratio etc, are to be taken into account by using for which the site survey approach and planning. An appropriate planning tool should be considered for this purpose.

1) Building materials (concrete, sheetrock, wood, steel, etc);
2) Building configuration (closed, semi-closed or open space); and
3) Building furnishings (cabinets, partitions, furniture, etc).

Periodic monitoring is desirable for maintaining wireless coverage .

3.2.6 *Connecting Hardware*

The ends of cable terminating in work areas or on intermediate equipment like LAN switches, splitters, etc, need to be provided with connectors. There can be variety of equipment which may be connected to the cable ends. Hence a careful planning should be done to identify types of connectors with flexibility to connect variety of equipment keeping in view also the fact that the cable ends are permanently wired on to connector panels in the work areas. Details of the typical connecting hardware are given in Annex A.

3.3 Backbone Cabling Media Distribution and Building Pathways

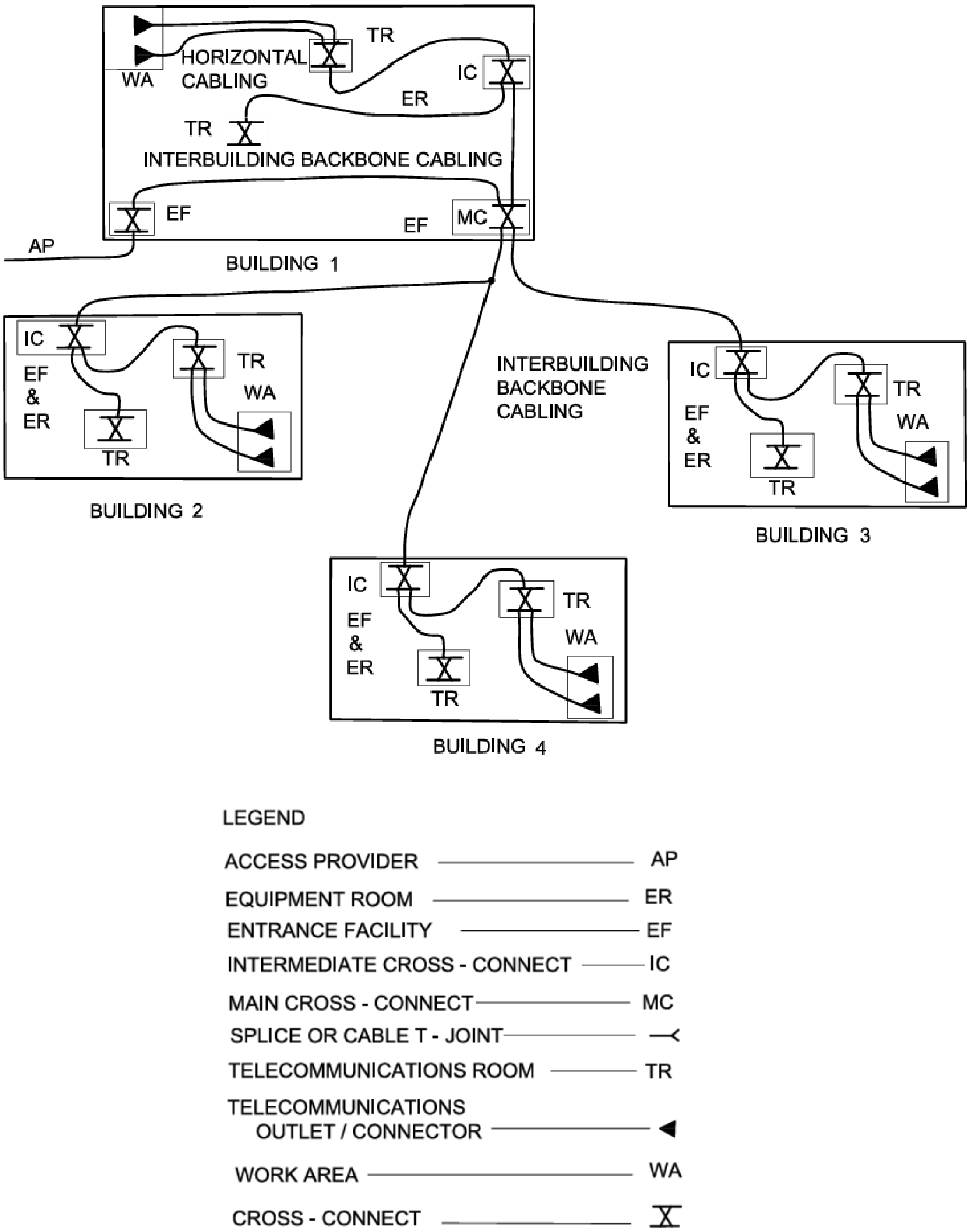
The backbone distribution system provides interconnection between telecom spaces, that is, telecommunication rooms, equipment rooms and entrance facilities. It consists of the backbone cables, intermediate and main cross-connects, mechanical terminations and patch cords or jumpers used for backbone-to-backbone cross-connection. This includes,

a) Vertical cable connections between floors (risers);
b) Cables between an equipment room and building cable entrance facilities; and
c) Cables between buildings (inter building).

The elements of the telecommunications cabling system structure are:

a) Horizontal cabling,
b) Backbone cabling,
c) Work area,
d) Telecommunications rooms,
e) Equipment rooms, and
f) Entrance facilities.

Figure 1 illustrates a representative model for the various functional elements that comprise a building campus/complex telecommunications cabling system. It depicts the relationship between the elements and how they are configured to create a total system.



NOTES

1. This figure is not meant to be an all-inclusive representation of the telecommunications cabling system and is provided only as a typical example.
2. All cross-connects located in the telecommunications rooms (TRs) in this figure are horizontal cross-connects (HCs).

FIG. 1 TYPICAL TELECOMMUNICATIONS CABLING SYSTEM

3.31 *Backbone Cabling and Topologies*

Cabling between the building cross-connect (main or intermediate) and the horizontal cabling (floor distribution) [HC (FD)] is designated as backbone cabling. In a multi-building complex, inter-building cabling, though terminating in the EF, is designated as inter-building backbone cabling. The cable(s) can be of any type, for example, copper pair, optical fibre or coaxial.

3.3.1.1 The two primary options for connectivity are:

a) Star topology, where the HC (FD) is connected directly to the main cross-connect (campus distributor) [MC (CD)] which is further connected to inter building backbone, where applicable.
b) Hierarchical star topology, where some or all of the HCs (FDs) are connected to an intermediate cross-connect (building distributor) [IC (BD)], which in turn, is connected to the MC (CD).

3.3.1.2 The best design is the star design between the building MC and the HCs. However, in some extremely large buildings (for example, high-rises), a hierarchical star may be an option for consideration. The trade-offs between different cable sizes and labour cost is to be considered to determine a suitable cost effective solution. The direct connections between HCs are generally avoided. Although this kind of connectivity might be of value in providing a redundant path, a user should design a link from HC to HC only in specific applications. The best design is the star design between the building MC and the HCs.

3.3.1.3 A typical star configuration in a building with MC (CD) or HC (FD) is given Fig. 2.

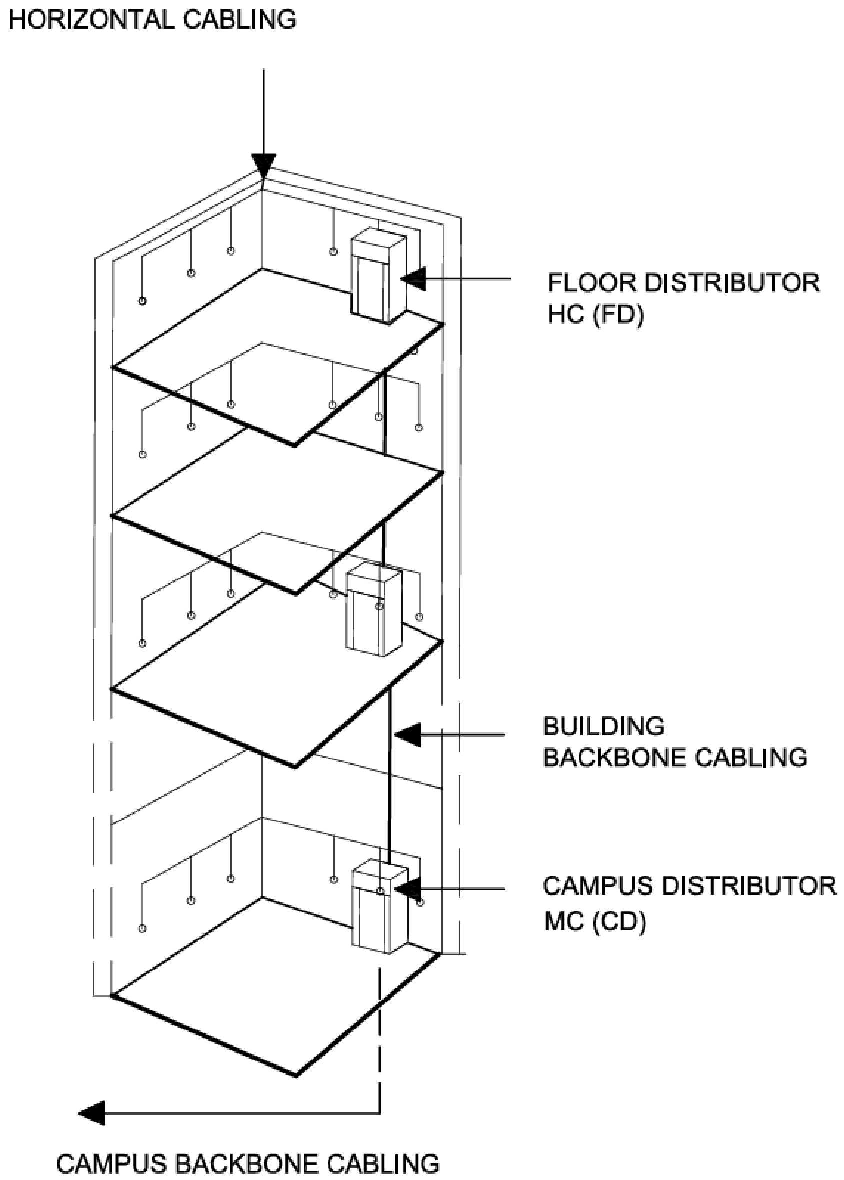
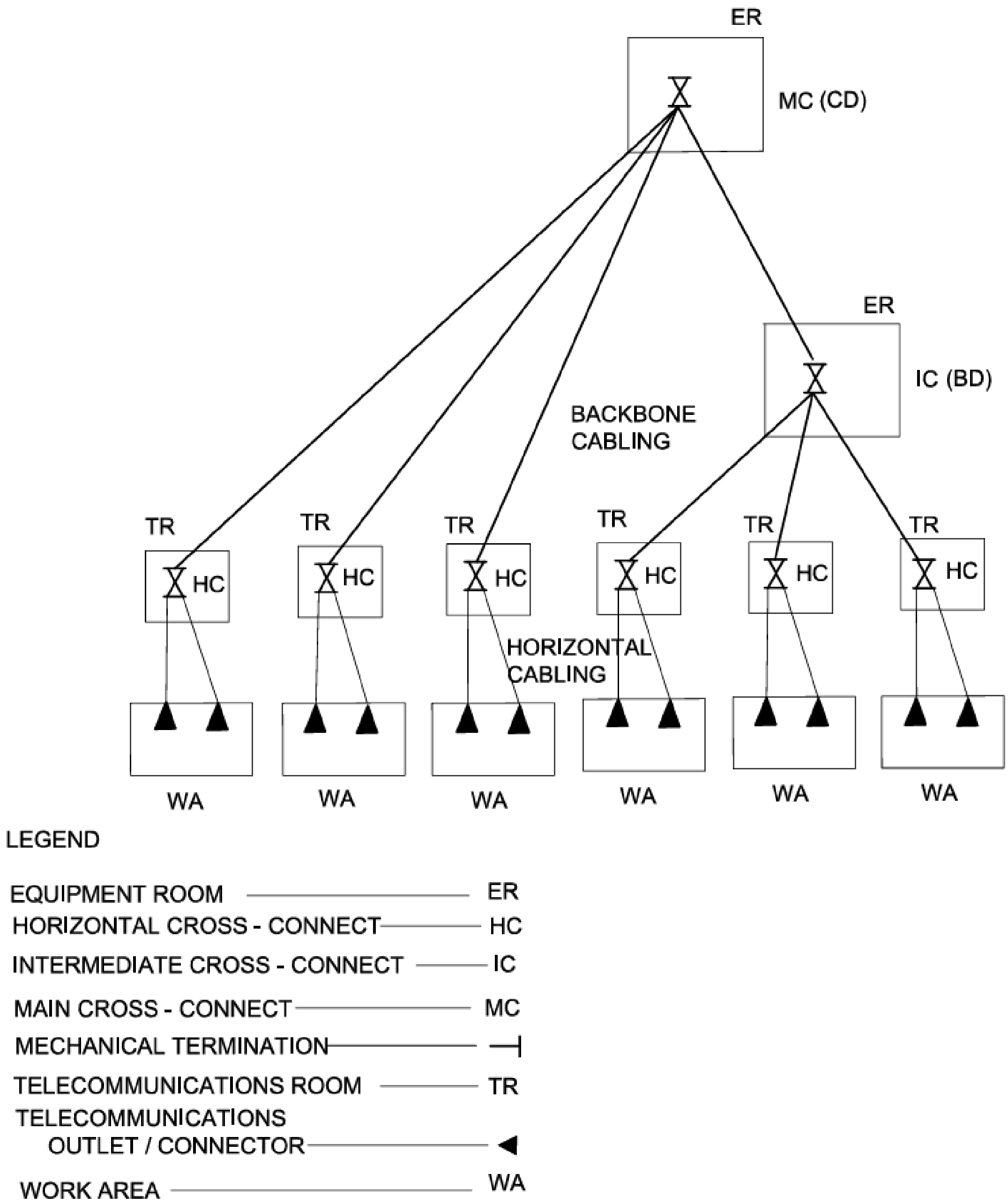


FIG. 2 TYPICAL CABLING STAR CONFIGURATION IN A BUILDING

3.3.1.4 An example of backbone hierarchical star topology with addition of IC (BD) isshown in Fig. 3.



NOTES

1 Backbone cabling covers intra and inter building cabling.

2 IC is a cross-connect for in building cabling.

FIG. 3 EXAMPLE OF BACKBONE HIERARCHICAL STAR TOPOLOGY

3.3.2 *Inter-Building Pathways*

In a campus environment, inter-building pathways are required to connect separate buildings. For this, underground, buried, aerial and tunnel are the main pathway types used. As the complexes have varying conditions of land features and locations, size and use of building, choice if any or combination of the pathways need to be made based on local requirements. The cable running over the pathways generally terminates at the entrance facility of the building at both ends.

3.3.2.1 *Underground inter-building backbone pathways*

The pathway shall be fully covered and the cabling shall be installed within protective conduit or ducting for the entire external section of the cable route in all inter-building pathways. Provision should be made for existing as well as future demand. Underground pathways consist of conduit, ducts and troughs; possibly including manholes. The manhole can be planned normally, if

a) The cable requires joint;
b) The distribution of copper/fibre pair is required midway; or
c) Numbers of bends in the path are more than two.

Each manhole should be dimensioned to accommodate spare cable of 2 m to 4 m length in each direction, which is generally kept in spare loop to take care of maintenance needs. All conduit and duct shall have a diameter of at least 100 mm. Bends are not recommended; however, if required, there should be not more than two 90° bends.

In a multi-building and multi-operator campus, an Underground Cable Vault (UCV) may be considered close to entrance facility. Manholes/pull holes may also be provided for O and M activity in the outside plant pathway system for the pulling, placing, and splicing of cables. Size of UCV, manholes and pull holes should be decided based on the pathway capacity, number and types of cables, etc. All such points should be covered with properly marked iron covers of appropriate thickness and structural support below them keeping in view the load they are expected to bear due to pedestrian or vehicle movement.

In the planning for underground cabling, the following shall be considered:

a) Limitations dictated by the topology (this includes land development);
b) Grading of the underground pathway to permit proper drainage;
c) Need to vent gaseous vapours; and
d) Amount of vehicle traffic to determine the amount of cover over the pathway and whether or not concrete encasement is required.

3.3.2.2 *Direct buried inter-building backbone pathways*

In this case, the telecommunications cables are completely covered in earth. Direct burial of telecommunications cables is achieved by trenching, augering or boring (pipe-pushing). When selecting a route for the pathway, it is important to consider the landscaping, fencing, trees, paved areas and other possible services. Direct burial has the challenges of cable repair in case of faults and also in future upgradation.

3.3.2.3 *Aerial inter-building backbone pathways*

An aerial pathway consists of poles, cable-support strand and support system. Some considerations to make when using aerial backbone include the following:

a) Appearance of the building and surrounding areas;
b) Separation and clearances for electrical installations and roads;
c) Span length, building attachments, storm loading and mechanical protection; and
d) Initial number of cables and future growth potential.

3.3.2.4 *Tunnel inter-building backbone pathways*

Tunnels provide pathways for conduit, trays, wire-ways or support strand. Normally tunnels support other building services too. Hence, the location of telecom pathways within a tunnel should be planned to allow for accessibility as well as for separation from other services. In general, tunnelling inside the premises for telecom services alone may not be cost effective.

3.3.3 *Backbone Building Pathways*

Backbone building pathways can be built in various ways depending upon the building layout, locations of TR/TE, etc. While designing and implementing such pathways, certain requirements need to be met and precaution taken. Typical topologies and requirements/ precautions relating to these are described below:

a) *Vertically pathway topology* – Vertically aligned TRs with connecting sleeves or slots are the most common type of backbone pathway though it is not a necessary condition. Vertical alignment is desirable because the building planner can stack them with other mechanical spaces, and it makes distribution of telecom cables more efficient because of shorter conduits and cabling runs. If the TRs/TEs are not aligned vertically above one another, the conduits interconnecting them will have horizontal offsets. There shall be not more than two 90° bends in any such conduit run. Any bend shall have an inside radius10 times the diameter of the conduit (typically 1 m). If these conditions cannotbe met, then intermediate pull boxes shall be used wherever a non-standard transition is required. This pull box shall be at least 600 mm x 600 mm in the plane of the attached conduits, and 150 mm deep. All conduits other than simple sleeves between floors shall be fitted with a continuous 1.5 mm nylon pull rope, or a 0.6 mm steel fish wire or a 0.5 mm fibre composite fish wire.

b) *Conduits, trays, slots, sleeves, and ducts* – All rigid metallic conduit pipes shall be of steel and shall be conforming to accepted standard [8-6(1)]. The wall thickness of the pipe shall be not less than 1.6 mm (16 SWG) for conduits up to 32 mm diameter and not less than 2 mm (14 SWG) for conduits above 32 mm diameter. These shall be solid drawn or reamed by welding and finished with galvanized or stove enamelled surface.

All non-metallic conduit pipes and accessories shall be of suitable material complying with the accepted standards [8-6(2)] for rigid conduits, and accepted standards [8-6(3)] for flexible conduits. Such pipes shall not be exposed.

The vertical backbone pathway consists of telecommunications rooms located on each floor, tied together by sleeves or slots. In this context, the term 'sleeve' refers to a circular opening in a wall, ceiling or floor to permit the passage of cables between adjacent spaces. A 'slot' is the same as a 'sleeve', except that the shape of the opening is usually rectangular. The cable sleeves or slots are positioned adjacent to a wall on which the backbone cables can be supported. The recommendation in respect of slots and sleeves are as under:

1) Slots with a minimum 25 mm high curb.
2) Sleeves to extend a minimum of 25 mm above the floor level and a maximum of 77 mm above the floor level. Sleeves should be located at a minimum of 25 mm from the wall or between adjacent sleeves to provide room for bushings, but not so far from the wall that it becomes a tripping hazard or create too large a cable span from the sleeve to the backboard/tray.

c) *Riser systems* – For connectivity to TR/TE on upper floors from the building EF, conduit or raceway should preferably be provided vertically. Vertically mounted ladder rack shall be mounted on the wall between incoming and outgoing sleeves within the TR/TE. The ladder rack should be used to provide strain-relief for cables transiting TR/TE within the riser system. If the building plan is large enough to require a second communications TR/TE on one or more floors, then the riser pathway should preferably be duplicated from the EF up to second set of TR/TE.

d) *Vertical pathway size* – A minimum of three 100 mm diameter conduits, or equivalent raceway cross section, should be provided between the TR/TE on adjacent floors and between the EF and the first floor TR/TE.

e) *Access to the roof* – For installations like antenna, powering the roof top/tower top equipment, access shall be provided through suitable number of conduits. This connectivity from the roof should be seepage and rodent proof. A minimum of two 75 mm and one 20 mm conduit shall extend from the topmost TR/TE to the roof terminated in a weatherproof metal enclosure. Sometimes, it may not be feasible or desirable to have direct vertical access, thus requiring horizontal extension from the rooms before vertical extension, the user may keep this in view for taking action with respect to architectural considerations.

f) *Pathway finish details* – Conduit shall be free of burrs or sharp edges. Sheet metal sleeves, if used, shall have rolled edges. Conduits or sleeves shall protrude at least 25 mm from the surface they penetrate but not more than 75 mm. Conduits shall be fitted with a smooth bushing.

g) *Fire protection of shafts* – All penetrations shall be filled with fire resistant material. Fire compartment plan and integrity of compartment should be maintained by either blocking permanently or by recognized systems automatically responding to temperature increase.

h) *Open cable shafts* – Open cable shafts should be used when available and where large quantities of cables are required on a floor that is distant from the main ER. Backbone cable pathways shall not be located in elevator shafts.

j) *Enclosed metallic raceways or conduits* – Enclosed metallic raceways or conduits are also used as vertical and horizontal cable pathways. It should be bonded to form a common bonding network.

k) *Cable trays* – A cable tray can be used as a vertical cable pathway within shafts or as part of the pathway between vertically aligned TRs. A cable tray can be open or covered and provides a means for attaching vertical cable runs to the cable tray members. The cable tray can also accommodate ethernet LAN cables running from building management system and other low voltage automation system in the building.

3.3.4 *Ethernet in the First Mile (EFM)*

Ethernet in the first mile (EFM), also known as ethernet to the last mile, describes the access network from the access point to the subscriber's premise. The first mile is the critical connection from business and residential users to the public and the public network.

Ethernet is the dominant mode of digital connectivity to user computers and other devices. Local Area Network (LAN) connectivity is extended to the end user computers through ethernet cable and connector. Ethernet cables generally used are Cat 5e and Cat 6. However, higher categories of cables are available (Cat 7 and Cat 8), which supports data rates of 10 Gbps and 40 Gbps. In many implementations, backbone and horizontal cabling may be on optical fibre. Such implementations address the Cat 5e/Cat 6 cable length limitations as only the last drop from TR/TE to the work area will use Cat 5e/ Cat 6 cable.

However, in many large buildings, optical to ethernet converters/switches may be required to be installed beyond TR/TE also, which may be installed in safe places in corridors false ceiling, work area, etc, where provision for supply of power should also be made. This holds true for Cat 5e/Cat 6 backbone and/or horizontal cabling also. Cabling to work area may be through conduits inside the wall or conduits on open surfaces. In cases where multiple tenants want to set up their own LAN, theymay set up their system and horizontal cabling. However, they should preferably use backbone cabling of the building to reach EF for further connectivity to a telecom service provider for internet/leased bandwidth, etc.

3.4 Horizontal Cabling Media Distribution and Building Pathways

A horizontal distribution system consists of the horizontal cabling, the horizontal pathways supporting the horizontal cabling, and the telecom spaces that support the horizontal pathways. As horizontal distribution systems, cabling, and pathways often change direction, elevation, or physical orientation to accommodate obstructions, barriers, and other building systems, the use of the term horizontal in the name of the element does not require that the elements be placed or installed parallel to the ground or floor.

3.4.1 *Horizontal Cabling Systems*

The horizontal cabling is the portion of the telecommunications cabling system that extends from the work area telecommunications outlet/connector to the horizontal cross-connect in the telecommunications room (TR). The horizontal cabling includes horizontal cables, telecommunications outlet/connectors in the work area, mechanical terminations, and patch cords or jumpers located in the telecommunications room, and may include multi-user telecommunications outlet assemblies and consolidation points.

3.4.1.1 The following media types can be considered as options for horizontal cabling:

a) Four-pair 100 Ω unshielded twisted-pair (UTP) or screened twisted-pair (ScTP) cables with a distance limit of 90 m taking care of 10 m patch cord/jumper cable required for work area.
b) In case of optical fibre, OM cable normally of grade lower than or equal to the backbone cable may be selected. Such limitation is not faced if OS or appropriate ITU-T standard single-mode cables as mentioned in **3.2.4.2** are used. Distance limits with respect to data rate to be supported on horizontal cabling system may be seen from table under **3.2.4.2**. Care should be taken that the equipment for corresponding fibre interface is selected.

While laying cables, maximum recommended length of cable by including provision for jumper cables/patch cords in TR and extension in work area should be kept in view.

3.4.2 The requirements for horizontal pathways, measures for avoiding electromagnetic interference in the design of cabling pathways are described in **3.4.2.1** and **3.4.2.2**.

3.4.2.1 *Horizontal pathways*

Horizontal pathways are used for distributing, supporting, and providing access to horizontal cabling and telecom associated connecting hardware between the telecom outlets/connectors and the HC, typically located in the ER, TR or TE. Horizontal cabling is contained within horizontal pathways. Generally, the horizontal pathways are one of two types:

a) Continuous pathways (for example, conduit, cable tray, cable matting) used for containment of telecom cabling.
b) Non-continuous pathways (for example, the space between cable supports such as J-hooks) through which cables are placed between physical supports or containment components.

A pathway component should be designed to accommodate all standards compliant cabling and address the potential need for change and expansion during the life cycle of the cabling system and building. The emphasis should be first on the design of pathway systems and then on the cabling systems design. This approach helps to ensure a robust pathway system that supports the cabling installation over the facility's life cycle. As frequently accessing or changing the horizontal cabling leads to disruption to occupants, the choice and layout of horizontal cabling types are important to the design of the building structured cabling system. The following should be considered for the horizontal distribution system's design:

a) Allow for the accommodation of change over the facility's life cycle with the goal of reducing long-term maintenance and operational costs.
b) Utilize standardized cabling, components and systems.
c) Include appropriate pathway and cabling components to accommodateease of access and a variety of user specified technology applications.

The horizontal cabling system should be designed in order to support various telecom applications, including,

a) Voice services;
b) Data services;
c) Audio and video services; and
d) Building signalling systems [for example, smart building ICT systems,building automation systems (BAS), and fire safety and security systems.

It is preferable to have provision for conduits, junction box, etc, during planning and construction stage for providing radio/wireless data equipment at the centre line of rooms and corridors to avoid unplanned provisions later on.

3.4.2.2 *Avoiding electromagnetic interference (EMI)*

Avoiding electromagnetic interference (EMI) is an important consideration in the design of cabling pathways. Providing physical separation from sources of EMI for these elements of the telecom infrastructure inherently provides separation of their contents (for example, cable and connecting hardware).

The telecom pathways should be located away from sources of EMI to the extent feasible, including,

a) Electrical power cabling and transformers;
b) Rf sources;
c) Large motors and generators;

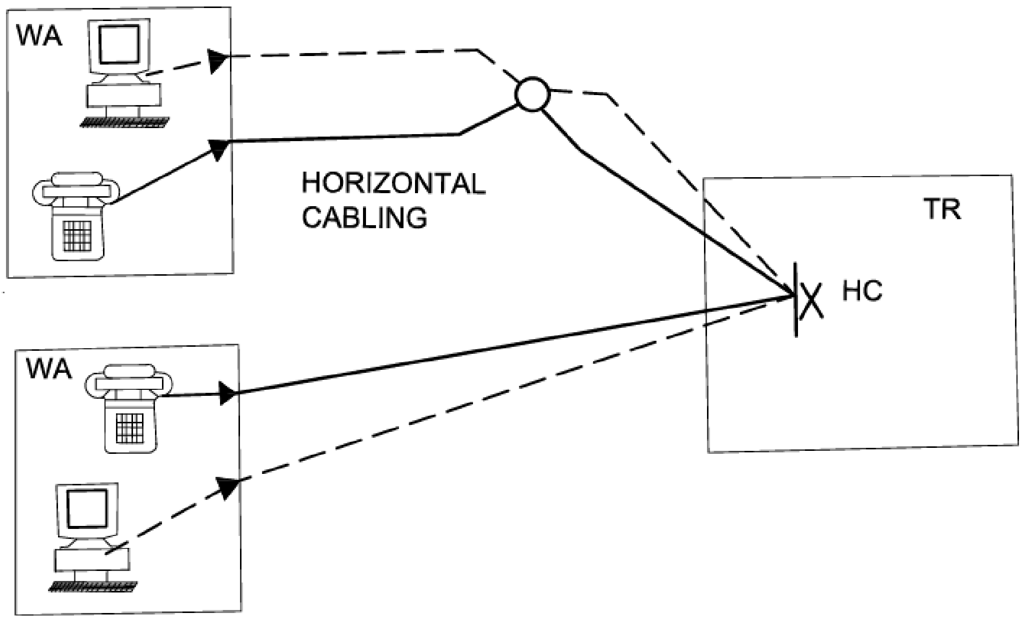
d) Induction heaters;
e) Arc welders;
f) X-ray equipment; and
g) Photocopy equipment.

3.4.2.3 *Topology*

Horizontal cabling should be installed in a physical star topology. Each telecom outlet/connector should be cabled directly to an HC (FD) in the appropriate telecom space. Exceptions to this practice are possible, when,

a) A consolidation point (CP) or multi-user telecommunications outlet assembly (MUTOA) is used to connect the open office cabling;
b) A transition point (TP) is required the connect to under-carpet cabling; or
c) Centralized optical fibre cabling is implemented from main cross-connect (campus distributor) [MC (CD)] to the work area(s).

Some applications may utilize a bus, ring, or tree topology, which can be implemented within a physical star topology. However, in case of large number of work areas, ring or tree topology may require intermediate distribution points like MUTOA, etc. Typical horizontal and work area cabling using a star topology is shown in Fig. 4.



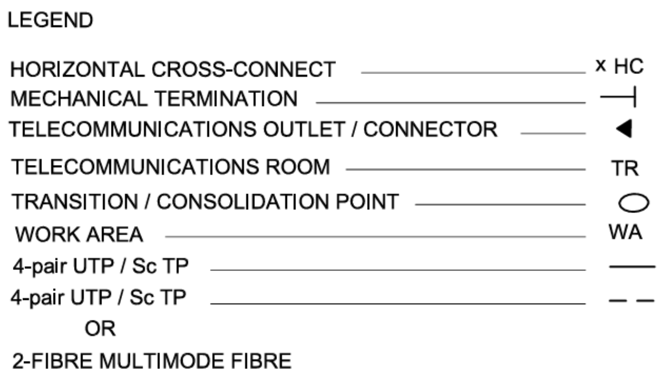


FIG. 4 TYPICAL HORIZONTAL AND WORK AREA CABLING USING A STAR TOPOLOGY

3.4.2.4 *Work areas and open office cabling*

3.4.2.4.1 The work area includes those spaces in a building where occupants normally work and interact with their ICT equipment. While work areas have traditionally been fixed, discrete locations, open office cabling design practices have introduced flexible layouts to support collaborative work by small teams. Such spaces are often rearranged to meet changing requirements of group work. Many other open office work situations also require frequent reconfiguration. An interconnection in the horizontal cabling allows open office spaces to be reconfigured frequently without disturbing horizontal system cabling runs. Work area equipment that may require access to the horizontal cabling includes,

a) Telephones;
b) Networking equipment;
c) Fax machines;
d) Computers;
e) Network peripherals; and
f) Any device plugged into a telecom outlet/connector that is located withinthe work area.

3.4.2.4.2 The key elements of open office cabling are the MUTOA and CP. To accommodate equipment in the work area, following components are typically used as needed:

a) Telecom outlet/connector.
b) Work area equipment cords.
c) MUTOAs and CPs.
d) WAPs.

Some of these components and requirements or recommendations relating to them are described below:

1) *Multi-user telecom outlet assembly (MUTOA)* – The MUTOA serves as a method of connecting more than one user (work area) to the horizontal cabling

system. MUTOAs may be advantageous in open office spaces that are moved or reconfigured frequently. A MUTOA facilitates the terminationof horizontal cabling system cables in a common location within a furniture cluster or similar open area. The use of MUTOAs allows the horizontal cabling to remain unchanged when the open office plan is changed. Work area equipment cords originating from the MUTOA should be routed through work area pathways (for example, furniture pathways). Each furniture cluster should have one MUTOA which may typically serve 12 work spaces. The work area equipment cords shall be connected directlyto work area equipment without any additional connections. For copper cables, any combination of horizontal, work area cables and equipmentcords may not exceed 100 m. The work area cables shall be connected directly to work station equipment without the use of any additional intermediate connections (*see* Fig. 5).

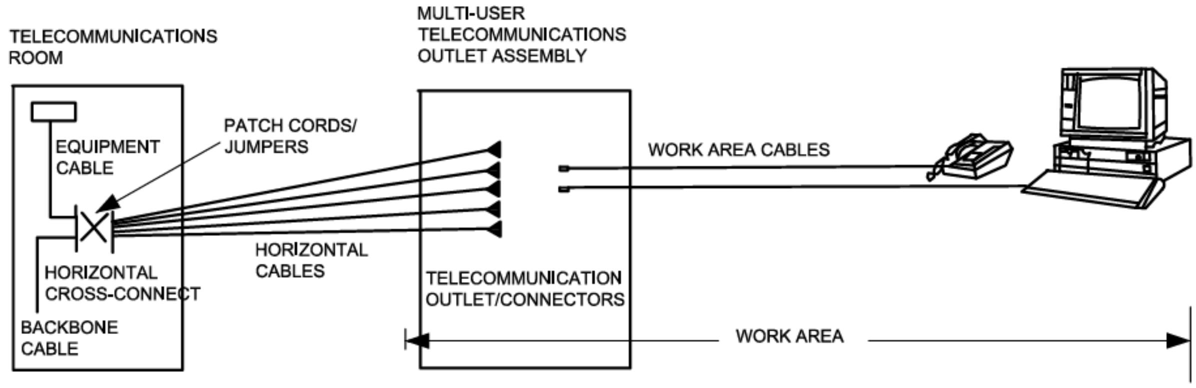


FIG. 5 APPLICATION OF MULTI-USER TELECOMMUNICATIONS OUTLET ASSEMBLY

2) *Consolidation Point (CP)* – The consolidation point (CP) is an interconnection point within the horizontal cabling system. Like the MUTOA, a CP may be used for balanced twisted-pair cabling or optical fibre cabling. The functional difference between the CP and the MUTOA in the open office environment is that the CP introduces an additional connection for each horizontal cabling run. A CP may be useful when reconfiguration is not so frequent as to require the flexibility of the MUTOA. The CP may be located in the suspended ceilings, access floors, modular office furniture or work area. Further CPs may serve a zone consisting of number of work areas even in different rooms.

Some additional considerations and guidelines that apply specifically to the CP are as under:

i) Cross-connections should not be used at a CP. Not more than one CP should be used within the same horizontal system cable run so as to avoid additional points of failure. Depending upon the size and number of the cables, there can be a single CP for all cables or separate CPs for different sets of cables.
ii) For balanced twisted-pair cabling, the CP should be located at least 15 m from the HC (FD) in order to reduce the effect of Near End Cross Talk (NEXT)

and return loss from multiple connections in close proximity.

iii) CPs shall be located in fully accessible and permanent locations. CPs shall not be located in an obstructed area.

iv) The CP should be sized and cabled so that it meets the telecom requirements of the zone it serves. If the floor space requirements change for an existing CP, then the CP should be reconfigured to accommodate the new requirements (*see* Fig. 6).

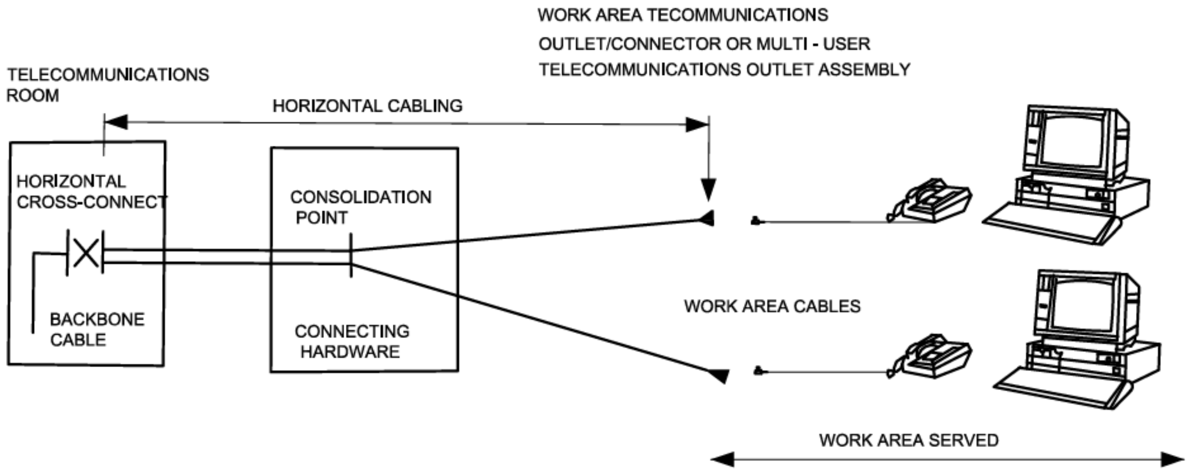


FIG. 6 APPLICATION OF CONSOLIDATION POINT

3.4.2.5 *Centralized optical fibre cabling (fibre to the desk)*

The HCs (FD), deployed throughout a building and located on each floor of a building, offers maximum flexibility to the user, especially in the deployment of distributed electronics or in multi-tenant buildings. In spite of the advantages of distributed cross-connections, some users may prefer data networks with centralized electronics which requires centralized cabling to provide connections from the work areas to the centralized cross-connect. Any of the following methods can be used for cabling:

a) Pull-through cabling from the centralized cross-connection;
b) Interconnection cabling in a floor-serving telecom space; and
c) Spliced cabling in a floor-serving telecom space.

However, flexibility for rearrangement of work areas and need for additional work areas in future by the user should be kept in view while adopting any of the above methods.

4 SPECIFIC REQUIREMENTS FOR TELECOM INFRASTRUCTURE CABLING

4.1 Telecommunications Bonding and Grounding

The bonding and grounding (earthing) infrastructure of a telecom installation is an essential part of an information technology systems (ICT) design. Grounding systems are an integral part of the signal or telecommunications cabling system that they support. In addition to helping protect personnel and equipment from hazardous voltages, a proper grounding system may reduce electromagnetic interference (EMI) to and from the telecommunications cabling system. Improper grounding can produce induced voltages and those voltages can disrupt other telecommunications circuits. Grounding and bonding shall meet the appropriate requirements and practices of applicable standards.

The overall purpose for the ICTs bonding infrastructure is to equalize potentials between metallic surfaces predominantly in the event of lightning, a.c. electrical system faults, electromagnetic induction, or electrostatic discharge.

The Telecommunication Main Grounding Bus Bar (TMGB) serves as the dedicated extension of the building a.c. grounding (earthing) electrode system for the ICTs infrastructure. It serves as the central attachment point for the Telecom Bonding Backbone (TBB). Telecom Grounding Bus Bar (TGB) is the grounding (earthing) connection point for ICTs infrastructure systems (for example, cabling, pathways) and ICTs equipment in the area served by an ER or TR. The TMGB and TGB should be a pre-drilled copper bus bar with holes for use with standard-sized lugs. A TBB is a ICTs bonding conductor to connect equipment/TRs/TEs on multiple floors of a building with an ultimate connection to the TMGB. Typical telecommunication grounding and bonding arrangement is shown in Fig. 7.

NOTE- Grounding and earthing are used inter-changeably

TMGB is recommended for minimum dimensions of 6.35 mm thick, 101.6 mm wide and variable in length. The TBB dimensions are as under:

TBB Size AWG	*TBB Length Linear* m
Less than 4	6 (13.29)
4 to 6	4 (21.14)
6 to 8	3 (26.65)
8 to 10	2 (33.61)
10 to 13	1 (42.39)
13 to 16	1/0 (53.46)
16 to 20	2/0 (67.40)
Greater than 20	3/0 (84.97)

NOTE — The figures given in parentheses are in mm^2.

4.1.1 *Meshed Bonded networks*

The mesh bonded networks provide enhanced immunity to EMI compared to that provided by the other bonding networks. This may be preferred for application, where high density of ICT equipment are installed, for example data centres, hospitals, airports. A merged MESH-BN and protective earthing network in buildings shall include the interconnections to the integrated lightning protection system, bonding measures of antenna installations (including satellite receiving equipment under private property) and cable networks, bonding measures of information technology cabling. The typical indicative diagram for meshed bonded network is given in Fig 8.

NOTE – For further information refer special publication, ISO/IEC 30129 : 2015 'Information technology — Telecommunications bonding networks for buildings and other structures'.

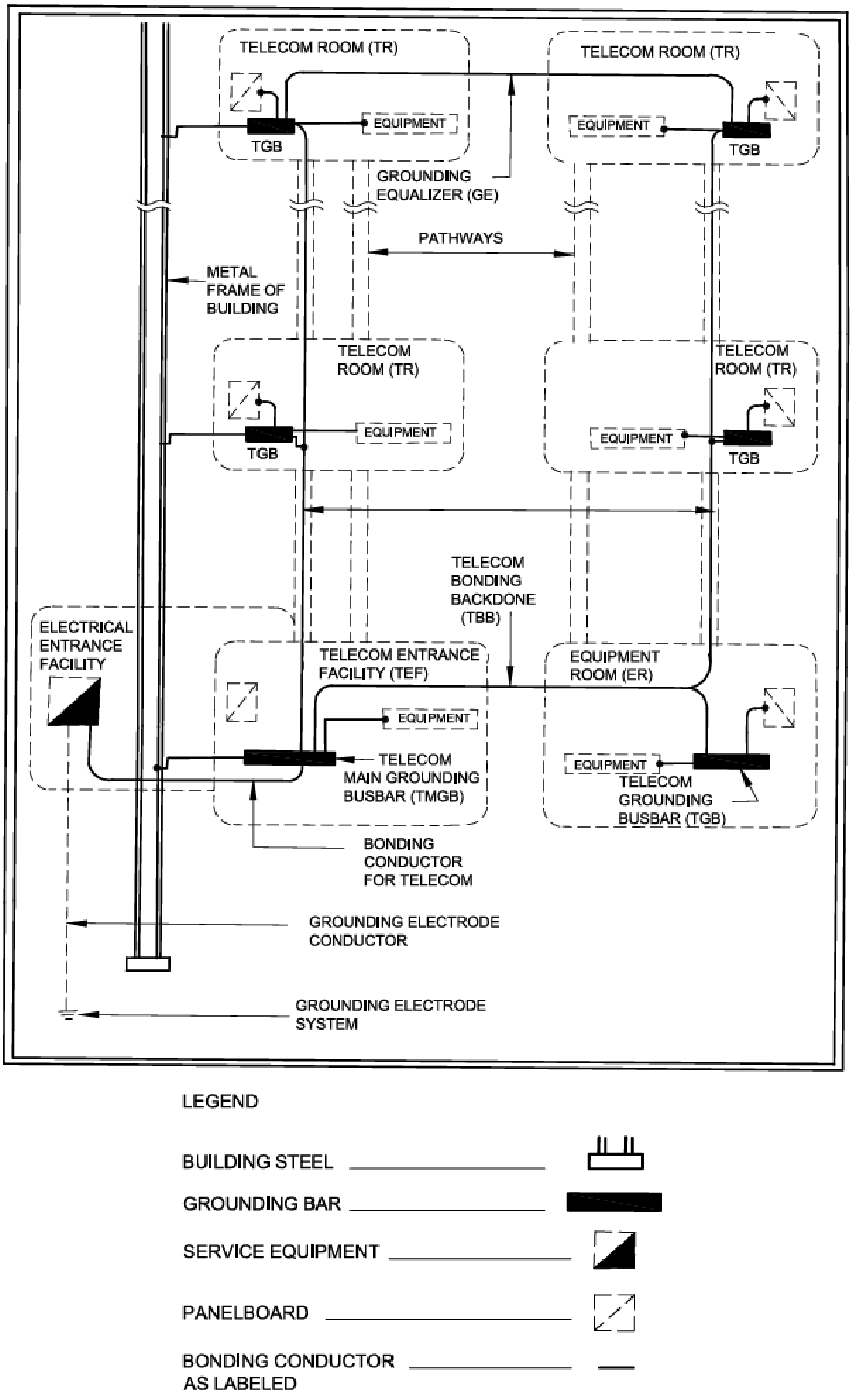


FIG. 7 TYPICAL TELECOMMUNICATION GROUNDING AND BONDING ARRANGEMENT

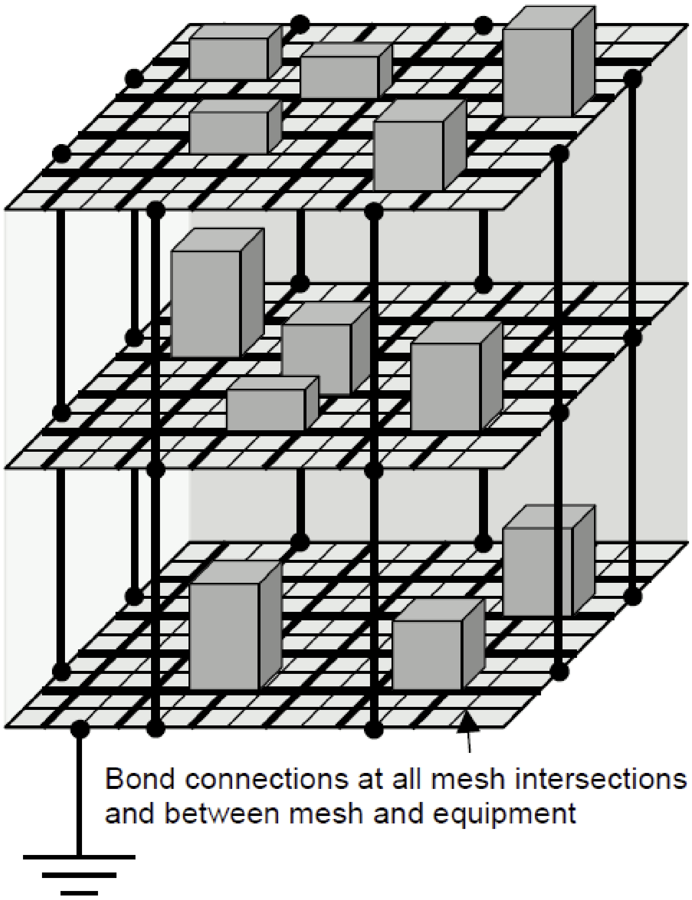


FIG. 8 MESH-BN WITH EQUIPMENT CABINETS, FRAMES, RACKS, CBN AND GLOBAL EARTHING BONDED TOGETHER

4.2 Installation and Workplace Safety

4.2.1 *Cabling Installation Guidelines*

The installation of system components has a tremendous effect on the final performance level of the network; therefore, it is essential to ensure that the performance of the entire network is not diminished through improper installation. The cables can be easily damaged if they are improperly handled or installed. It is imperative that certain procedures be followed in the handling of these cables to avoid damage and/or limiting their usefulness.

Care shall be taken not to stretch or abrade cables during installation, that is, the pulling tension for cables shall not be exceeded. Cables that pass through the infrastructure of the building shall be suitably protected against damage. Through walls and floors, this shall involve an appropriate type of sleeve; through any form of metalwork or stiff plastic then a rubber grommet shall be used.

To ensure cable management and also strain relief, cables shall be properly dressed using velcro cable ties. However, cable's ties should never be over tightened. On vertical runs, the cables shall be dressed and tied from the bottom up, thus putting minimum strain on the cables. In order that the system may be easily re-routed, or damaged sections quickly replaced, free access to the cable should be ensured and where possible, it is important to leave draw cords in ducting, piping etc, for future use.

4.2.1.1 *Improvement areas*

a) *Do not exceed the maximum tensile load* — On runs from 40 m to 100 m, use proper lubricants and make sure they are compatible with the cable jacket. On runs over 100 m, use proper lubricants and pull from the middle out to both ends. If possible, use an automated puller with tension control or at least a breakaway-pulling eye.

b) *Maintaining minimum bending radius* — Sharp bends in the cable may damage the insulating material, thus causing unacceptable losses in the transmission medium. Therefore, the internal radius of every bend in a cable shall be such as not to cause damage to the cable, nor impair the characteristics of the cable.

c) *Proper cable slack at outlet points and patch panels* — Install the system such that sufficient slack remains to enable re-termination of the outlets, a minimum of twice, and a limited scope for movement of the cabinets.

d) *Patch panels and cable management* – Where possible, patch panels shall be installed within the communications units from the top, continuing downwards.

e) *Electromagnetic compatibility (EMC)* — As a passive medium, structured cabling need not comply with the EMC regulations. However, telecom designers should be aware that cabling, when connected to transmission equipment, could radiate, receive and conduct electromagnetic disturbances and act accordingly. When crossing mains cables, this shall be done at right angles.

f) *Maintaining proper cable routes* — Cable shall not be routed over pipes, conduits, other cabling, ceiling tiles, etc, but shall rest directly on the supporting surface so as to minimize the potential for sharp bends, kinks, etc. Every cable used shall be supported in such a way that it is not exposed to undue mechanical strain so that there is no appreciable mechanical strain on the terminations.

g) *Labelling* — The cable shall be clearly labelled at both ends, as outlined in the documentation and/or drawing. Each 8P8C connector (information outlet) shall be individually labelled. The label shall contain a unique identification, as outlined in the documentation and/or drawing, and shall be indelible and placed behind a transparent cover. At the patch panels, each socket shall be labelled according to its corresponding outlet identification.

4.2.2 *Workplace Safety*

Following measures shall be ensured for workplace safety:

a) To maintain workplace safety, personal protective equipment (PPE) like protective clothing, helmets and goggles should be used to protect the personnel from injury or infection from hazards such as physical, electrical, heat, chemical and biohazards.

b) Lighting in telecom spaces shall be provided in an adequate amount such that continuing work operations, routine observations, and the passage of employees can be carried out in a safe and healthful manner. Certain specific tasks in centres, such as splicing cable and the maintenance and repair of equipment frame line-ups, may require a higher level of illumination and adequate provisioning should be provided for the purpose.

c) While working with optical fibre installation, the real issue of eye safety isgetting fibre scraps into the eye. The broken ends of fibres and scraps of fibre created during the termination and splicing may also be dangerous. Therefore, protective eyewear such as safety glasses should be worn by personnel while carrying out splicing and termination operations. Further, fibre optic splicing and termination use various chemical cleaners and adhesives as part of the processes. Therefore, careful handling of fibre, cleaner and adhesive shall be ensured by the use of safety gloves and respiratory masks.

5 OTHER APPLICATIONS IN TELECOM INFRASTRUCTURE CABLING

5.1 Electronic Access Control (EAC)

EAC is important for overall personal safety and the protection of physical and intellectual property. EAC devices can include locks, integrated electronic devices controlling a single door or room, or a complex system of interconnected electronic devices controlling a zone, building, or campus. Access to private or secured spaces can be controlled in a great variety of methods. In addition, the user often has multiple levels of access required within a space. Personnel may have access to any given number of these. This access level may be required to change during the course of the day, week, or month. In contrast to a lock-and-key system, a modern computer-supported control system can meet these and many other user goals. This system employs programmable EAC. Time-of-day and day-of-the-week access levels can be applied to all personnel who have authorized entry. Additional precautions should be taken against weaknesses in the EAC system (for example, piggybacking, tailgating, unauthorized entry). A great number of possibilities exist from the passive card to biometrics and any combination in between. A user may issue smart cards.

A typical EAC cable consists of four individually shielded pairs that are used for the door strike, card reader, door contact, and request for exit. The four individual wirepairs may be supplied individually or in a group. Coloured foil shields or jacket colours may be used to designate the intended purpose of each of the wire pairs within the cables.

In a shared communication environment, the EAC data travels along with other building systems and data networks packets on the same physical network. This is often accomplished through an ethernet connection. It may also use building automation networks. Another media for shared communication relies on a private branch exchange and local analog telephone line. (*See* Annex A for details.)

5.2 Video Surveillance

Video surveillance is the extension of human vision to areas requiring surveillance. Some primary applications of this technology include investigation, prosecution, deterrence, observation and intrusion detection. In addition to traditional capture devices that operate within the visible band of the electromagnetic spectrum, other technologies provide unique viewing capabilities using IR, thermal and film cameras. (*See* Annex A for details.)

ANNEX A

(*Clauses* 3.2.4, 3.2.4.1, 3.2.6, 5.1 *and* 5.2)

ADDITIONAL GUIDELINES FOR INFORMATION AND COMMUNICATION ENABLED INSTALLATIONS

A-1 GENERAL

This annex contains information which supplements the text of this Section. The information can be used to make decisions while exercising options from among various types of hardware, cables, etc, and also for guidance.

A-2 CONNECTORS AND CONNECTING HARDWARE

Various types of connecting hardware may be as described below.

A-2.1 Balanced Copper Twisted-Pair Connectors

a) *Insulation displacement contact (IDC) connectors* — The insulation displacement contact (IDC) is a gas-tight physical contact between twoelectrical conductors. The gas-tight contact is established by a cold weld with the elimination of the air gap between the conductor and the IDC and therefore the possibility of contact interface corrosion. Such contact creates a reliable, long-lasting connection with stable electrical properties. IDC connectors also eliminate conductor preparation (for example, insulation removal), reducing the termination time and the number of tools.

b) *Modular plug* **—** Modular plugs have IDC contacts designed for either stranded or solid conductors as well as connectors having universal contacts that accept both stranded and solid conductors. Materials used to build modular plugs are typically flame retardant polycarbonate (body) and phosphor bronze with gold plating over nickel in contact area (contacts).

c) *Modular jack* **—** Modular jacks are available in various sizes and shapes (keyed and unkeyed). The number of positions indicates the connector’s width, while the number of contacts installed into the available positions indicates the maximum number of conductors the connector can terminate.

A-2.2 Optical Fibre Connectors

The most common optical fibre interfaces include,

a) *LC connector* — It is a simplex connector that can be converted to a duplex using a clip. It is keyed, low-loss, pull-proof and wiggle-proof. It can be terminated in many different ways, including using anaerobic (quick cure) adhesive, cleave and crimp, and hot melt. This is often referred to as a small form factor (SFF) connector. The LC connector provides a pull- proof design and small size perfect for high-density applications. It is available in simplex or duplex versions. The LC connector is provided with a 1.25 mm ferrule. It also incorporates a unique latching mechanism providing stability in system rack mounts.

b) *Subscriber connector (SC)* — It is a simplex connector that can be converted to a duplex using a clip. It is keyed, low-loss, pull-proof, and wiggle-proof. It can be terminated in many different ways, including using anaerobic (quick cure) adhesive, cleave and crimp, and hot melt. The SC connector is a snap-in connector that latches with a simple push-pull motion, with a 2.5 mm ferrule and is widely used for its excellent performance. It is also available in a duplex configuration.

c) *Straight tip (ST) compatible* — It is a simplex connector. It is a keyed, low loss connector. It can be terminated many different ways, including using anaerobic (quick cure) adhesive, cleave and crimp and hot melt.

d) *Splices (Optical fibre connectors)* – These are used for adding optical fibre cable lengths. There are two primary splicing methods for optical fibres, fusion and mechanical. Both methods are field proven and have excellent long-term reliability when completed according to the manufacturer's instructions. Splices and stripped optical fibre cables are protected andsecured by a splice enclosure. When a splice enclosure is used for splicing inside a building, it is generally secured to a rack or wall. In both cases, the splice enclosure contains the optical fibre splices in splice trays or organizers, typically in groups of 6, 12, 24, or more optical fibres per splice tray or organizer.

A-2.3 Coaxial Connectors

Connectors are installed on the end of a coaxial cable to provide electrical and mechanical connection to a system component. Either male or female connectors can be attached to coaxial cable, but most installations use male connectors on cable ends.

There are many styles of coaxial cable connectors. Three popular styles are:

a) BNC-style connector,
b) F-style connector, and
c) N-style connector.

A-2.4 Connecting Hardware

Cables are terminated in outlets in work areas or intermediate equipment through connecting hardware. Basic connecting hardware styles are:

a) Telecom outlets/connectors, including multiuser outlets;
b) Patch panels;
c) Connecting (wiring) blocks;

d) Cable assemblies;
e) Optical distribution frames; and
f) Splices.

To facilitate their installation, servicing, administration and maintenance, connecting hardware of different styles of connectors may be considered to be grouped in one unit. However, depending upon the given situation, one or more type of connecting hardware (copper pair, coaxial or optical) may be installed on separate panels/frames.

A-3 CLASSIFICATION OF CABLES BY FIRE SAFETY PROPERTIES

A-3.1 Twisted Pair Cables

Different communication cable types and their markings on cable sheath are asgiven below:

Marking	*Cable Type*
CMP	Communications plenum cable
CMR	Communications riser cable
CMG/CM	Communications general-purpose cable
CMX	Communications cable, limited use
CMUC	Under carpet communications wire and cable

A-3.1.1 *Type CMP (Communications Plenum Cable)*

Type CMP communications plenum cables are suitable for use in ducts and plenums and they have adequate fire-resistant and low smoke-producing characteristics.

A-3.1.2 *Type CMR (Communications Riser Cable)*

Type CMR communications riser cables are suitable for use in a vertical run in a shaft when penetrating one or more floors as they have fire-resistant characteristics and thus be capable of preventing the carrying of fire from floor to floor.

A-3.1.3 *Type CMG/CM (Communications General-Purpose Cable)*

Type CMG general-purpose communications cables are suitable for general-purpose communications use, with the exception of risers and plenums, and these cables are resistant to the spread of fire.

A-3.1.4 *Type CMX (Communications Cable, Limited Use)*

Type CMX limited-use communications cables are suitable for use in dwellings and raceways as being resistant to flame spread.

A-3.1.5 *Type CMUC (Under Carpet Communications Wire and Cable)*

Type CMUC under carpet communications wires and cables are suitable for under carpet use and they are resistant to flame spread.

A-3.2 Optical Fibre Cables

Different optical fibre cable types and their markings on cable are as given below:

Marking	*Cable Type/Suitability*
OFNP	Non-conductive optical fibre plenum cable
OFCP	Conductive optical fibre plenum cable
OFNR	Non-conductive optical fibre riser cable
OFCR	Conductive optical fibre riser cable
OFNG	Non-conductive optical fibre general-purpose cable
OFCG	Conductive optical fibre general-purpose cable
OFN	Non-conductive optical fibre general-purpose cable
OFC	Conductive optical fibre general-purpose cable

A-3.2.1 *Types OFNP and OFCP*

Types OFNP and OFCP non-conductive and conductive optical fibre plenum cables are suitable for use in ducts and plenums and they have adequate fire-resistant and low smoke-producing characteristics.

A-3.2.2 *Types OFNR and OFCR*

Types OFNR and OFCR non-conductive and conductive optical fibre riser cables are suitable for use in a vertical run in a shaft when penetrating one or more floors and have the fire-resistant characteristics capable of preventing the carrying of fire from floor to floor.

A-3.2.3 *Types OFNG and OFCG*

Types OFNG and OFCG non-conductive and conductive general-purpose optical fibre cables are suitable for general-purpose use, with the exception of risers and plenums, and these cables are resistant to the spread of fire.

A-3.2.4 *Types OFN and OFC*

Types OFN and OFC non-conductive and conductive optical fibre cables are suitable for general-purpose use, with the exception of risers and plenums and have resistance to the spread of fire.

A-4 BALANCED TWISTED-PAIR CABLE NOMENCLATURE

Details of nomenclatures of twisted pair cables using various combinations of overall screen type and individual pair screen type, as follows, are given in Table 2:

Overall Screen Type (*x*)	*Individual Pair Screen Type* (*y*)
Overall screen absent (*U*)	Individual screens absent (*U*)
Overall foil screen (*F*)	Individual foil screens
(*F*)Overall braid screen (*S*)	
Dual overall screen (foil + braid) (*SF*)	

Table 2 Balanced Cable Nomenclature
(*Clause* A-4)

Sl No.	**Global Abbreviations** (*x*/*y*)	**North American Abbreviation**	**Overall Braid Screen**	**Overall Foil Screen**	**Individual FoilScreen**
(1)	(2)	(3)	(4)	(5)	(6)
i)	*U*/*U* TP	*U* TP	No	No	No
ii)	*U*/*F* TP	*S* TP	No	No	Yes
iii)	*F*/*U* TP	*F* TP, *S*cTP, PiMF	No	Yes	No
iv)	*F*/*F* TP	*S* TP, *SS* TP	No	Yes	Yes
v)	*S*/*U* TP	*S* TP	Yes	No	No
vi)	*S*/*F* TP	*S* TP, *SS* TP	Yes	No	Yes
vii)	*SF*/*U* TP	*S* TP, *SS* TP	Yes	Yes	No
viii)	*SF*/*F* TP	*S* TP, *SS* TP	Yes	Yes	Yes

NOTE – The abbreviations represent as follows:

a) F/F TP – Foil-screened foil-screened twisted-pair (Individually foil-screened twisted-pair in overall foil screen).
b) F/U TP – Foil-screened unscreened twisted-pair (Unscreened twisted-pair in overall foil screen).
c) S/F TP – Braid-screened foil-screened twisted-pair (Individually foil-screened twisted-pair in overall braidscreen).
d) S/U TP – Braid-screened unscreened twisted-pair (Unscreened twisted-pair in overall braid screen).
e) Sc TP – Screened twisted-pair.
f) SF/F TP – Braid-screened-foil-screened foil-screened twisted-pair (Individually foil-screened twisted-pair inoverall foil and braid screen).
g) SF/U TP – Braid-screened-foil-screened unscreened twisted-pair (Unscreened twisted-pair in overall foil andbraid screen).
h) U/F TP – Unscreened foil-screened twisted-pair (Individually foil-screened twisted-pair).
j) U/U TP – Overall unshielded twisted-pair with unshielded twisted-pair.

A-5 ELECTRONIC ACCESS CONTROL (EAC) AND VIDEO SURVEILLANCE

A-5.1 Electronic Access Control (EAC)

An EAC system allows several levels of security. Once the number and type of people are determined, a user or access level for each person is established. Access levels are incorporated into the system integration and the areas of access are determined. Factors affecting the user level include security clearances, job title, rank, short-term employee and employee type. The access level is determined by the physical layout of building and is directly related to the doors and other portals it controls.

The basic components of an EAC system include,

a) A computer,
b) One or more control panels, and
c) One or more peripheral devices connected to the control panels (forexample, card reader, siren and sensor).

The host computer runs the EAC software, manages the system parameters, maintains the system database, and controls all communication with the control panels. The host computer receives all event and alarm transactions from the control panels. It then saves them into separate history files that may be used to run reports by specific criteria.

The control panels manage the activation of peripheral devices by turning the devices on or off and controlling access to certain areas through card readers and door-locking hardware.

Media for communications may include the following:

1) *Balanced twisted-pair* —– Shielded twisted-pair, unshielded twisted-pair, and screened twisted-pair.
2) *Optical fibre* — Multi-mode and single-mode.
3) *Wireless* — Microwave, radio frequency (RF), and infrared (IR).
4) Cellular networks connection.

A-5.2 Video Surveillance

A-5.2.1 In addition to traditional capture devices that operate within the visible band of the electromagnetic spectrum, other technologies that provide unique viewing capabilities are, as follows:

a) *IR cameras* —– These refer to specially designed imagers capable of seeing into the low IR bandwidth. They are sometimes referred to as starlight cameras because of their night time viewing capabilities.

b) *Thermal cameras* —– They capture heat or temperature values of a scene rather than light values, regardless of how bright or dark the scene appears to the human eye. Although the identification of colours and details are impossible with thermal cameras (because they only view temperature), these cameras are quite useful in viewing dark scenes for activities that have heat signatures.

c) *Film cameras* —– They have been on the market for many years. These self-sustaining units are equipped with traditional camera film, which permanently stores the scenes. The film requires replacement when exhausted.

A-5.2.2 Camera placement is based on security objectives identified through a need-assessment. Video surveillance applications include two typical types of camera mounts, as follows:

a) *Fixed* —– It refers to a camera dedicated to single view that does not change unless the camera is physically moved.

b) *Pan and tilt* —– It refers to a camera with a pan and tilt that allows for a 180º or 360º view, which is controlled electronically from a remote viewing station.

From a practical standpoint, the trade-off between the two types is that a pan and tilt provides a more flexible area of coverage at a higher cost than a fixed camera. Pan and tilt technology allows for auto-panning where the camera moves in a predefined cycle. Camera mounting locations are typically dictated by the available physical infrastructure and are balanced against the required field of views. Connectivity of cameras to the main system in a building environment is generally through coaxial cables.

A-6 OVERVIEW OF IN-BUILDING SOLUTIONS (IBS)

A-6.1 General

The information in this annexure can be used to plan IBS to provide seamless mobile data and voice experience for indoor users including in areas like lifts, staircase and basements. IBS is a telecommunications infrastructure designed to enhance wireless network coverage. It is particularly useful in establishments such as offices, malls, hospitals, airports, sport arenas, multistorey residential complexes and other areas, where outdoor mobile signals may be weak due to distance and structural obstructions.

A-6.2 Types of In-Building Solutions

The various types of IBS technologies, to enhance indoor connectivity, are as under –

A-6.2.1 *Distributed Antenna Systems (DAS)* – It consist of multiple antennas distributed throughout a building or a venue. These antennas connect to a radio frequency source(s) and distribute signals effectively overcoming signal degradation in indoor environments. Typical layout of a DAS is shown in the Fig 9. Following are the main components of DAS:

a) *Distributed antennas* – Acts as radiating source for RF signals. These are distributed throughout the building based on radio network planning.
b) *Splitter* – A passive component that divides the RF signal power equally among multiple output ports.
c) *Coupler* – A passive device that extracts a small portion of the signal from the main feed while allowing most of it to continue.
d) *Radio Unit* – The radio frequency or mobile signal source that connects the in-building system to the mobile network.
e) *RF or fibre cable for signal distribution* – The RF is used in passive DAS to carry the radio signals up to the antennas while fibre cable is used to connect master and slave unit in case of active DAS.

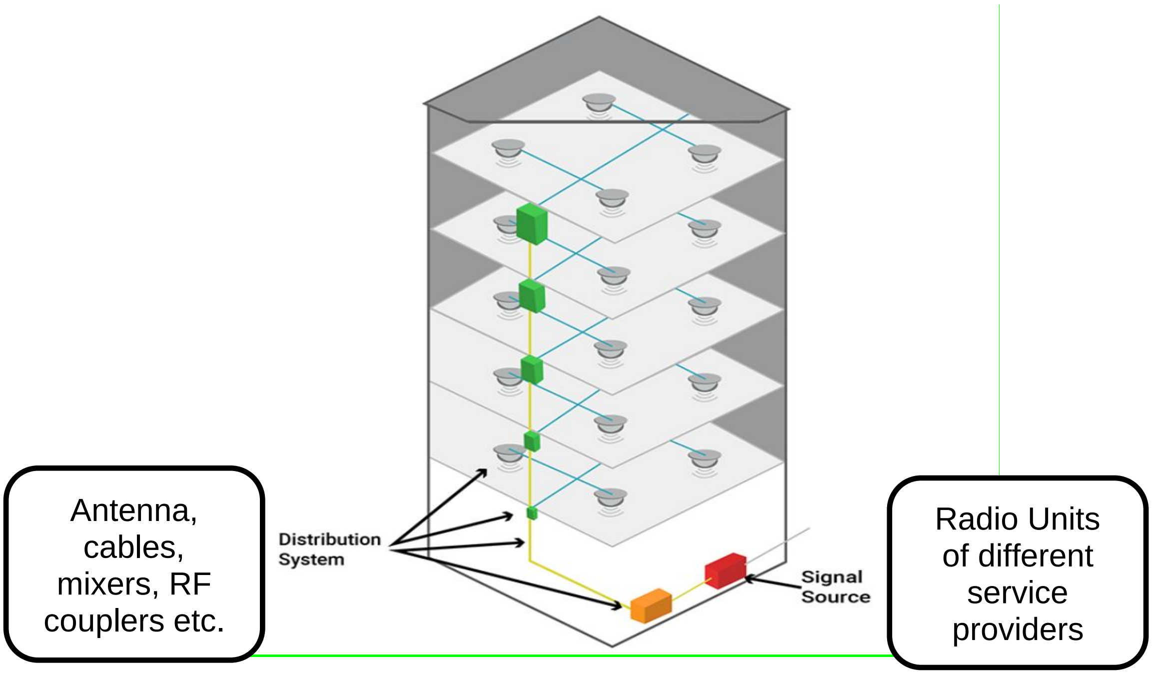


FIG. 9 TYPICAL COMPONENTS OF A DISTRIBUTED ANTENNA SYSTEM (DAS)

A DAS can support multi frequency bands to carry radio frequency signals of multiple service providers for different technologies (2G/3G/4G/5G etc.) using common DAS. This common DAS infrastructure provide considerable cost savings with improved building aesthetics while providing seamless mobile coverage including in basements, lifts and lobbies.

There are different types of distributed antenna systems suitable for different use cases. Overview of some important DASs are covered below.

1) *Passive Distributed Antenna System (DAS)* **–** In passive DAS, only passive components are used to distribute the RF signals. The size of the cable depends upon the frequency in use, coverage and capacity requirement. The

distribution of combined mobile signal is done using passive components in the network like RF cable, couplers and splitters. The RF signal is coupled with the antennas installed across the floor(s) for radiating in different sections of the building as indicated in the Fig 10.

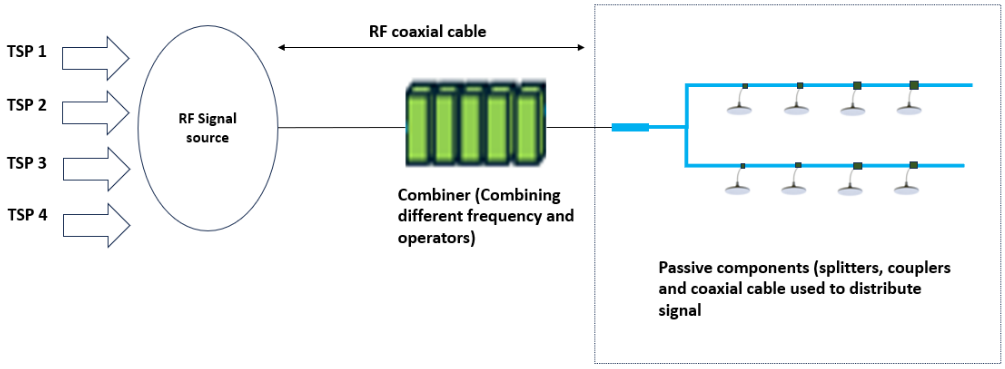


FIG. 10 KEY COMPONENTS OF TYPICAL PASSIVE DAS

2) *Active Distributed Antenna System* – This type of system is used where the coverage is required in a huge building and airport etc. where conventional passive cable system does not give adequate coverage due to high losses in the coaxial cables as shown in Fig 11.

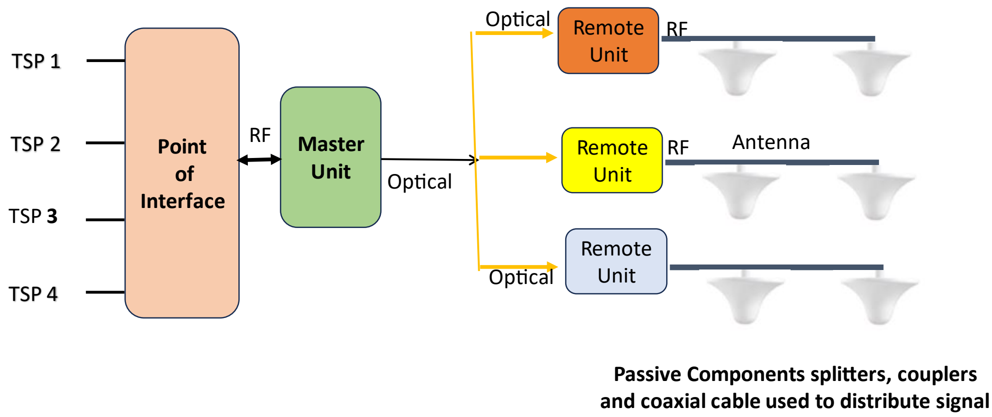


FIG. 11 KEY COMPONENTS OF TYPICAL ACTIVE DAS

A-6.2.2 *Leaky Feeder Cable System* – In this system this is a special type of cable known as leaky feeder cable in which the slots are cut as window in the cable itself and when the RF signal is pumped in it which get radiated through these windows which acts as an antenna as indicated in Fig 12. Such cables are generally used in the tunnels where installation of active components may be difficult.

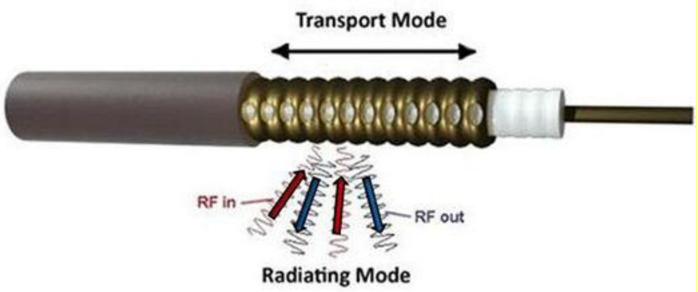


FIG. 12 TYPICAL LEAKY CABLE INSTALLATION IN A TUNNEL

A-6.2.3 *Small Cells, Including Femtocell and Pico Cells* – They are low-powered radio access nodes designed to cover small geographic areas, such as a single room or a specific area in a larger venue. They complement main cellular networks by providing targeted coverage and traffic capacity.

A-6.3 Key Considerations for planning an In-Building Solution

a) *Coverage Requirements* – Determining the appropriate coverage levels for an in-building solution depends on user density and the types of applications being used. High-density areas require a robust network capable of handling simultaneous connections from multiple users. The design should account for variations in density across different floors and zones to ensure uniform coverage. Additionally, the nature of services being provided whether voice, video, or data—plays a crucial role in coverage planning.

b) *Interference Management* – Effective interference management is essential to maintain signal quality within an indoor environment. Identifying potential interference sources, such as nearby wireless networks, electronic devices, and structural obstacles, helps in mitigating performance issues. To minimize interference, strategies such as frequency planning, power control, and spatial diversity should be implemented.

c) *Capacity Planning* – Proper capacity planning ensures that an in-building solution can handle both current and future network demands. By analyzing user behaviours and application requirements, network designers can forecast growth in user numbers and data consumption patterns.

d) *Aesthetics and Integration* – Careful placement of antennas, cables, and other infrastructure components helps maintain the visual appeal of the space. Where possible, discreet installations such as ceiling-mounted antennas or concealed cabling are preferred. Engaging stakeholders including building owners, architects, and end-users during the IBS design phase ensures that the network aligns with both functional and aesthetic requirements.

NOTE – The relevant standards, prescribed by Telecom Engineering Centre (TEC), Department of Telecom, Ministry of Communications, may be referred at [https://www.tec.gov.in] for the implementation of in-building solutions.

ANNEX B

(*Foreword*)

STREET FURNITURE FOR ICT INSTALLATIONS

B-1 Street furniture, such as streetlights, utility poles, bus stops, and traffic signals, is expected to play a significant role in enabling ICT infrastructure, especially as India deploys next-generation technologies targeting the mobile devices used by public. As ICT installations expand, these existing structures provide an efficient and cost-effective foundation for small cell and air fibre, supporting enhanced connectivity, quicker deployments, and seamless integration into urban landscapes. The Telecom Regulatory Authority of India (TRAI) and the PM Gati Shakti National Master Plan recognize the potential of street furniture in, integrating digital connectivity into public infrastructure. Additionally, the Telecommunications (Right of Way) Rules, 2024, defines small cells as having a coverage range of up to 2 kilometers, reinforcing their role in improving network reach

Further, under the PM Gati Shakti National Master Plan, 26.5 million units of street furniture have been mapped digitally to simplify planning, accelerate approvals, and reduce site survey timelines. This creates a ready-to-use foundation for 5G and future ICT infrastructure, helping embed digital connectivity into public infrastructure efficiently.

The guidelines for earmarking and use of street furniture are expected to be put in place by DoT/TRAI in due course.

Some of the important aspects of use of street furniture which require consideration for effective ICT deployments are given below.

B-1.1 Structural and Positional Aspects

The aspects include, but not limited to:

a) Load-bearing requirements to support equipment such as small cells and associated hardware.
b) Telecom equipment designs blend with urban aesthetics to avoid visual clutter.
c) Proximity to existing power sources.
d) Protection of pedestrian and vehicle traffic.
e) Public safety.
f) Structural stability and safety considering the weight and required height for installation of equipment as well as sharing among service providers.

B-1.2 Administrative Aspects

The following aspects are applicable:

a) Easy right of way (RoW) for installation and maintenance and upgrades of the equipment.

b) Possibility of development of a GIS-mapped inventory of street furniture assets, detailing specifications like load capacity, power availability, and contact information for streamlined maintenance and coordination.
c) Adherence to municipal guidelines and permissions for ICT installations on public or private street furniture

LIST OF STANDARDS

The following list records those standards which are acceptable as 'good practice' and 'accepted standards' in the fulfilment of the requirements of the Code. The latest version of a standard shall be adopted at the time of enforcement of the Code. The standards listed may be used by the Authority for conformance with the requirements of the referred clauses in the Code.

In the following list, the number appearing in the first column within parentheses indicates the number of the reference in this Part/Section.

	IS No.	*Title*
(1)	9537 (Part 2):1983	Specification for conduits for electrical installations – Part 2 Rigid steel conduits
(2)	9537 (Part 3):1983	Specification for conduits for electrical installations – Part 3 Rigid plain conduits for insulating materials
	3419:1989	Specification for fittings for rigid non-metallic conduits (*second revision*)
(3)	9537 (Part 5):2000	Specification for conduits for electrical installations – Part 5 Pliable conduits of insulating materials

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