Indian Institute of Technology Hyderabad
India

CAMPUS DESIGN PROJECT FOR INDIAN INSTITUTE OF TECHNOLOGY, HYDERABAD DETAIL DESIGN ASSISTANCE (PHASE 3)

FINAL REPORT

October 2014

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

NIHON SEKKEI, INC.
NIHON SEKKEI INTERNATIONAL INC.
APL DESIGN WORKSHOP INC.

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LIST OF ABBREVIATIONS

AHU	Air Handling Unit
ASHRAE	American Society of Heating, Refrigerating & Air Conditioning Engineers
ASPE	American Society of Plumbing Engineers
BAC	Bidding Assistance Consultant
BOD	Biochemical Oxygen Demand
BOQ	Bill of Quantity
BS	British Standard
CD	Construction Document
CNG	Compressed Natural Gas
COD	Chemical Oxygen Demand
CONV	Convention Center
CPWD	Central Public Works Department
CR	Chilled Water Return
CS	Chilled Water Supply
DD	Detail Design
ECBC	Energy Conservation Building Code
EMR	Electric Machine Room
EPS	Electric Pipe Shafts
FCU	Fan Coil Unit
GoI	Government of India
GoJ	Government of Japan
GRIHA	Green Rating for Integrated Habitat Assessment
HP	Hyperbolic Parabolic Shell
HVAC	Heating, Ventilation & Air Conditioning
IEC	International Electrotechnical Commission
IGH	International Guest House
IIT	Indian Institute of Technology
IITH	Indian Institute of Technology Hyderabad
IS	Indian Standard
ISHRAE	Indian Society of Heating, Refrigerating & Air Conditioning Engineers
JICA	Japan International Corporation Agency
KNC	Knowledge Center
LAN	Local Area Network
LC	Local Consultant

KNC	Knowledge Center
LAN	Local Area Network
LC	Local Consultant
LED	Light Emitting Diode
LP	Liquid Propane
M/P	Master Plan
MDF	Main Distribution Frame
MEP	Mechanical, Electrical & Plumbing
NBC	National Building Code
ODA	Official Development Assistance
RC	Reinforced Concrete
RCC	Research Center Complex
SATREPS	Science and Technology Research Partnerships for Sustainable Development
SC	Sports and Cultural Complex
SD	Schematic Design
SMACNA	Sheet Metal & Air Conditioning Contractors National Association
SPR	Salient Project Report
SS	Suspended Solids
STP	Sewage Treatment Plant
TERI	The Energy and Resource Institute
TIP	Technology Incubation Park
UoT	University of Tokyo
UPS	Uninterrupted Power Supply

CHAPTER 1

BACKGROUND AND OBJECTIVES OF THE PROJECT

Chapter 1 Background and Objectives of the Project

1.1 Background

The Indian Institutes of Technology (IITs) are the best higher education institutions for science and technology in the Republic of India (India). The first IIT was established in 1950 and seven IITs had been established by 2007. In IITs, students who have passed the very selective entrance examination, which has an extremely low acceptance rate, study under the guidance of first-class teaching staff in the country's top-level learning environment. ITTs have contributed greatly to the identification, training and supply of high-quality human resources. The Government of India (GoI) established eight new IITs in 2008 and 2009 as a measure to strengthen and expand human resource development in science and technology in order to achieve its goal of further socio-economic development, and to meet the demand for human resources in the industrial sector.

Against this background, in a joint statement made public by then Japanese Prime Minister Shinzo Abe during his visit to India, an intention to provide assistance for a new IIT was expressed on behalf of the Government of Japan (GoJ). In October 2008 the governments of the two countries announced, under the Five Priority Areas of Assistance in the Joint Statement towards India-Japan Strategic and Global Partnership, that it had been agreed that the GoJ would provide assistance to the Indian Institute of Technology, Hyderabad (IITH) that had been founded in August 2008. Later, in January 2009, the official mission dispatched by the GoJ and the IITH agreed that the GoJ and Japanese academia would jointly assist the IITH using various assistance tools including the Official Development Assistance (ODA). The two parties also agreed that measures to promote interaction in research and development between the IITH and universities and research institutions should form the basic components of ODA, and that these measures should be included;

(1) Establishment of an educational and research environment in the new campus of the IITH with an ODA loan from the GoJ;
(2) Promotion of the exchange of personnel and reinforcement of the system for the implementation of educational and research activities under the technical cooperation scheme; and
(3) Implementation of projects under the Science and Technology Research Partnership for Sustainable Development (SATREPS).

The GoI has a site of approximately 2 km^2 set aside for the construction of the IITH campus in the suburbs of Hyderabad. ARCOP Associates Private Ltd., the Indian subsidiary of a design office based in Canada, was selected in April 2009 as the consultant to formulate the master plan for the new campus. ARCOP submitted the final draft* of the master plan, "IITH Campus Development Draft Master Plan" (referred to below as "M/P") in January 2010.

A plan to construct groups of facilities for around 30,000 people on the site which has an area of approximately 2km^2 in four phases, covering periods of 5 years, 10 years, 30 years and 100 years after the commencement of the construction, is described in the M/P.

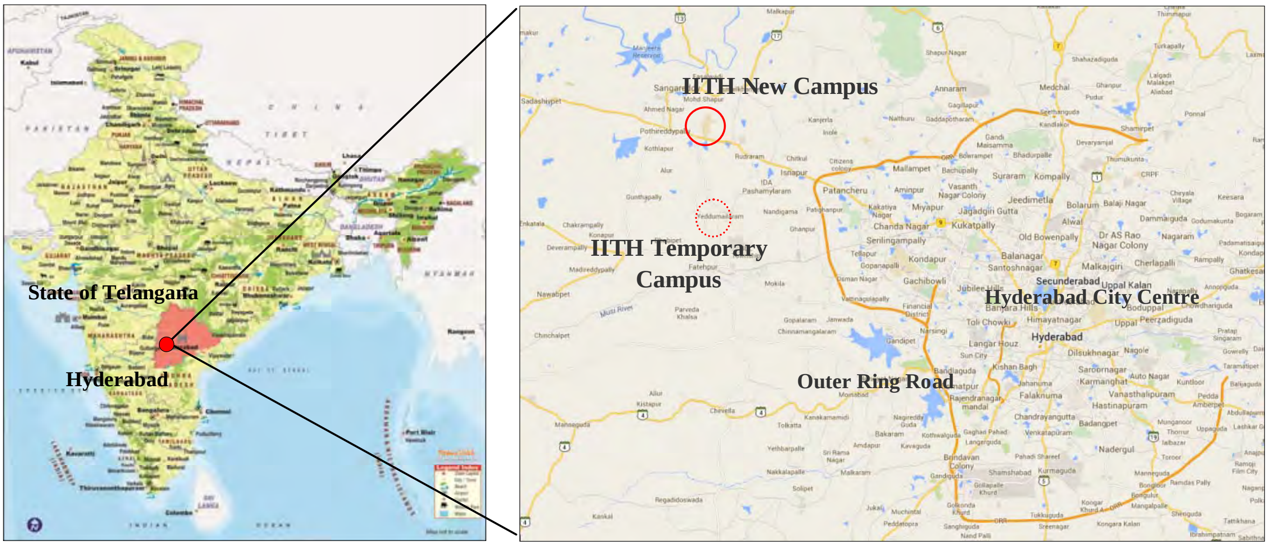
The GoI submitted a request for the provision of an ODA loan of roughly 12.8 billion yen (7.8 billion yen for facility construction and 5 billion yen for the procurement and installation of equipment) to the GoJ in June 2009. The IITH submitted the Salient Project Report (SPR) to the GoJ in August 2010. In the report, the IITH proposed that the ODA loan would be used for the construction of six facilities as symbols of the partnership between Japan and India (Knowledge Center (KNC), International Guest House (IGH), Convention Center (CONV), Sports and Cultural Complex (SC), Technology Incubation Park (TIP) Research Center Complex (RCC)).

The GoI submitted a revised request for the provision of an ODA loan for the two facilities of IGH and SC in April 2011. The GoI requested additional facilities of KNC, CONV, RCC, TIP, 8 faculty buildings, Hostels and Lecture Halls etc. in November 2011.

In response, Japan International Cooperation Agency (JICA) decided to provide assistance in the development of the schematic designs of the facilities through a technical assistance project related to the ODA loan, "Campus Design Project for Indian Institute of Technology, Hyderabad through Academic Exchange and Interdisciplinary Collaboration". Following on from these schematic designs, JICA appointed the Consortium of Nihon Sekkei International Inc., Nihon Sekkei Inc., APL Design Workshop Inc., and PADECO Co.,Ltd to execute Basic Design through the preparatory survey for IGH and SC from August 2011 to March 2012. CONV, TIP and other facilities were executed between May 2012 and March 2013.

JICA decided to provide technical assistance in the detail design drawing development of the schematic design of the facilities for IGH and SC as these were the facilities most urgently required by the IITH for the new campus master plan. JICA has assigned the Consortium of Nihon Sekkei International Inc., Nihon Sekkei Inc. and APL Design Workshop Inc. (referred to below as "the Consultant") to execute the detail design assistance including construction methods and selection of applicable materials for the building construction. In addition to the above two buildings, the Consultant continuously executed the detail design assistance for TIP and CONV since May 2013.

* There is no revision for the master plan as of Oct 2014. .



Source: http://www.delhitourism.gov.in/, http://maps.google.co.jp/

Figure 1.1.1 Hyderabad City and IITH location

1.2 Objectives of the Service

The Schematic Design (SD) of KNC and RCC by the University of Tokyo Campus Design Team (UoT) started in May 2013. The consultant worked together with UoT from the technical point of view. The Detailed Design Assistance (DD) started from March, 2014. The objective of this service is to assist IITH in the development of the detailed design and the documents including the specifications required for the construction of the KNC, and the RCC based on the SD developed by UoT and the Consultant team. Assistance in the implementation of the competitive tender for the construction is also required. After this stage, IITH will appoint a local consultant in India for the Construction Documents stage in continuation of the yen loan project.

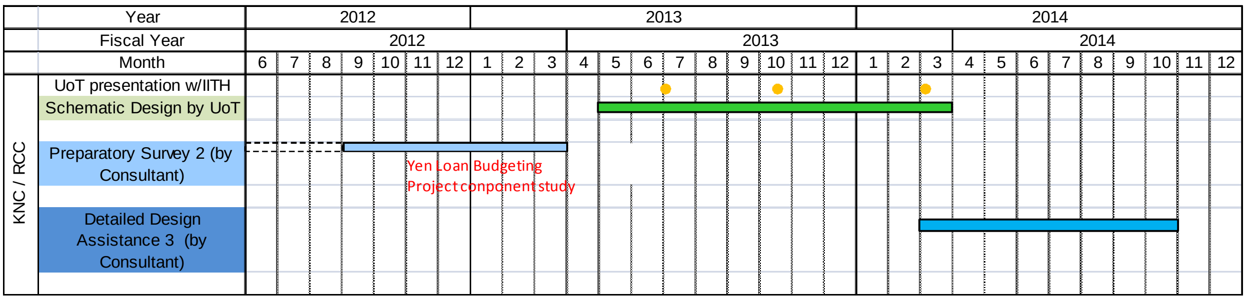


Figure 1.2.1 Phase 3 Project Schedule

The goals and the expected outcomes of the project are as follows:

(a) Overall Goals

The overall goal of the Project is to design and construct new campus facilities in IIT-H for creation of cutting-edge educational and research environment thereby contribute to economic growth of India as well as acceleration of Indo-Japan relationship through academic exchange and collaboration.

(b) Project Purpose

The purpose of the Project is to facilitate the design of selected buildings to be supported by the Loan Project based on academic exchange and collaboration between India and Japan.

(c) Expected Outcomes

- Promotion of academic tie between India and Japan through academic collaboration and design of specific aspects of IITH campus.
- Documents and drawings for selected buildings in IITH to be supported by the Loan Project.
- Achievement of design consistency of selected buildings in IITH to be supported by the Loan Project.

1.3 The Service

1.3.1 Organization of the Service

The consultant has proposed that the local consultant to be involved during the design stage for the following reasons:

(a) It is important to have the local consultant‘s involvement. The buildings which the Consultant designs must comply with the building codes in India such as the Central Public Works Department standard known as CPWD and By-laws. These regulations require a wide range of rules and steps to follow. .

(b) The particular design should be reviewed regularly if the local construction methods are applicable. Especially it is important to obtain the information regarding CPWD’s performance and regulations.

(c) Though the project from an early stage, it will be possible to transfer the Consultant’s method and develop the Local Consultant’s skills

1.3.2 The Services to be provided by the Local Consultant

(a) Providing information about Indian laws and standards

(b) Providing information about local construction methods and materials

(c) Providing information for specifications and unit rates in relation to construction cost (and the building cost assumption)

(d) Monitoring and providing information to aid the design according to the environmental standards in India, such as The Energy and Resource Institute (TERI)

(e) Supporting the development of detailed design drawings made by the Japanese consultant

1.3.3 Organization for Design Development Service

The Consultant has appointed ASTUTE Engineering Services (referred to below as “ASTUTE ”) in accordance with JICA standard of the local consultant appointment guideline.
ASTUTE is one of three consultants who are working on IITH new campus project besides ARCOP and CCBA. They are especially involved in providing design services for the Hostel buildings, Dining Hall and the Main building. Their main office is located in Pune. Astute as the local architects represents all the engineering consultants which involve the design development services.

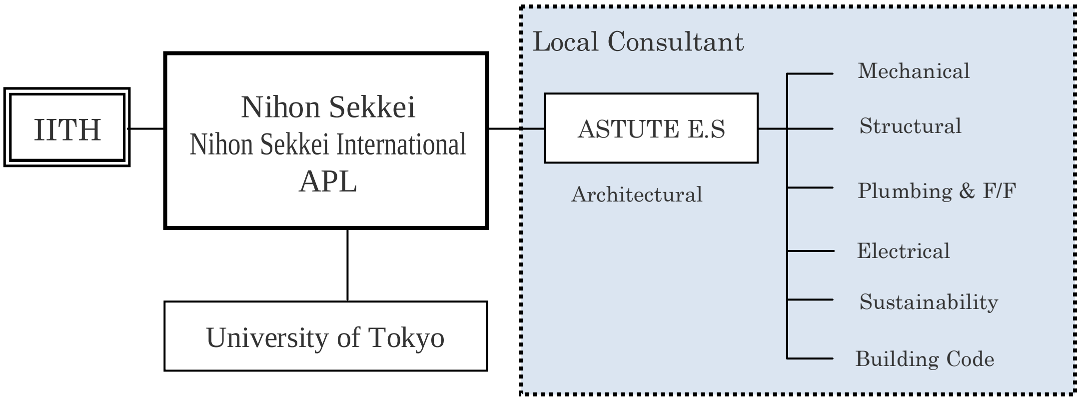


Figure 1.3.1 Organization for Design Development Service

1.3.4 Demarcation of the Services

The detail design assistance work has been carried out according to the following scope of service in between the Consultant and the Local Consultant (LC). The Consultant provided a set of drawings which shows the concept sketches and major drawings as well as the structural, mechanical, electrical and plumbing design concept drawings. The local consultants completed the design development drawing set based on the Consultant’s drawings in the local manner followed by the Consultant’s review.

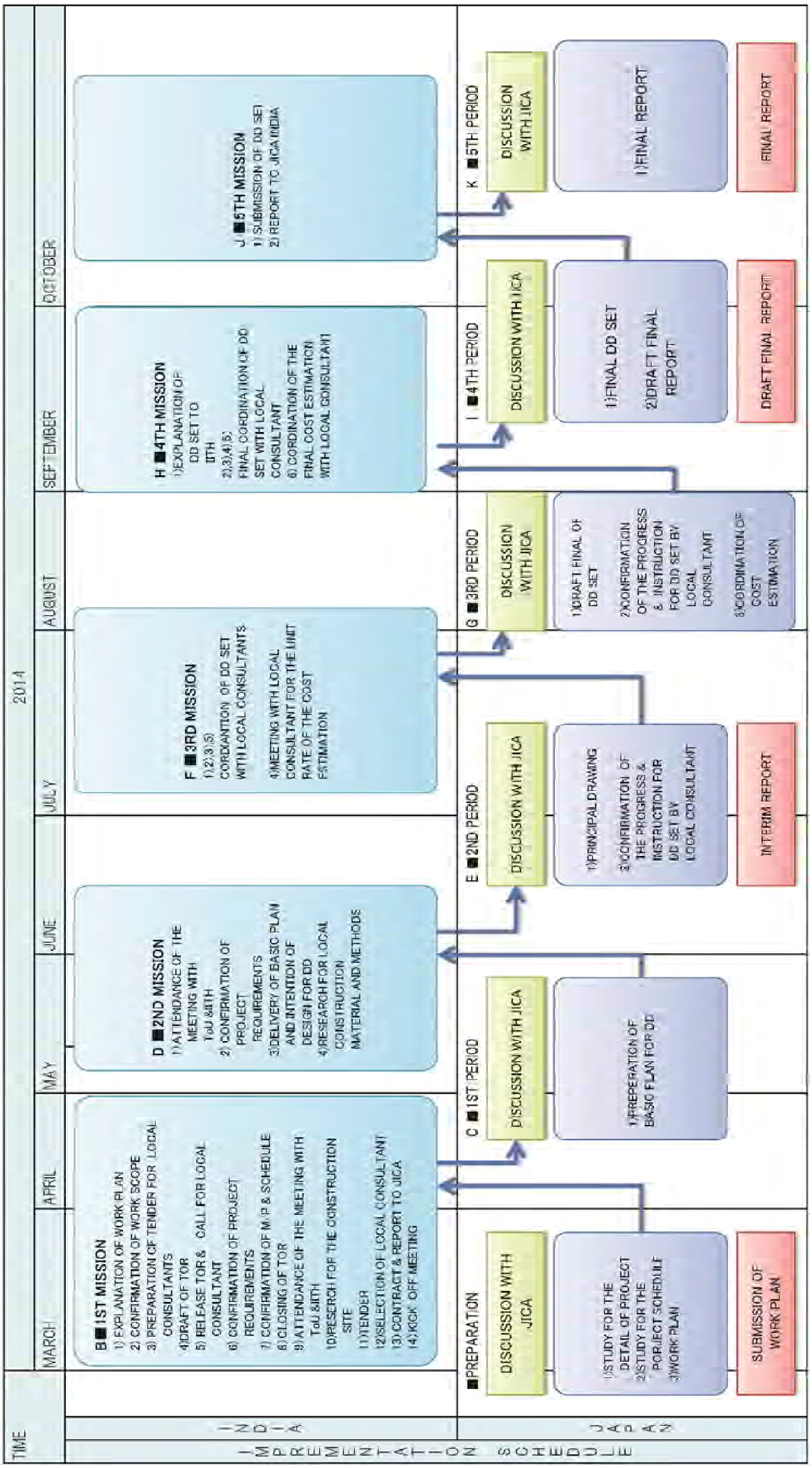
Table 1.3.1 Basic Demarcation for Detail Design Assistance

	The Consultant	LC side	Remarks
Prepare major drawings for Architectural, Structural, and Mechanical, Electrical & Plumbing (MEP) work	Yes		
Prepare other detailed design assisitance drawings for Architectural, Structural and MEP		Yes	
Review of applicable building codes and any related regulations.		Yes	
Basic planning of building equipments and furniture	Yes		
Detail design assistance of building equipments and furniture		Yes	
Preparation of detail design assistance report	Yes		
Cost Review	Yes		
Provide the information of the local market prices		Yes	
Prepare the document for DD drawings in connection with “Green Rating for Integrated Assessment” (GRIHA)		Yes	
Any other related documents	Yes	Yes	

1.3.5 Work Flow

Based on the work plan, the consultants follow the implementation schedule as shown below. When it is necessary, the consultants shall have discussions with the UoT Campus design team.

Table 1.3.2 Survey Schedule



CHAPTER 2

NEW CAMPUS DEVELOPMENT AND MASTER PLAN

Chapter 2 New Campus Development and Master Plan

2.1 Overall Master Plan

IITH plans to construct the academic and residential facilities shown in Table below. By the time Phase-1A and 1B constructions are completed, IITH will possess substantial academic and research capabilities up to approx. 4,500 students and 1,000 faculty and educational staff members.

Table 2.1.1 Facilities to be constructed during Phase 1A and 1B

IITH's Phase	Fund	No.	Building
1-A	Indian Side	1.	Hostel (M) x 8 buildings
		2.	Hostel (F) x 2 building
		3.	Dining Hall
		4.	Faculty Residence x 3 buildings
		5.	Staff Residence x 2 buildings
		6.	3 Engineering Department Building
		6-1.	Chemical Department
		6-2.	Civil Eng. Department
		6-3.	Mechanical Department
		7.	Infrastructure Work
1-B	Japanese ODA Loan, FY-	1.	International Guest House (IGH)
		2.	Sports Complex (SC)
		3.	Athletic Field & Water Basin
	Japanese ODA Loan, FY-	1.	Technical Incubation Park (TIP)
		2.	Convention Village (CONV)
		3.	Knowledge Centre (KNC)
		4.	Research Center Complex (RCC)
		5.	Lecture Hall Complex
		6.	Student Commons
		7.	8 Department Buildings
		7-1.	Chemistry
		7-2.	Electrical Eng. Computer Science
		7-3.	Material Science & Eng.
		7-4.	Bio-X (Biomedicine & Biotech)
		7-5.	Mathematics
		7-6.	Physics
		7-7.	Liberal Arts
		7-8.	Core Laboratories
		8.	Main Building and Other Facilities
		9.	Students Hostels with Dining Facilities
		10.	Research Equipment

The figure below shows the plots and facilities to be covered by the Phase-1A and 1B constructions. The academic buildings located in the campus center area are currently under construction, as well as the student hostels and dining hall adjacent to the center area. The hostel buildings are working on the finishes.

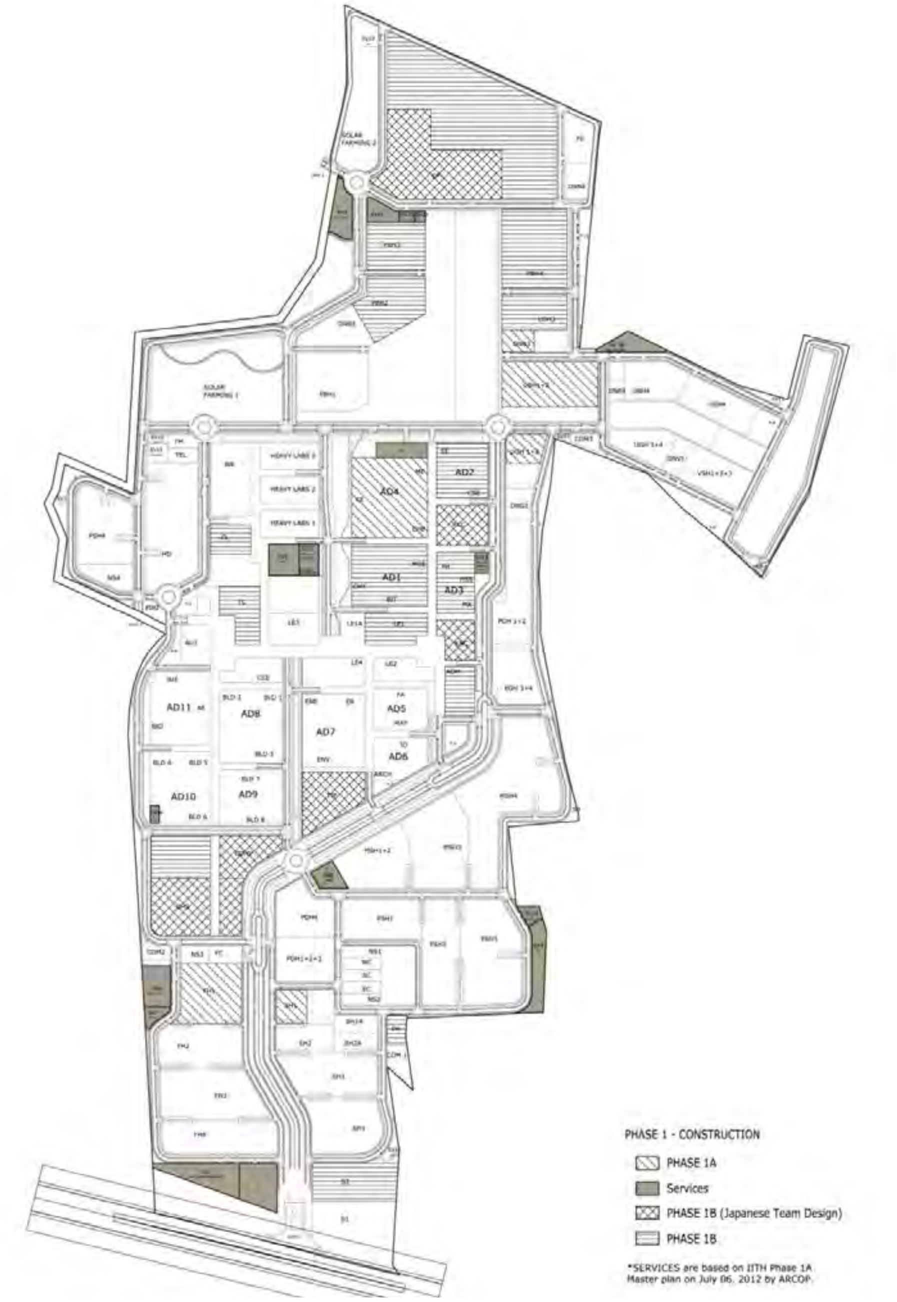


Figure 2.1.1Campus M/P Phase 1A and 1B

2.2 Phase 1A Master Plan

The Phase 1A M/P is currently under construction as well as three academic buildings, the faculty & staff housing, and hostels. The Phase 1A infrastructure construction includes the campus main road, substations for providing utilities, and routes for supplying utility services to each plot. The infrastructure systems for RCC and KNC shall be supplied from these substations. The following figure shows the Phase 1A infrastructure and buildings which are currently under construction. . The utility supply routes are shown in 2.3.

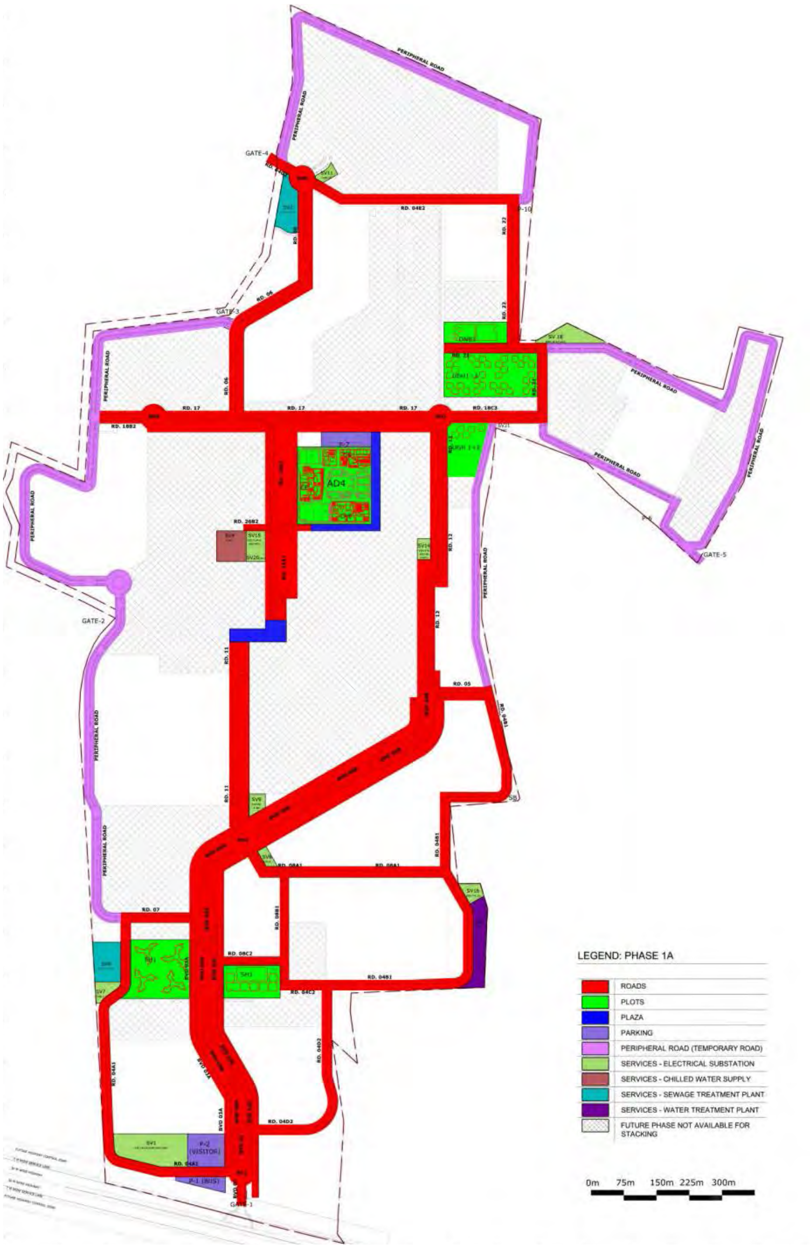


Figure 2.2.1 Campus M/P Phase 1A

According to IITH, most of the buildings currently under construction were originally planned to be completed by March 2014. However, because of delays, their main goal is to complete the two hostel buildings and first four floors of chemical building. The rest of the buildings including faculty housings and other hostel towers along with two academic buildings shall be completed by December 2014 and March 2015. By following the GRIHA construction guideline, the management of the site and safety is well controlled compared to other private developers' constructions in India. The GRIHA agency's inspections occur regularly based on their construction control guideline. The following chart shows the GRIHA's checklist during the construction. The sustainable approach regarding GRIHA is in 3.1.2.

Table 2.2.1 GRIHA Checklist for Site Visit

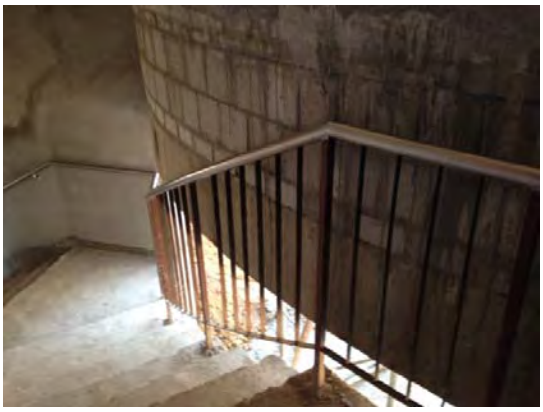
1	Nearest bus station, rail station, public transport, Existing sewer line, Existing water supply line, Existing electric line.
2	PERT chart
3	Site barricading to restrict construction activity to designated locations.
4	Phasing plan
5	Construction management plan
6	Sedimentation tanks and erosion control channels
7	Top soil preservation
8	Trees protection
9	Soil testing report
10	Work order for plantation, if applicable at this stage
11	Various Purchase Orders (e.g. Outdoor lights, controls, etc., if applicable at this stage)
12	Utility corridors
13	Signages, Safety hats, boots, harnesses, safety nets, etc.-on site and contract copy document (if required)
14	Labour hutments
15	Arrangements for drinking water and toilet facilities
16	Arrangement for reducing air pollution (e.g.Wheel washing facility, Site barricading, Covering of dusty material, Sprinkling of water, Proper stack height of chimney of DG sets.)
17	Medical facility for on-site workers
18	Wateruse minimization efforts during construction (e.g., use of gunny bags/water ponding/admixtures/leakage checking for water pipes, records of water used for curing, etc.)
19	Arrangement for fly ash content in structural concrete,building blocks, masonry, plaster (as applicable)
20	Waste management plan for construction waste, including waste generated in construction workers colony

Following are the photos from the construction site of the new campus.

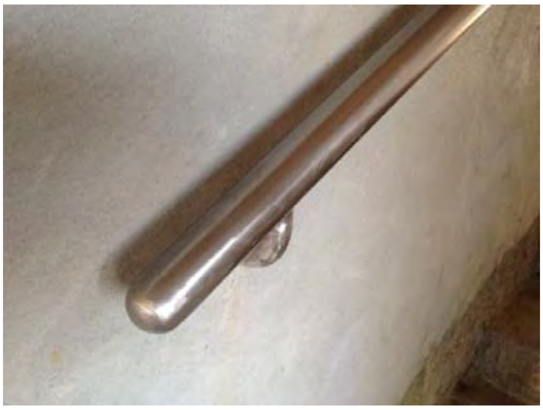
Table 2.2.2 Phase 1A Construction Progress

 FACULTY HOUSING: The structural framing system is very complicated. It seems to be very difficult to construct.	 DINING HALL: The quality of the exposed concrete is good.

 CHEMISTRY BUILDING： The overall execution level is good. The facility will be opened once the fourth floor is completed. It will be in use during the remainder of the construction period	 WINDOW STILL： The detail of the window frame is simple compared to the Japanese standard.	 SHADING FIN： Simple and easy installation
 HOSTEL： Most of the concrete frames are completed.	 RADIENT COOLING： It is common in India to imbed the system into the slab. However, in this case, it is installed above the slab	 FINISHING STONE： A white lime stone (Bettam Chara) is widely used in the area. But it is very brittle and can only be used in sizes less than 300mm by 300mm
 DISCUSSION WITH IITH:	 BEFORE CASTING CONCRETE： The execution level is good. The number of rebar’s is less than the Japanese standard.	



STAIRS & HANDRAIL:
IITH concerns the maintenance issues. The detail reflects their concern.



HANDRAIL DETAIL

EXPOSED CONCRETE FINISH:
Fine finish

STRUCTURE:
Good quality

CAMPUS OVERVIEW FROM CHEMICAL BUILDING
Civil Engineer Building on the right

2.3 Infrastructure Plans

(a) Power Supply

On IITH campus, the electricity with 3φ3W 33kV 50Hz is supplied to the main substation located in the south end of campus by an electric power company. The electricity is distributed to 11 substations located on campus after transforming to 3φ3W 11kV. The electricity is transformed from 3φ3W 11kV to 3φ4W 415-240V by a transformer of each substation and is supplied to each facility. The emergency generator which can serve 30-40% of the commercial power supply load is installed in the main substation. The cable for electricity is installed in a trench and is extended as infrastructure work to the primary side of the main circuit breaker of Pillar Box at the site boundary on incoming cabling route. The cabling within the site from Pillar Box will be included in the scope of the work of the building side.

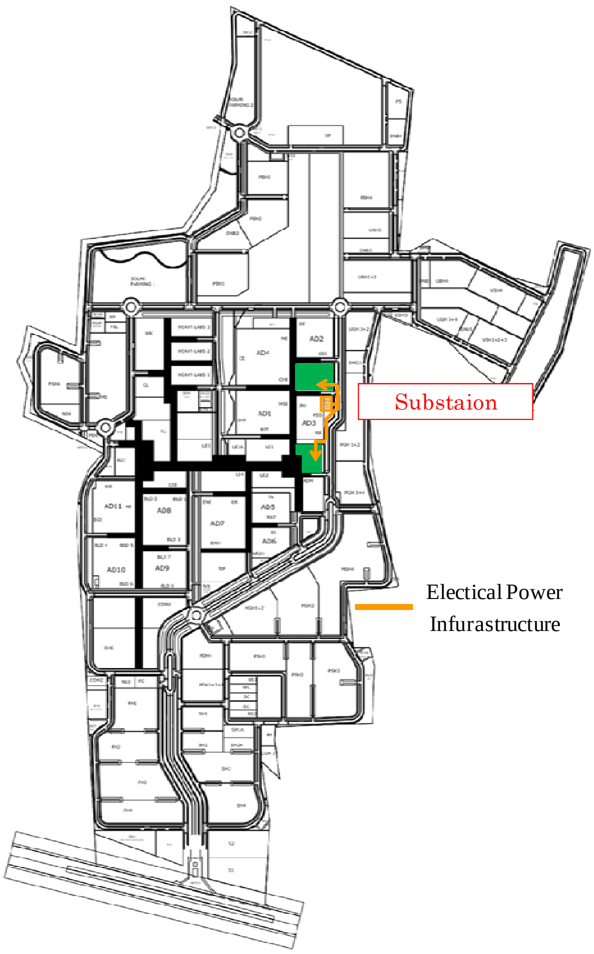


Figure 2.3.1 Power Supply

(b) Communication

On IITH campus, the communication network will be planned for telephone and LAN system. The optical cable is used for supplying the communication network to each facility.

(c) Water supply

In the IITH campus, two kinds of water (city water and flushing water) are supplied. Water is supplied to a receiving water tank located in the south-eastern part of campus from the water company. The water is distributed to a water tank in each zone and supplied to each facility as drinking and public use water.

In addition, the reuse water is distributed to each facility after treatment and is used such as the flushing water for toilets, irrigation water, and the air conditioning make-up water. Rainwater and well water are also reused with processing water.

As supply pressure of the city water and flushing water to the facility is 4.0 kg sqcm, the water can be supplied to an elevated water tank directly up to 30m high, on top of a building. The water is distributed to each designated place by gravity from the elevated water tank. As long as a building does not exceed 30m high, the water tank is not required.

The water consumption of the whole campus is expected to be 2,240m³ per day in total for a phase I. The breakdown of water consumption becomes general water 975m³, flushing water for restroom 450m³, irrigation water 500m³, and cooling tower make-up water 315m³ per day.

Figures of infrastructure of the city water supply and the flushing water supply are shown in Fig. 2.3.2 and Fig. 2.3.3

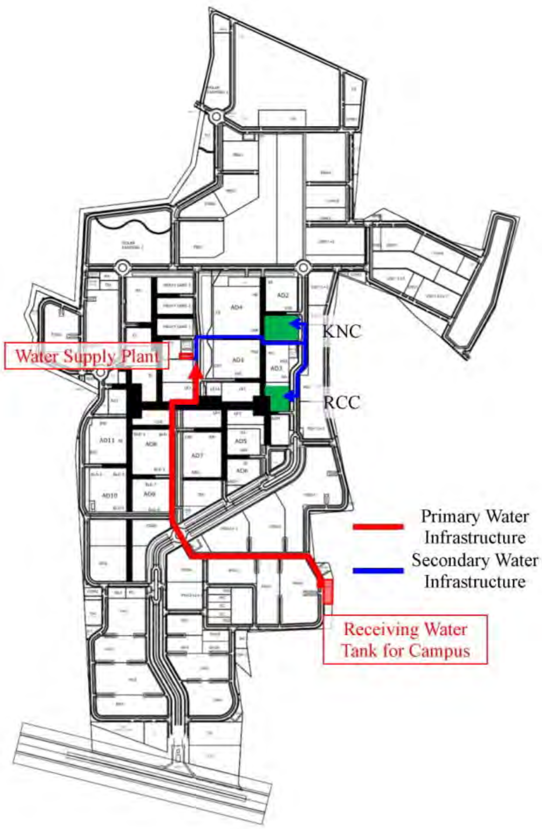


Figure 2.3.2 City Water Supply

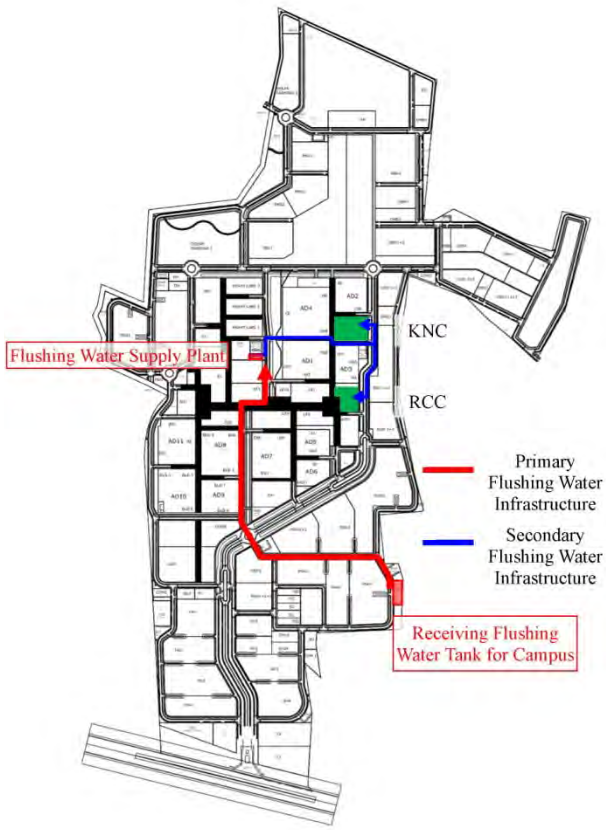


Figure 2.3.3 Flushing Water Supply

(d) Sewerage and Drainage

The soil water and general waste water from RCC and KNC are gathered in the Sewage Treatment Plant (STP) located in the north-western part of campus all together.

The water is treated primarily by a biological system and sand filter (an active carbon) and secondly by a sterilizer. After this it becomes reuse water. It is treated by water softener and some processing water is used as make-up water of the cooling towers. The cooling tower is for chilling the HVAC cooling water of the chiller.

The discharge quality of the water standard of the STP is Biochemical Oxygen Demand (BOD) 20ppm, Chemical Oxygen Demand (COD) 30ppm, Suspended Solids (SS) 40ppm, but the design standard is BOD 1-10ppm, COD 10-30ppm, SS <5ppm.

In addition, the rainwater from each site is collected in three storage reservoirs located on campus. It overflows to the outside of the campus when they reach at the full capacity.

Figures of sewage and drainage infrastructure are shown in Fig. 2.3.4 and Fig. 2.3.5

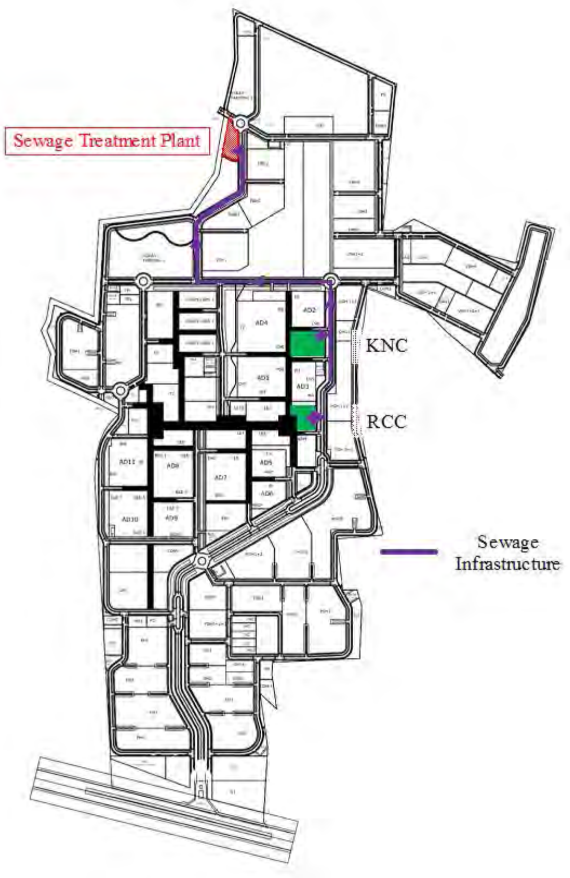


Figure 2.3.4 Sewerage Water

Figure 2.3.5 Drainage

(e) Chilled Water for Air Conditioning

As a heat source for air conditioners of the facility in the IITH campus, the centralized chilled water for RCC and KNC is supplied from central energy center located in the North part of campus. The chilled water is used as a heat source for the Air Handling Unit (AHU) and the Fan-Coil Unit (FCU).

As the air temperature of the summer exceeds 40 degrees Celsius in Hyderabad, the water cooled chiller is adopted because of its high efficiency.

As the primary side supply temperature of the chilled water is 6.7 degrees Celsius and return side temperature is considered to be 13.7 degrees Celsius, a water heat exchanger in the facility is adopted and chilled water is supplied to AHU and FCU for cooling.

A figure of the infrastructure of the chilled water supply is shown in Fig. 2.3.6

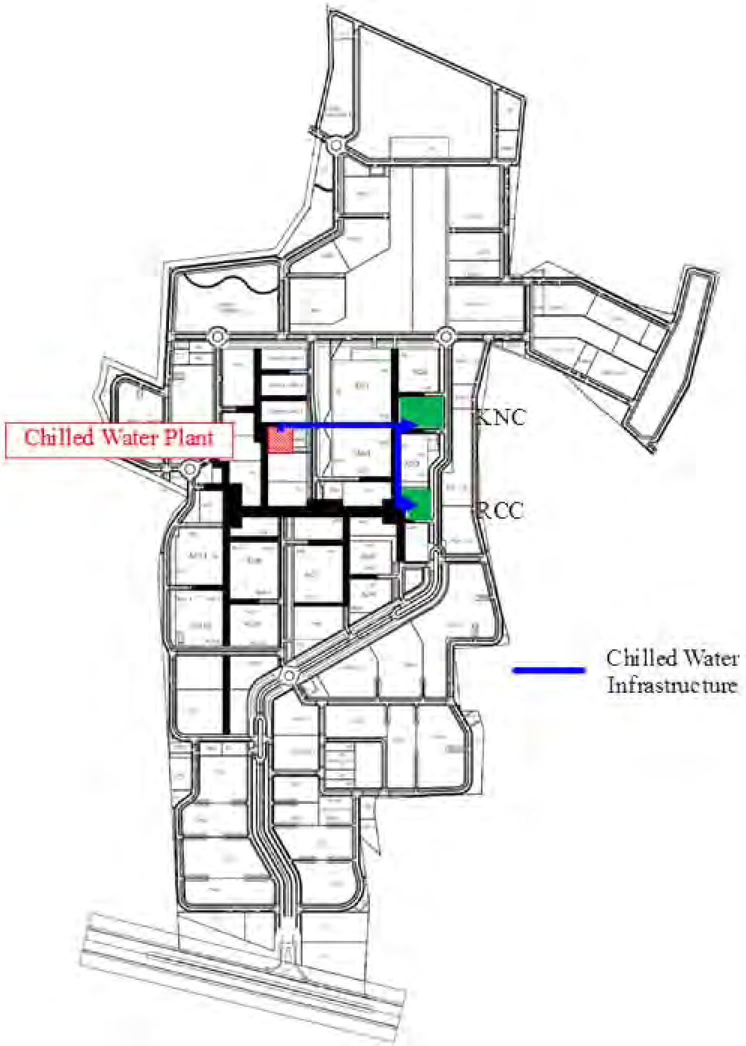


Figure 2.3.6 Chilled Water Supply

(f) Gas

A Liquid Propane (LP) gas tank in the IITH campus is located on the south side, and the LP gas is supplied to each facility by a centralized piping method. The central LP gas tank is planned however, the route is currently still under consideration.

In the future that gas will be changed to Compressed Natural Gas (CNG), and that the pipe of the LP gas line will be reused.

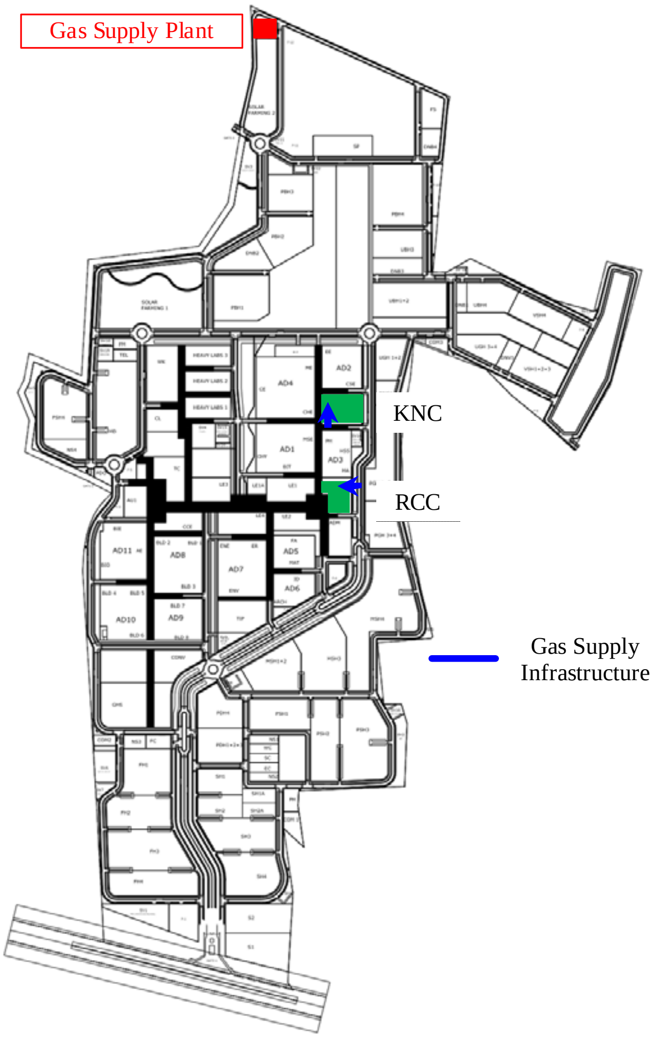


Figure 2.3.7 Gas Supply

(g) Solid Waste Treatment

Hyderabad city collects the solid waste in segregated manner, and the processing method is dumping (goods in open air storage).

The kitchen waste and the burnable are stocked separately and carried out by a collection car from each city.

2.4 Site Plot Information

IITH has provided master plan plot guidelines for each site. Each building needs to setback by 6m from the property line based on the fire fighting plan.

(a) KNC

The tap off points of Electrical LT line, Sewerage, and drainage are located in the north east corner. On the other hand, the tap off points for ELV line, water supply, and flushing water are in the south east corner. The LP gas line tap off is in the south west corner.

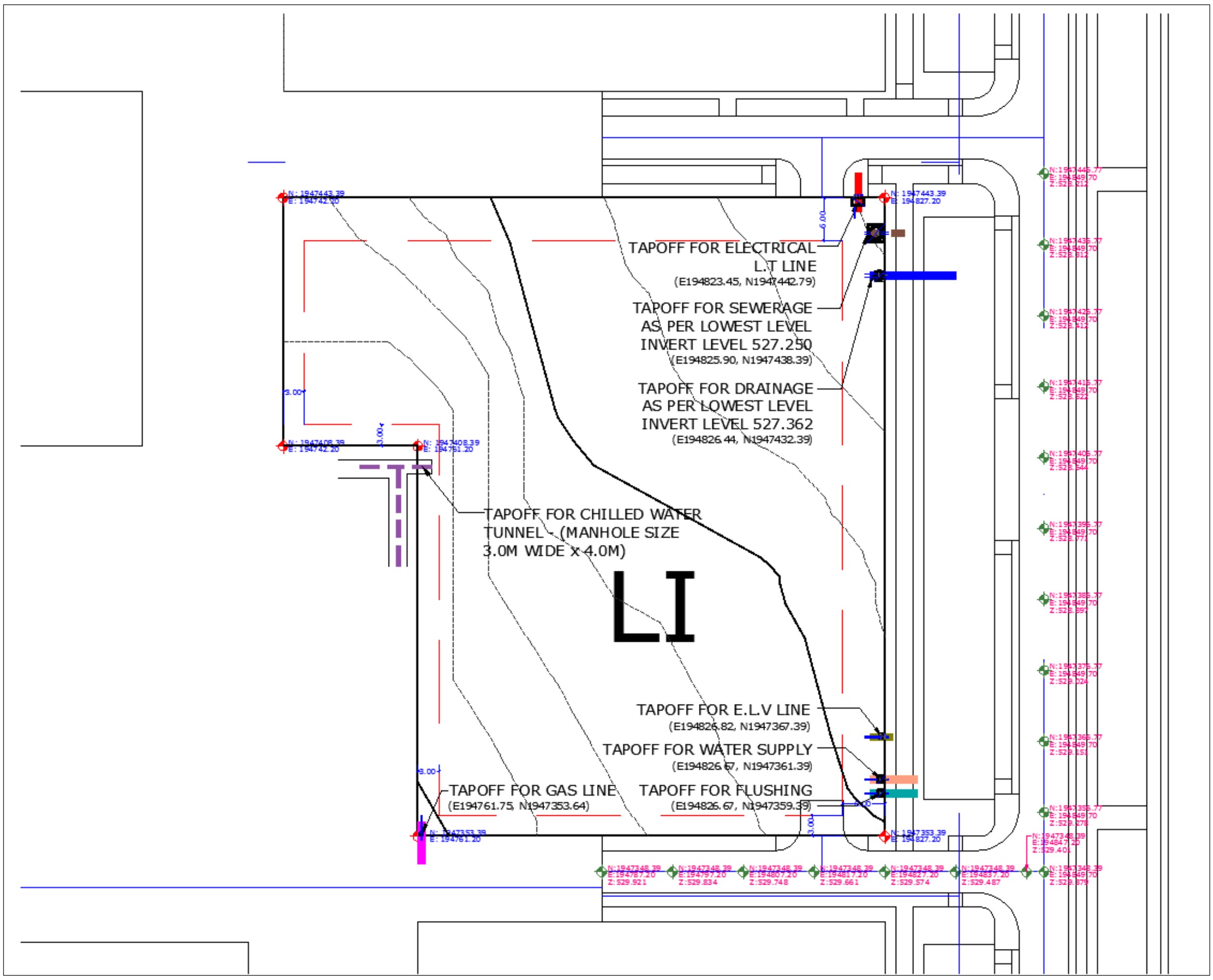


Figure 2.4.1 M/P Guideline for KNC

(b) RCC

The tap off points of Electrical LT line, Sewerage, and drainage are located in the north east corner. On the other hand, the tap off points for water supply, and flushing water are in the south east corner. The LP gas line and the ELV line tap off points are located in the south west corner.

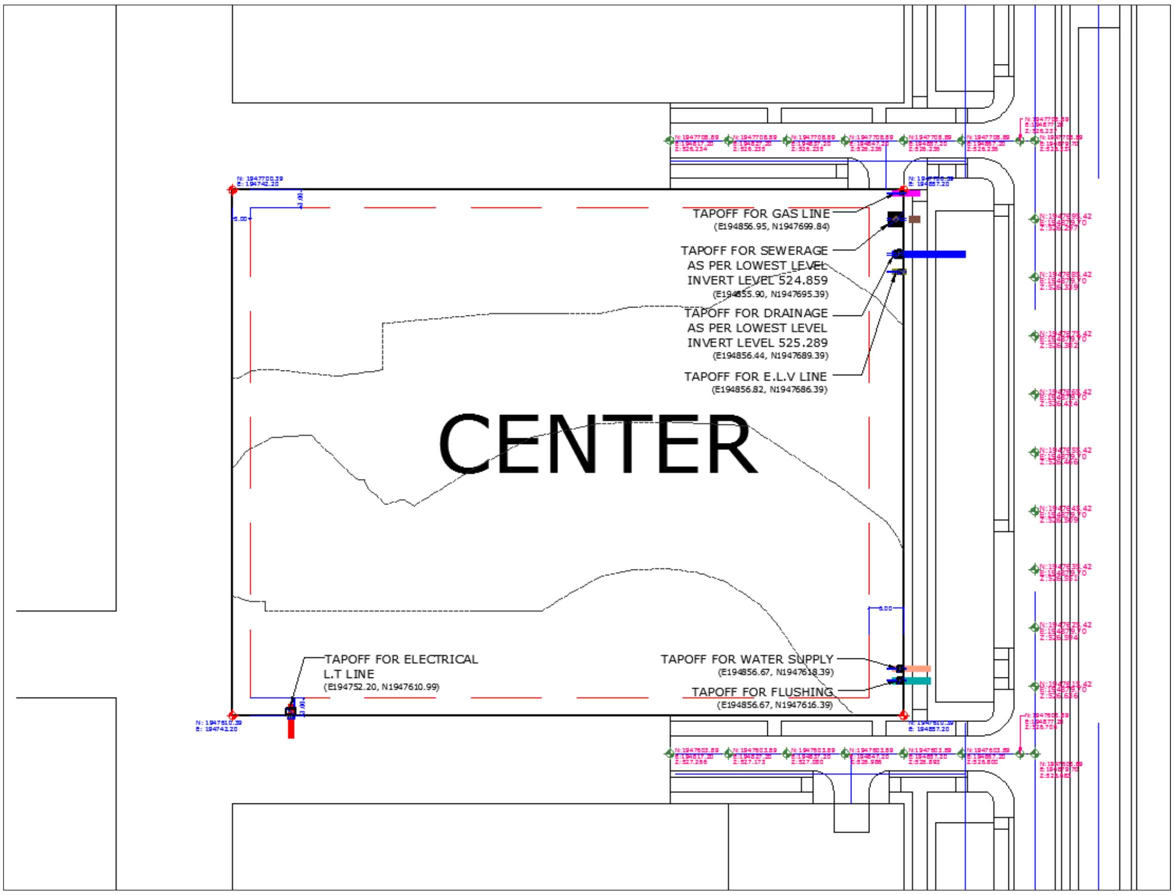


Figure 2.4.2 M/P Guideline for RCC

CHAPTER 3

DETAILED DESIGN ASSISTANCE

CHAPTER 3 DETAILED DESIGN ASSISTANCE

The scope of this project is as follows:

① Knowledge Center (KNC)

② Research Center Complex (RCC)

The following detailed design assistance will be provided:

・Architectural Design

・Structural Drawings, Structural Calculation

・Electrical Design Drawings

・Mechanical Design Drawings

・Outdoor Facilities Design Drawings

・Other Related Drawings

・Specifications to be concerned with as above

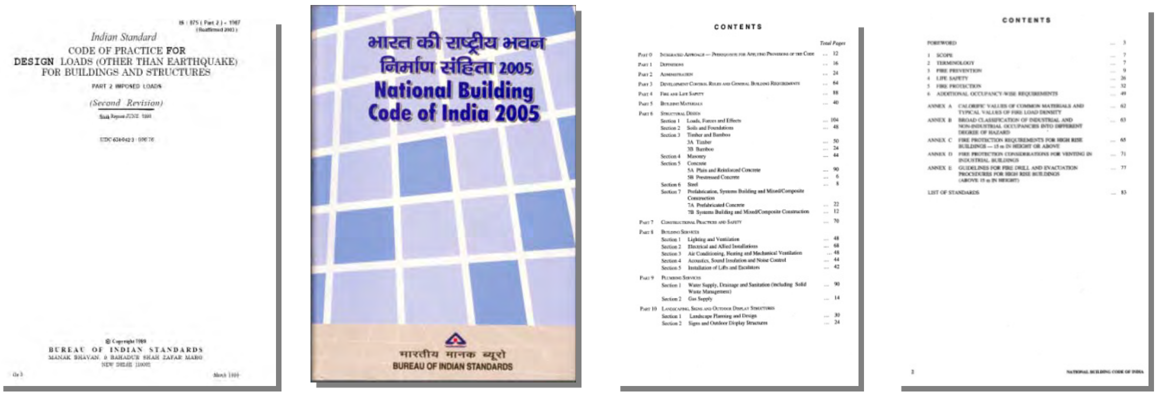
Figure 3.1.1 Location of Proposed Facilities Plot

3.1 The Building Codes, Building Standard and Precedent Research.

3.1.1 The Building Codes and Building Standard of India

All the facilities on campus shall meet the building codes and building standards of India. They shall also meet any related local laws and regulation in Andhra Pradesh. The main regulations and building codes are listed below:

- NBC (National Building Code)
- IS (Indian Standard of Building)
- BFC (Building Fire Code)
- ECBC (Energy Conservation Building Code)



IS NBC

Figure 3.1.2 Indian Standard and National Building Code of India

3.1.2 GRIHA

GRIHA is a rating system that helps people assesses the performance of their building against certain nationally acceptable benchmarks. It evaluates the environmental performance of a building holistically over its entire life cycle, thereby providing a definitive standard for what constitutes a 'green building'. GRIHA rating system consists of 34 criteria categorized under various sections such as Site Selection and Site Planning, Conservation and Efficient Utilization of Resources, Building Operation and Maintenance, and Innovation points. Different levels of certification (1star to 5 stars) are awarded based on the number of points earned. The new facilities on IITH new campus are required to obtain more than 4 stars as IITH requested.

Table 3.1.1 GRIHA Rating Points and Stars

Points achieved	GRIHA Rating
50-60	★
61-70	★★
71-80	★★★
81-90	★★★★
91-100	★★★★★

It is limited to evaluate the GRIHA point during the design stage. However, the currently evaluated GRIHA checklist is shown in the Appendix C.

It is considered to earn points for achieving the GRIHA 4 star rating by the use of natural light through windows and skylights, solar panels, LED lighting fixtures, high performance HVAC equipments, and sustainable toilet fixtures.

The following process shall also assist the projects from achieving GRIHA 4 star rating:

- Analysis by TERI as environmental consultants appointed by IITH
- Specification by the BAC (Bidding Assistant Consultant) appointed by IITH
- Soil conservation by Contractor
- Use of fly ash cement by Contractor

3.1.3 Precedent Research

Through precedent research, the following points have been exploited for the projects.

The precedent projects are chosen based upon some similarities with IITH project such as buildings function, geographical location and climate condition.

The reason for having precedent research is to promote higher level of design details. in order to execute the original design provided by UoT. Furthermore, the nano tech lab facility at Komaba Campus ,University of Tokyo is chosen as IITH also refers it.

(a) Nano tech lab, at Komaba Campus of University of Tokyo

This facility was analyzed as a reference for the RCC. The critical points taken from the precedent lab to develop RCC nanolab detailed design assistance are as follows:

(i) The space requirement under raised floor and above ceiling to accommodate Nano lab`s mechanical system

Based on the end user’s comments, especially the space above the ceiling is not enough. Therefore, the depressed slab level, the floor height and the space above ceilings were revised to provide sufficient room for Nano lab` mechanical system from the SD.

(ii) Cleanliness classification,

Based on the end user’s comments, the cleanliness of nanotech lab shall be consistently maintained within each lab by its tenants.

(iii) Special Toxic Gas Space

Special gases are to be placed by tenants. In order to enhance the safety of the building, and to protect habitants against toxic gases such as hydrogen and carbon dioxide, a central managing system is provided with a dedicated gas cylinder storage in a separate building, rather than installing gas cylinders in each laboratory.

(iv) Mechanical Shaft

In the research buildings of the Komaba campus, the pipes from the laboratories are installed on the outer periphery of the buildings. In RCC, the mechanical shaft is placed in the center of the buildings due to building location in relation with the main road and to aid future extension of mechanical system.

However, as the RCC is located along a main road, the view from the campus mall had to be considered. For this reason, as well as to aid future extension, a mechanical shaft was designed in the center of the building.

(v) Utility Lines of the Building Side

The utility scope and capacity of chilled water requirement (HVAC loads), ventilation and plumbing works were carefully studied and referred in the development of RCC design.

(b) National University of Singapore – U-town/ Educational Resource Center

This is one of the top ranked universities in Asia. Singapore also has a similar climate to that of India. The U-town campus is one of the biggest features of the university; it has student dormitories, faculty and staff residential facilities, and the academic facilities like IITH. It is very different from a typical university in Japan. However, it is a great example of student daily life and academic life on the same campus.

The design counteracts the hot climate by using fans and extensive external areas. The corridors between the rooms are facing the exterior space with canopies for good climate control. There are many exterior lounges for students to switch themselves to relaxed mode and study/active mode. In this way students can have discussions and group studies in a more relaxed atmosphere than a “formal” seminar room. These aspects are reflected in KNC as different study areas - especially for group study rooms and reading rooms.

In addition, the Education Resource Center is a modern facility which acts as a new type of library in the digital age, as Professor Desai requested. It connects student daily life and the academic campus. The use of transparent glass walls between the hallway and rooms is also applied at KNC in order to create open visible space. The height of the bookshelves dividing the group study rooms was shortened in order to maintain an unobstructed view throughout the stepped open shelf area. This will increase safety and discourage vandalism. The layouts of the furniture are designed accordingly.

(c) Hong Kong Polytechnic University

Hong Kong Polytechnic University has a state-of-the-art architectural design. It is a helpful reference to understand and execute the distinctive design of UoT because it shares many similar design features such as a complex building shape and the use of dry, finished concrete and metals in the interior spaces

Through this precedent research, it was clear that the in-situ reinforced concrete as the conventional method is much more suitable than pre-cast concrete structures. UoT had initially intended to use pre-cast concrete structures in order to achieve a three-dimensionally curved surface for the roof of the KNC.

The air-conditioning duct space below the stepped floor is provided by mean of the space between the stepped floor and the ceiling above the ground floor rooms instead of having double slab floor solution proposed by UoT. By doing so, the air-conditioning performance will improve and the ducting execution will become easier without compromising the UoT's aesthetic design intention.

At the entrance hall on ground floor, the ceiling surface is constructed with simple two-dimensional planes. In this way, the dynamic space under the arches was archived with a feasible construction method.

(d) Tama Art University Library, Hachioji, Tokyo

Tama Art University library is a very good example as a precedent. KNC and Tama Art University library share common building features such as being a main library on campus, using arched spaces with exposed concrete finish, and symbolic building on campus.

Tama Art University library is supported with arches made from metal plate and concrete. This type of structural system provides thin concrete finish wall but it is expensive. In KNC, thick concrete arch walls are proposed by UoT and its construction cost should be more economic compared to the wall made from metal plate and concrete. Special seismic systems are not directly applicable in KNC considering IITH campus site.

Exposed concrete building greatly reflects sound and increases the level of noise. Tama Art university library is equipped with noise control boards at the ceiling of public gathering area.

Similarly, in the ceiling of the stepped open access bookshelves area of KNC soundproofing boards shall be installed in order to maintain desirable sound level at the library building. The shading devices are provided in the west curtain wall façade of KNC to reduce the heat gain from the afternoon strong west sunlight.

3.2 Architectural Design

3.2.1 Design Concept

(a) KNC

Figure 3.2.1 KNC CG perspective

The library is one of the most important elements in the university campus.

This facility is named “Knowledge Center”, instead of “Library”. This term includes the positive and academic attitude to connect old wisdom and future creativity by the “knowledge” system. This building is composed of an inverted cone-shaped space, and has a wide range of contents from important historical books to new media by IT. It will be a completely new “Knowledge space” that never existed before.

An open space at the north of this site is reserved or building extension which will accommodate the increasing number of books in the future.

(b) RCC

Figure 3.2.2: RCC CG perspective

This facility is a collective of several research centers, and long-term tenants are not assumed. It is also expected to work as a showcase of the forefront research activities of IITH.

Its structure is RC and the building possesses 5 floors above ground. The ground floor and the first floor are called the "Mega Lab" and IITH is currently considering housing Nano tech laboratories at Mega Lab area. There are typical laboratories of Dry Labs and Wet Labs on the 2nd, 3rd and 4th floor. In general, Wet Lab handles chemicals, or other material in liquid solutions. Dry Lab uses primarily electronic equipment and handles dry materials which do not require the use of water. Common function such as administration offices and seminar rooms are located on the 2nd and 4th floor. The plan of this building is a doughnut-shape, and there is a mechanical void (a space for the mechanical equipment) in the center. This mechanical void also contributes to save energy, because it brings natural ventilation and sunlight to the rooms inside.

An open space is left on the east side of the RCC building for future extension.

3.2.2 Construction Site

The construction site of the KNC is at the center of the campus, and it is 1,300m away to the north from the main entrance of IITH campus. The construction site of the RCC is at the center as well, 1,500m away to the north of the entrance. There is a main street in the center of the campus, and this connects both sites as to be in the master plan. The built up area of the KNC is 6,605 square meters, and its altitude is 530m. The built up area of the RCC is 10,350 square meters, and its altitude is 528m.

3.2.3 Scale of Facilities

The outline of each facility is shown in the table below.

Table 3.2.1. Area of Each Facility

	KNC		RCC	
	SD	DD	SD	DD
Site Area	6,105 ㎡	-	10,350 ㎡	-
Total Floor Area	8,823 ㎡	7,879 ㎡	7,971 ㎡	8,519 ㎡
Construction Target Area	9,081 ㎡	8,739 ㎡	10,819 ㎡	11,737 ㎡
No. of Floors	4	4	5	5
Maximum Height	25.7m	28.4m	25.5m	24.4m

Note) Schematic Design (SD) is the design in March, 2014.

3.2.4 KNC Required Programs and Area

Table 3.2.2 KNC Required Programs and Area

	Category	Rooms	Area of Unit (sqm)	No.	Area (sqm)	Remarks
Interior	Open Shelf	Open Shelf	-	-	1927	
		Reading Room	-	4	824	
		Group Study Room	-	21	424	
		Printing Room		1	13	
		Manifolder Room	-	1	27	
		Micro Reading Room	-	1	16	
	Closed Shelf	Archive		1	140	
	AV Rooms	AV Room		1	176	
		Media Literacy Room		2	121	
	Common Space	Administration Office		1	172	
		Director’s Room		1	29	
		Meeting Room			39	
		Mini Kitchen		1	6	
		Janitor’s Room		1	12	
		Locker Room		1	6	
		Counseling Room		2	26	
		Publication Support Room		1	25	
	EV		-	-	88	
	Entrance Hall				489	
	Cafeteria				58	
	Lounge				66.00	
	ELV/ Telecom RM				16	
	WC				266	
	Storage		-	-	126	
	Electrical Room				68	
	Mech RM				567	
	Others		-	-	2,218	
				Total	7,879	
Covered Exterior	Under Canopy				860	
				Total	860	
				Construction Target Area	8,739	

3.2.5 KNC Architectural Concept Drawing

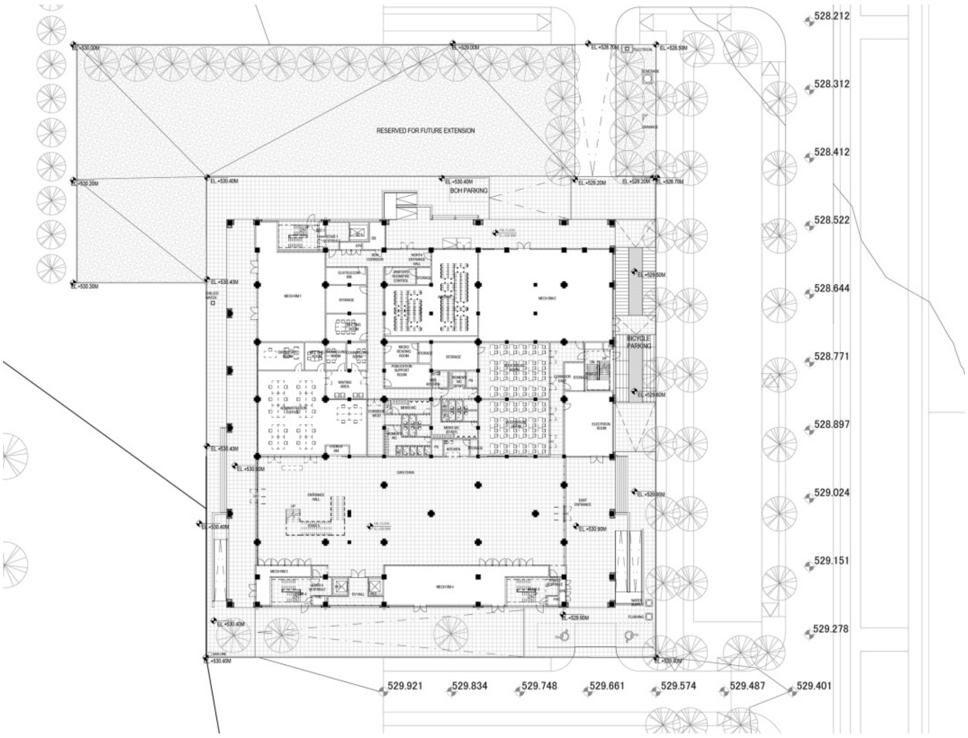


Figure 3.2.3 KNC Site Plan

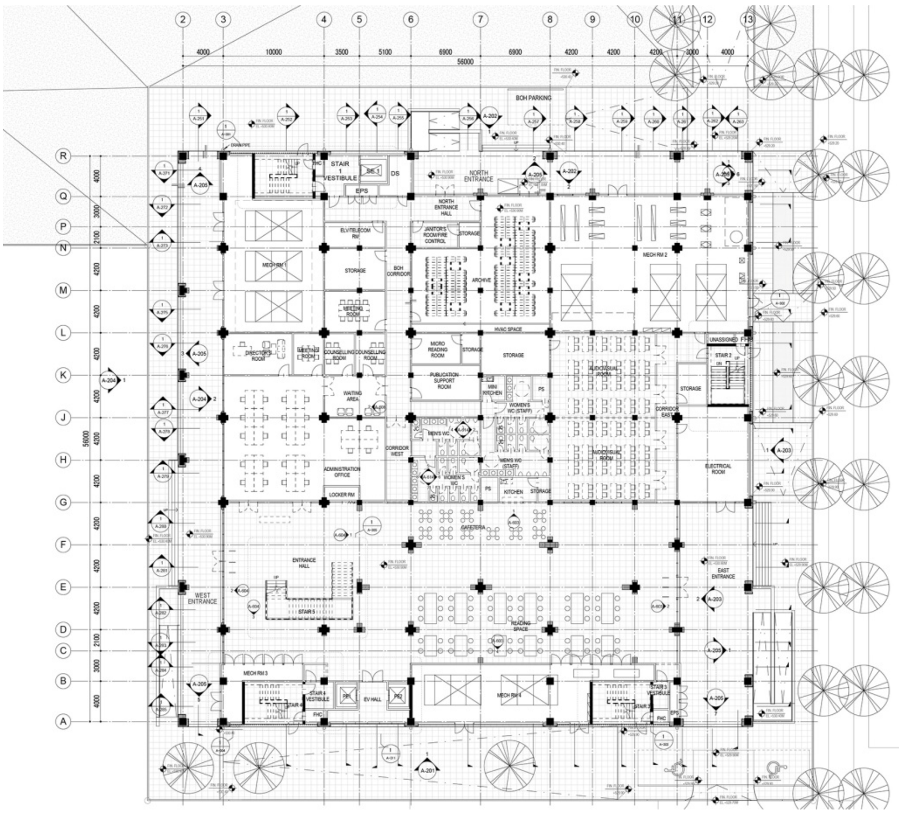


Figure 3.2.4 KNC Ground Floor Plan

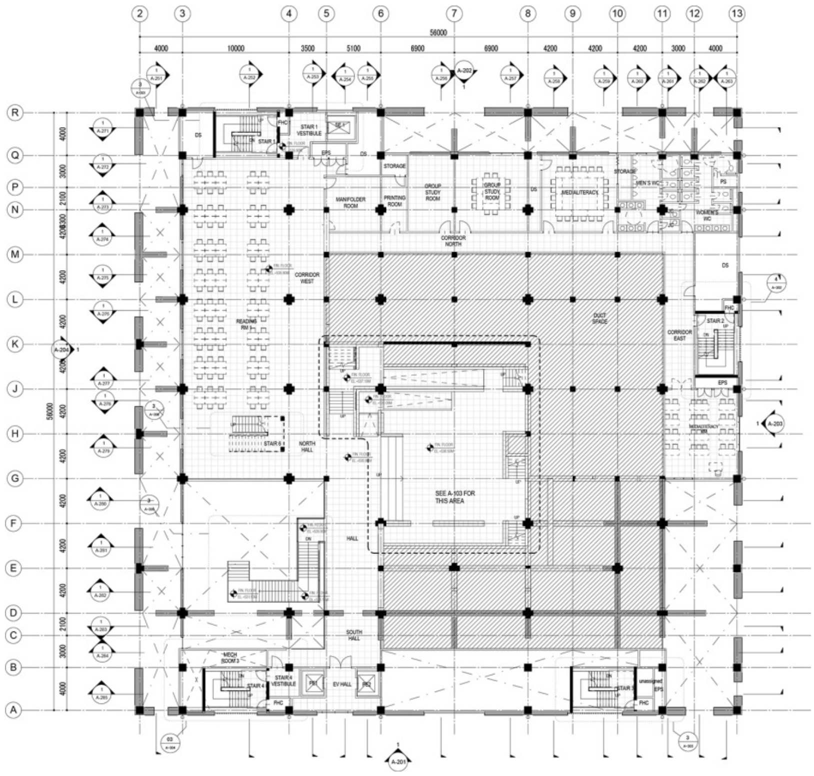


Figure 3.2.5 KNC 1st Floor Plan

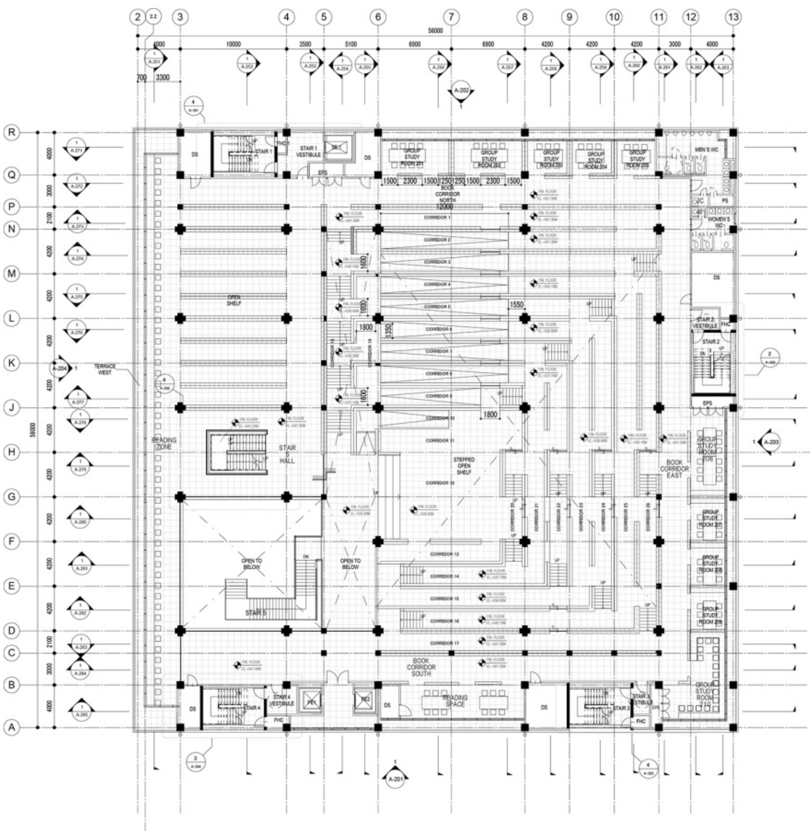


Figure 3.2.6 KNC 2nd Floor Plan

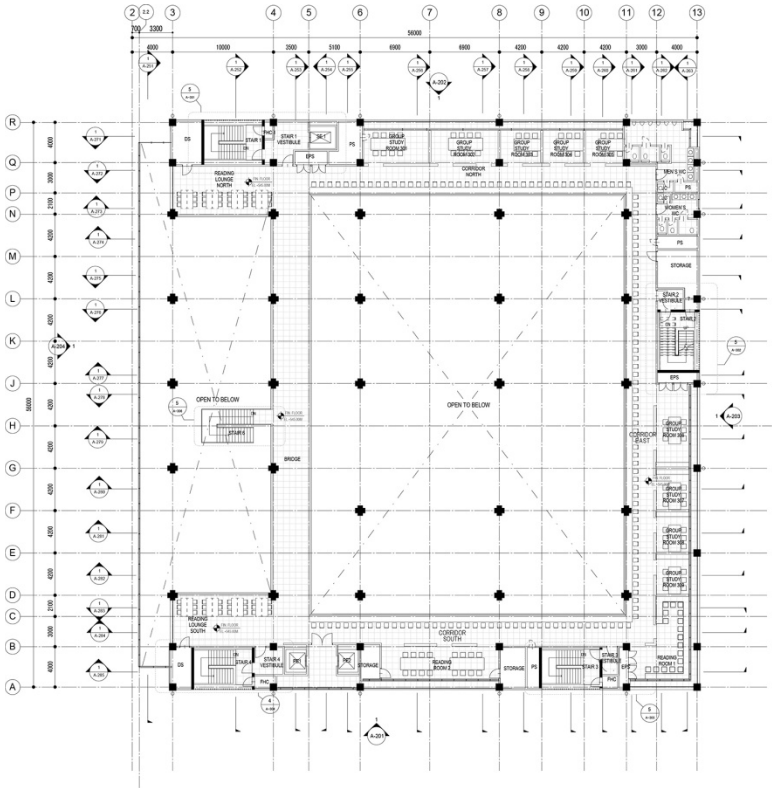


Figure 3.2.7 KNC 3rd Floor Plan

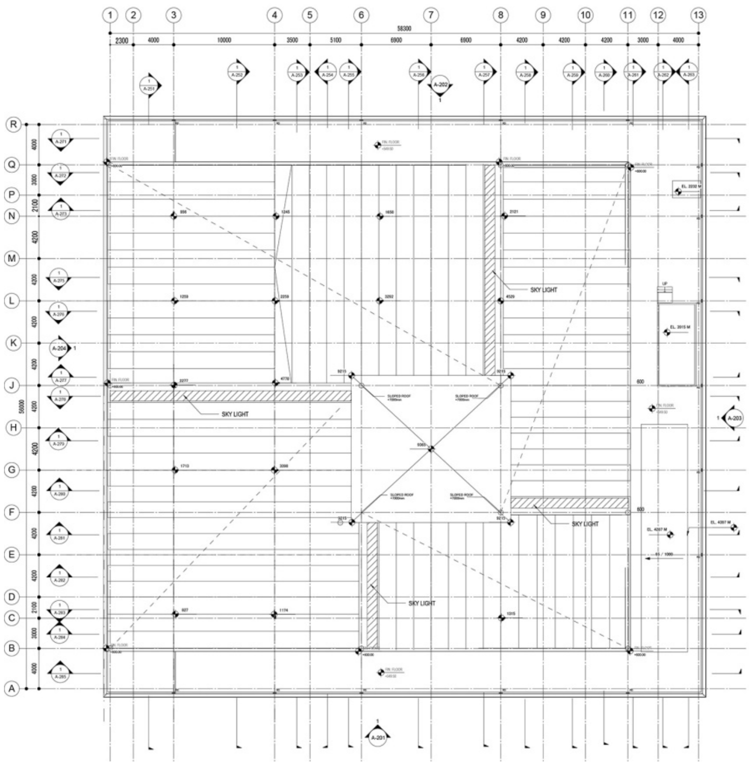


Figure 3.2.8 KNC Roof Floor Plan

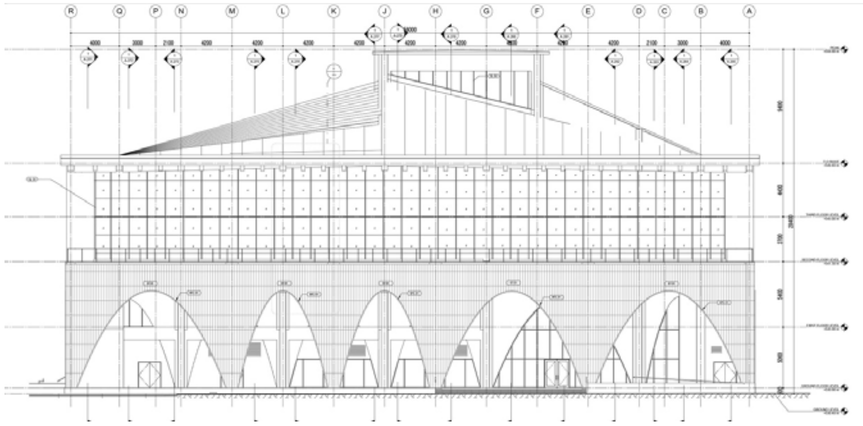


Figure 3.2.9 KNC West Elevation

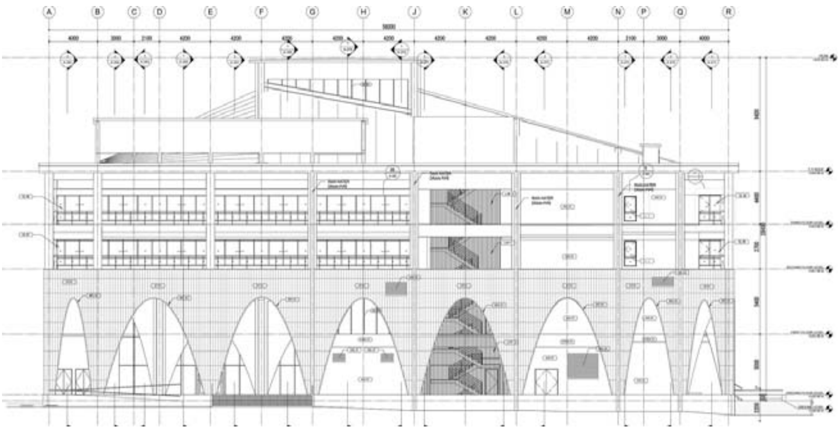


Figure 3.2.10 KNC East Elevation

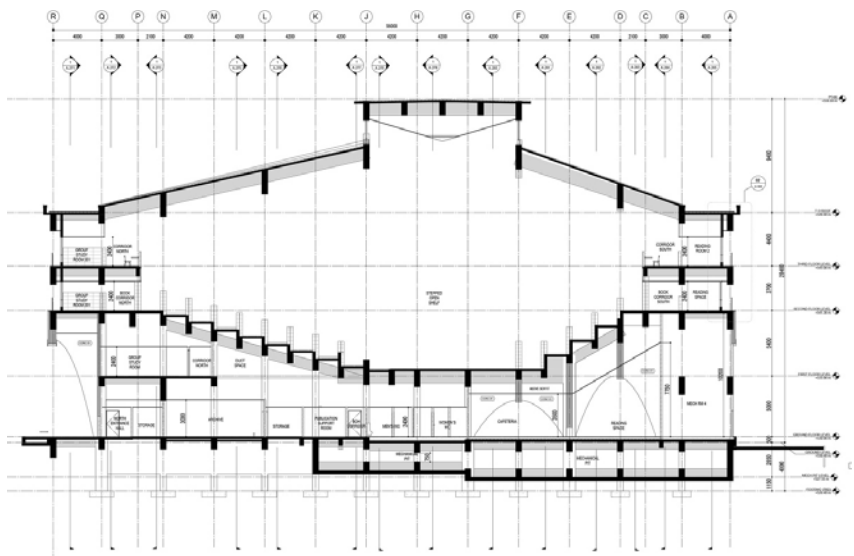


Figure 3.2.11 KNC Section

3.2.6 Policy of Architectural Detailed Design Assistance of KNC

(a) To utilize the design by UoT.

- To confirm the design intention with UoT and to reflect IITH's comments as users regarding the building itself, each function of the rooms and their performances.

(b) Planning of the Open Access Bookshelves Area

- To elaborate the design of bookshelves. The open access bookshelves area is an inverted cone-shaped space, and its floor gets higher and higher from the center to the outside. The bookshelves along the stepped floors are one of the most important factors of this facility.+
- To meet proper sound absorption, Heating, Ventilation and air Conditioning (HVAC) and lighting requirements for the library.
- To provide necessary number of bookshelves, strategies for millworks and fixtures and as well as lighting methods for the bookshelves
- To install sprinklers after discussion with IITH about the specification. The life safety regulations require sprinklers as well as specific fire fighting system because the facility accommodates books.

(c) Security Planning

- To provide thorough security planning to prevent library books from being stolen.

(d) Evacuation and Safety

- To rationally plan evacuation routes which comply with NBC. It is complicated to plan evacuation corridors because the space is shaped by stepped inverted cone floor and divided by multiple bookshelves.

(e) Coordination between Structure and Design

- To be sure to maintain the design intention. To create a structure system that is influenced by the aesthetic of the architecture.

(f) Consideration about the necessity about the future extension

- To consult with IITH about the necessity of future extension. for the flexibility of KNC building design is possible by allocating open space at the north of building. This open space will allow future extension of library to hold the increase numbers of the books.
- The increase numbers of books collections in the future can be accommodated with ease by leaving open site on the north. (Check with UoT and IITH about reserving the area for future extension and its location)

3.2.7 Contents of Study in Detailed Design Assistance of KNC

(a) Contents of the design review

The way of dividing the stone panels on the façade has revised from a typical layout of 600mm by 600mm to a long narrow one of 200mm by 1200mm requested by UoT.

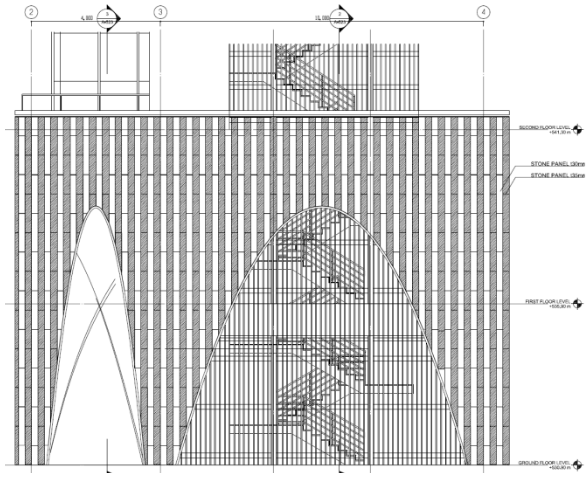


Figure 3.2.12 Stone Cladding Design

(b) Change by the detailed design assistance review

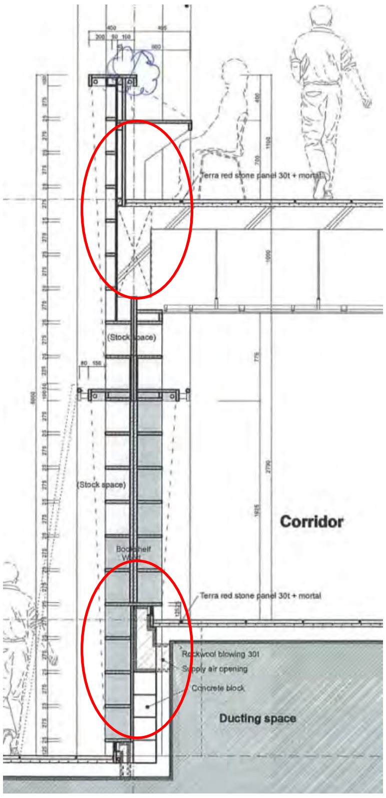
- The roof structure has been modified from the precast concrete to the typical reinforced concrete.
- The faming system was coordinated to answer all seismic, construction and economical aspects.
- Sound absorption material has been added to the ceiling of the stepped open access bookshelves area in order to improve the acoustic environment.
- Considering the construction aspects, the chamber with double slabs under the stepped open shelves is eliminated. The ground floor ceiling space is utilized as HVAC duct space for the open access bookshelves area.
- The area of flat roof has changed in order to coordinate the balance between interior walls and roof structure material, and in order to hide the ducting within the ceiling.
- The eastern stair on the entrance hall has been removed, because it was not necessary for evacuation route and it was also colliding with the structure member.
- For the integrated air conditioning, partitions between group study rooms were changed to the low bookshelves with openings above.
- The partitions between group study rooms are replaced with low bookshelves to provide safety and to protect vandalism requested by IITH.
- After discussion with the local consultant, the volumes of the water tanks have been revised.
- The floor height of the 3rd floor has been revised due to accommodate HVAC equipments, lighting fixtures and sprinklers.

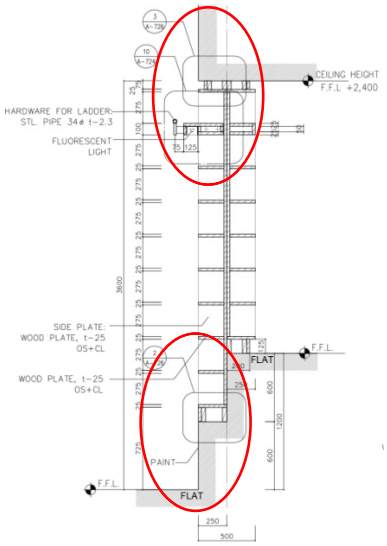
(c) Detailed analysis for Fire and Life Safety

- NBC classified the building in groups (A to J) according to the use or the character of occupancy. KNC is categorized as E-2 Library based on NBC fire and safety classifications. Travel distance and the regulations for the routes are followed with the E-2 regulations such as width of the egress stairs (more than 1.5 meters) and the travel distance within 45 meters.
- The elevator hall in the south side shall be segregated with 2 hour fire rated door. The elevator in the north side shall be used as fire lift in the case of emergency which is located near the fire control room.
- Fire hose closets were installed based on NBC.

(d) The bookshelves Detailed Design assistance

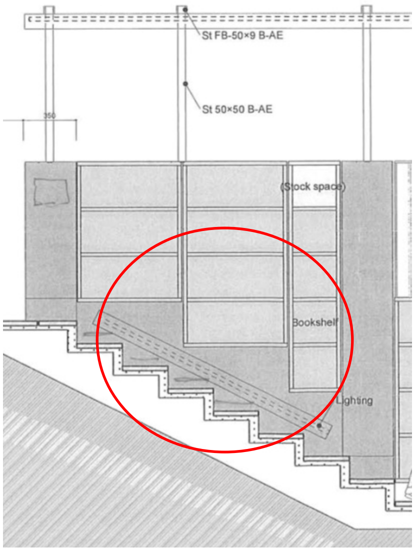
- UoT originally designed the fake bookshelves on the wall on the 3rd floor facing to the stepped open access bookshelves area. They are removed since they are conflicting with the beams and also they are placed too high to function as easily accessible bookshelves.
- Open bookshelves were disposed from each floor level surrounding the cone-shaped open space. By following the further structural analysis and design, additional beams supporting these bookshelves shall be required. In the area where beams are exposed at the same position as bookshelves surface, bookshelves are removed.

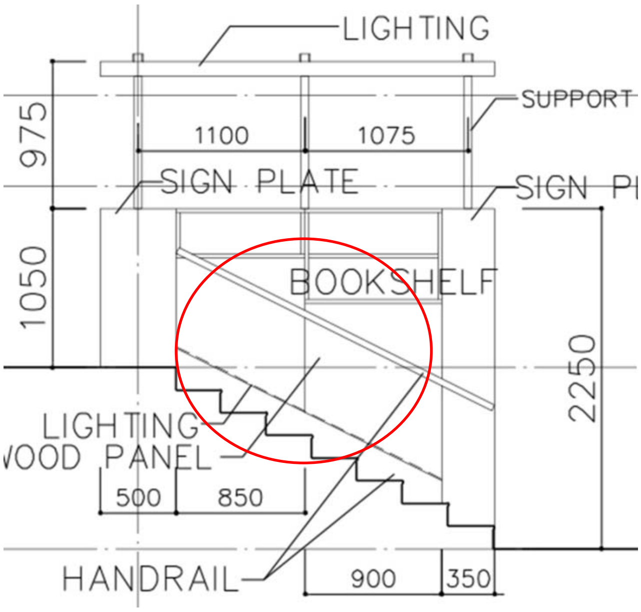




Left: Figure 3.2.13 The detail of bookshelves, in schematic design
Right: Figure 3.2.14 The detail of bookshelves, in design direction

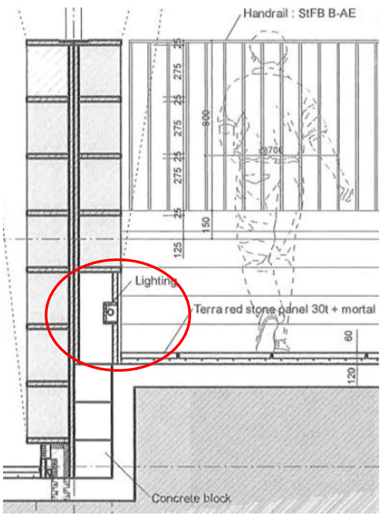
- In the open access bookshelves area, the bookshelves facing the stairs and slopes are removed to provide handrails for these stairs and slopes which is required by local building codes.

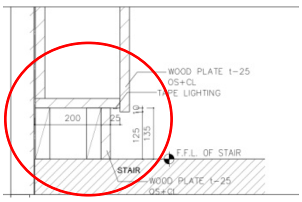




Left: Figure 3.2.15　The detail of bookshelves on the stair, in schematic design
Right: Figure 3.2.16 The detail of the stair, in design direction

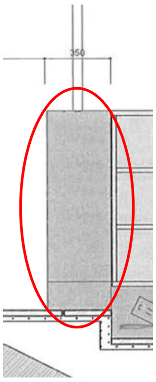
- In schematic design, foot lighting was planned on the wall of stairs on the stepped open shelf, but this turn to be difficult to construct after the consideration about the design detail. Foot lighting is modified from the fluorescent light to LED tape light, and it is included beyond the wall so that the light source cannot be seen directly.

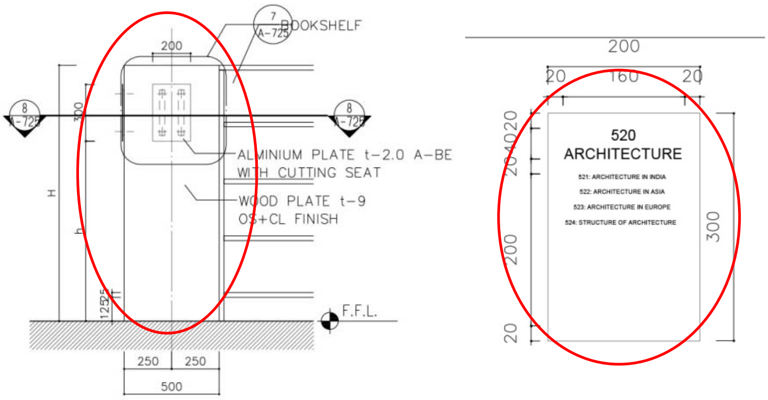




Left: Figure 3.2.17　The detail of foot lighting on the stair, in schematic design
Right: Figure 3.2.18 The detail of foot lighting, in design direction

- Sign panels on the bookshelves are designed in detail and the displayed contents are clarified.





Left: Figure 3.2.19 The detail of sign panel, in schematic design

Right: Figure 3.2.20 The detail of sign panel, in design direction

3.2.8 RCC Required Programs and Area

Table 3.2.3 RCC Required Programs and Area

Zone	Category	Room	Area (sqm)	No.	Area(sqm)	Remarks
Interior	Seminar Room	Seminar Room 301		1	94	
		Seminar room 302		1	111	
	Conference Room	Conference Room 204		1	69	
		Conference Room 301	1	1	110	
		Conference Room 302	-	1	130	
	Meeting Room	Meeting Room 101	43	2	86	
		Meeting Room 201		1	84	
		Meeting Room 202		1	84	
		Meeting Room 203		1	77	
	Laboratory	Dry Lab		20	866	
		Wet Lab		26	1468	
		Mega Lab Office		8	342	
		Mega Lab (Nano Lab)		2	1004	
	Administration Office	Administration Office		1	65	
		Janitor/ Security Room		1	22	
	EV				186	
	Entrance Hall			1	62	
	WC/ Shower Room		-		500	
	Mini Kitchen		-	5	43	
	Mech Room				390	
	Gas Cylinder Storage			1	125	
	Others				2602	
	Sub Total				8519	
Covered Exterior	Corridor				1521	
	EV Hall				438	
	Balcony				353	
	Mechanical Shaft				617	
	Sub Total				3218	
Construction Target Area					1,1737	

3.2.9. RCC Architectural Concept Drawings

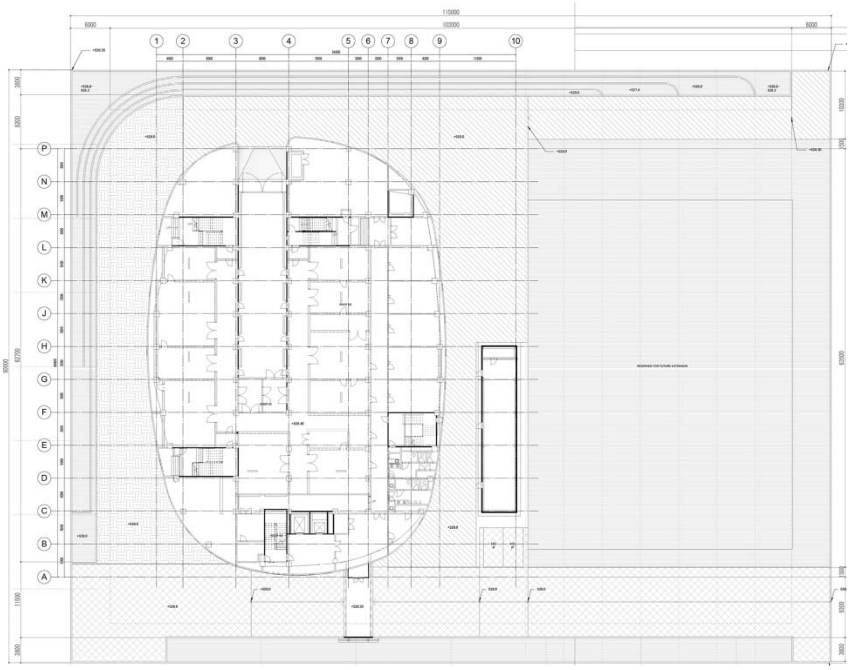


Figure 3.2.21 RCC Site Plan

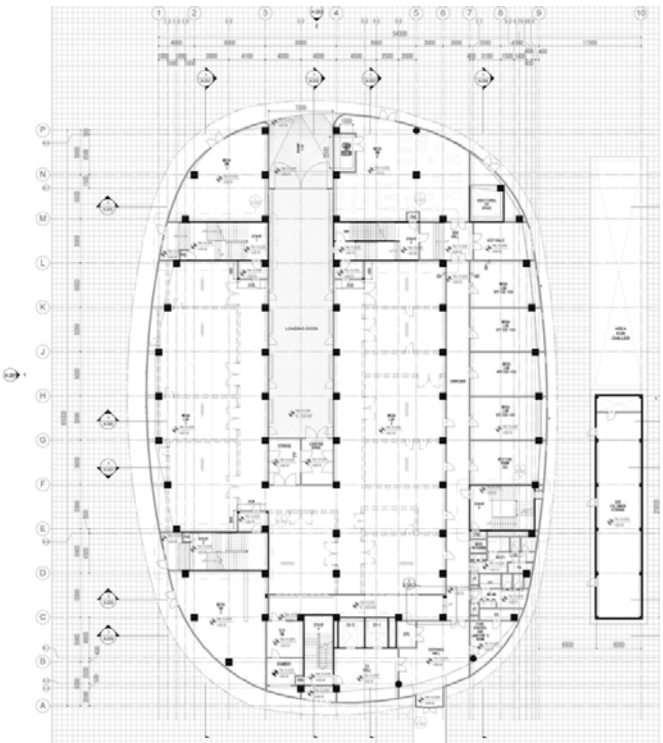


Figure 3.2.22 RCC Ground Floor Plan

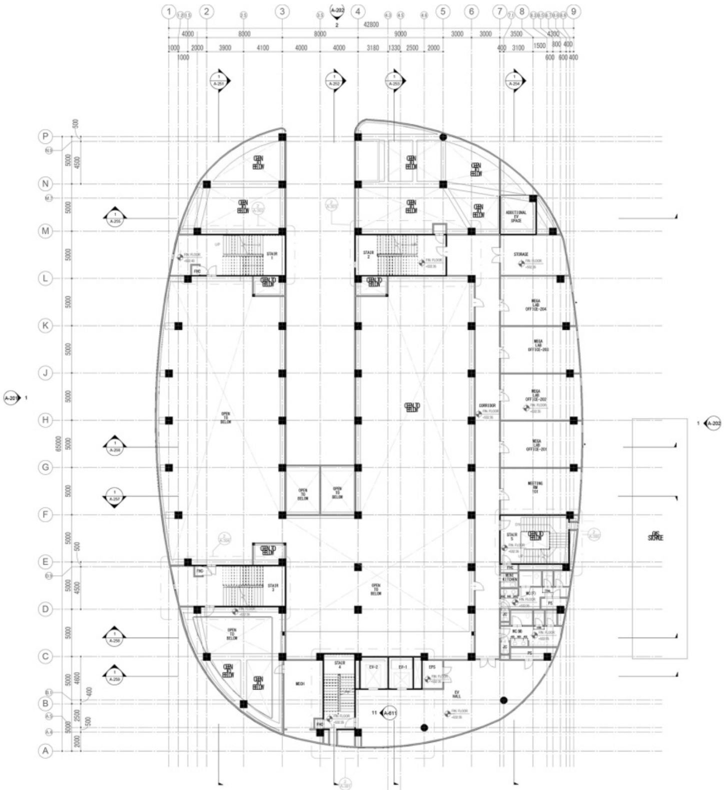


Figure 3.2.23 RCC 1st Floor Plan

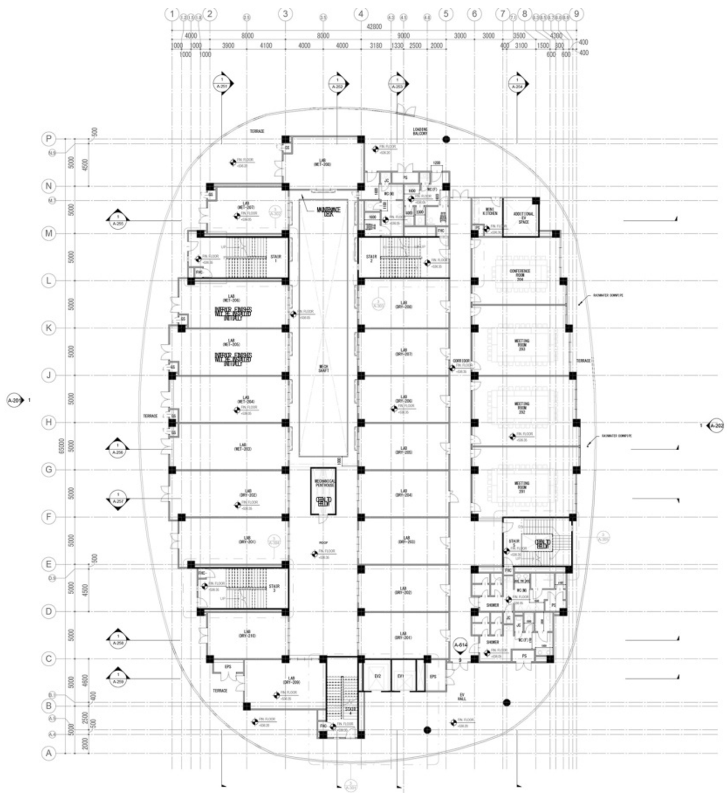


Figure 3.2.24 RCC 2nd Floor Plan

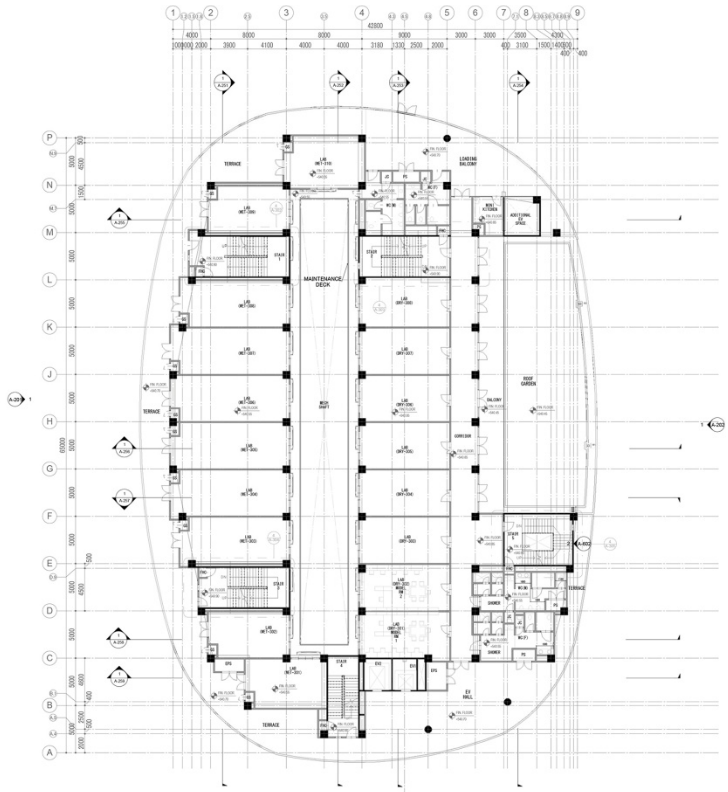


Figure 3.2.25 RCC 3rd Floor Plan

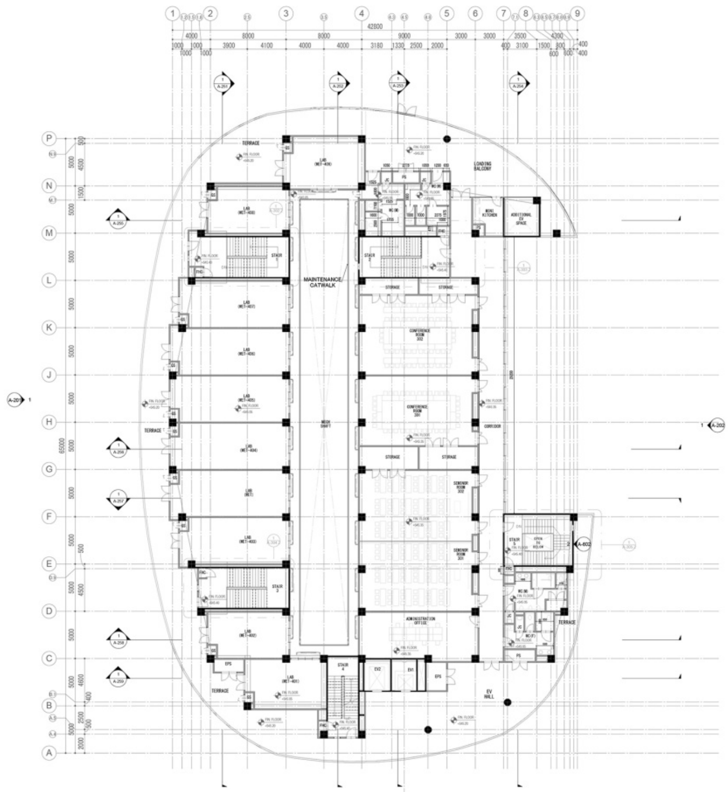


Figure 3.2.26 RCC 4th Floor Plan

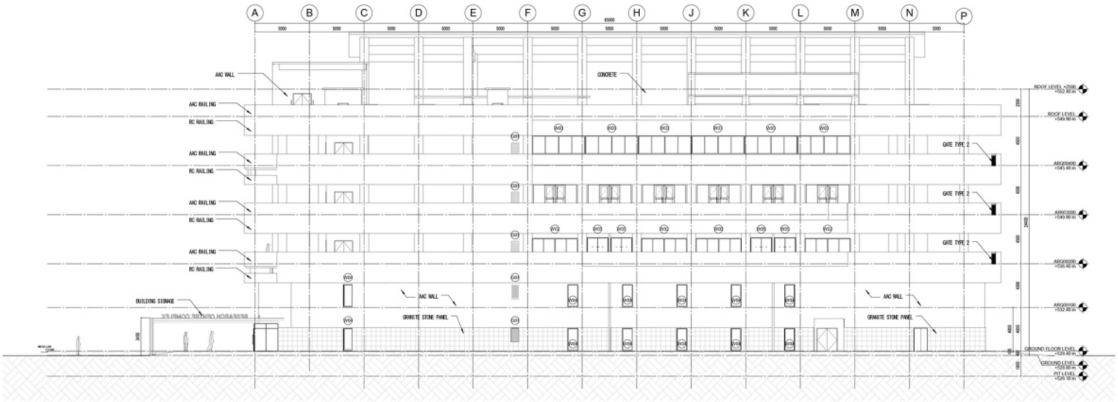


Figure 3.2.27 RCC East Elevation

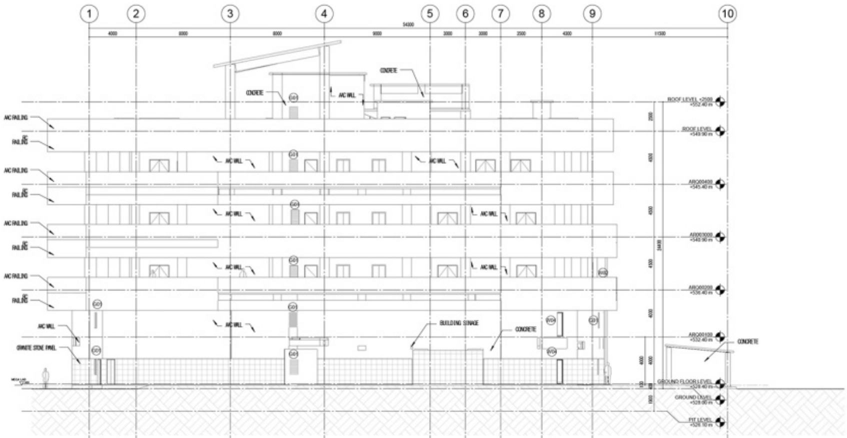


Figure 3.2.28 RCC South Elevation

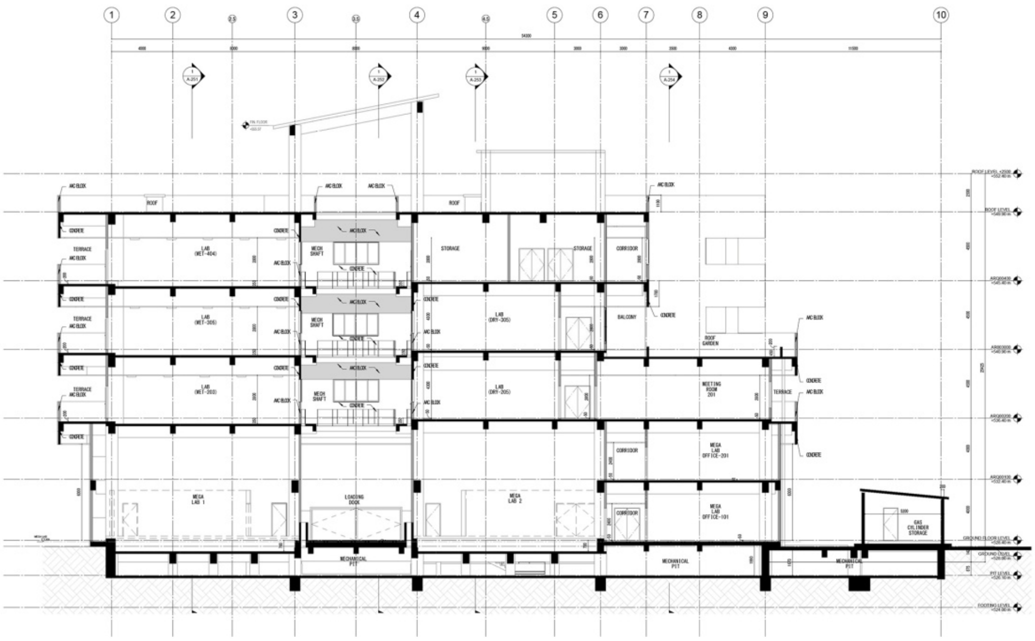


Figure 3.2.29 RCC Section

3.2.10 Policy of Architectural Detailed Design Assistance of RCC

To utilize the design by UoT.

- To confirm the design intention with UoT and to reflect IITH's comments as users regarding the building itself, each function of the rooms and their performances.
- To make sure if partitions, doors and mechanical equipments are easy to renew and maintain as lab tenants and layout are anticipated to change frequently
- To create common spaces such as seminar rooms and lounges in order to connect each research unit and new academic researches by encouraging communication between disciplines
- To locate the water supply, water drains and power sources in the mechanical shaft in order to make tenant's construction and daily maintenance easier.
- According to the NBC, the egress and occupancy loads were finalized as E-2 Laboratories.
- Passenger Elevators and Freight elevators

  There is one passenger elevator and another for freight (an additional elevator will be added later.) Kone elevators were selected for the academic buildings and hostels on the site that are currently under construction. It is easier for IITH to maintain the elevators if the same manufacturer is selected. IITH requested a 1,768kg capacity for the freight elevator. The other is a 15 person capacity type
- It is necessary to discuss with IITH about the needs of future extension.

3.2.11 Contents of Study in Detailed Design Assistance on RCC

(a) Contents of the design review

- The floor finish on the roof garden on 3F is changed from grass to the stone panel considering the use and easy maintenance

(b) Changes made by the detailed design Assistance review

- After discussion with the local consultants and co-coordinating with the NBC ,pressurized fans were added.
- After discussion with the local consultants, the capacity of the water tank has been revised.
- Freight elevators are now landing on the rooftop for the purpose of mechanical maintenance.
- The gas cylinder storage has been moved from the north side to the east side of the facility for the protection of underground pipes and to ease future extension.
- Considering the construction aspect, the material of the Wet Lab ceilings has changed from exposed concrete to a false ceiling in Wet Labs.
- Mega Lab raised floor level and ceiling height were revised based on precedent survey.

(c) Change by requests from IITH

- Galleries are added in order to see the inside of the Mega Lab from outside.
- A storage area to temporarily keep materials was added next to the loading space entrance.

(d) Detailed analysis for Fire and Life Safety

- RCC is categorized as E-2 Laboratories classifications. Travel distance and the regulations for the routes are followed with the E-2 regulations such as width of the egress stairs (more than 1.5 meters) and the travel distance within 45 meters.
- One of the elevators in the south side shall be used as fire lift in the case of emergency which is located near the fire control room.
- Fire hose closets were installed based on NBC.
- The pressurized fans shall be installed for egress stairs.

3.2.12 Scope of Work for the Laboratories in RCC

In the RCC, the laboratories are rental space. The scope of work for the laboratories in the RCC is planed as below.

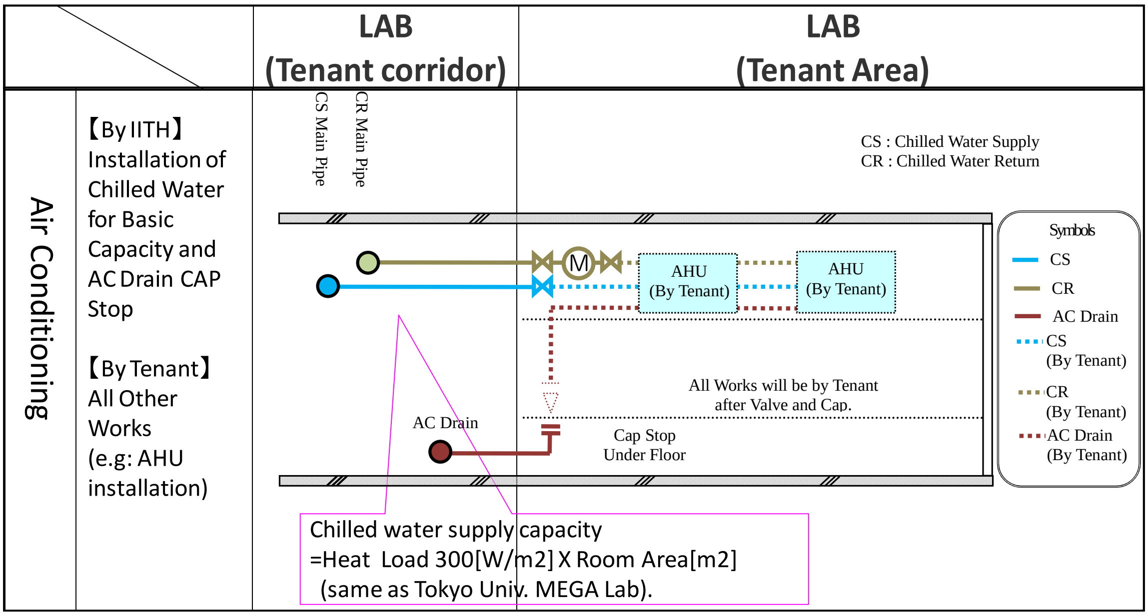
Scope	Legend	Remarks
IITH Work	▬▬▬	
Tenant Work	·········	

(a) Mechanical Equipment

i) Mega Lab

Mega Lab scopes of work are shown below

Mega Lab Air Conditioning Scope



Mega Lab Ventilation Scope

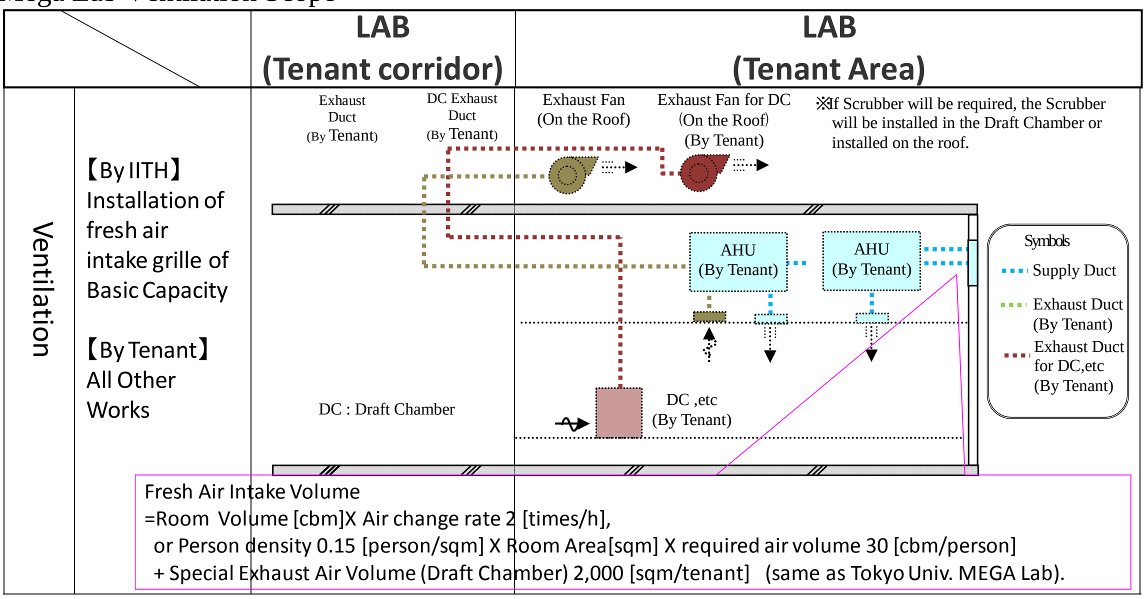
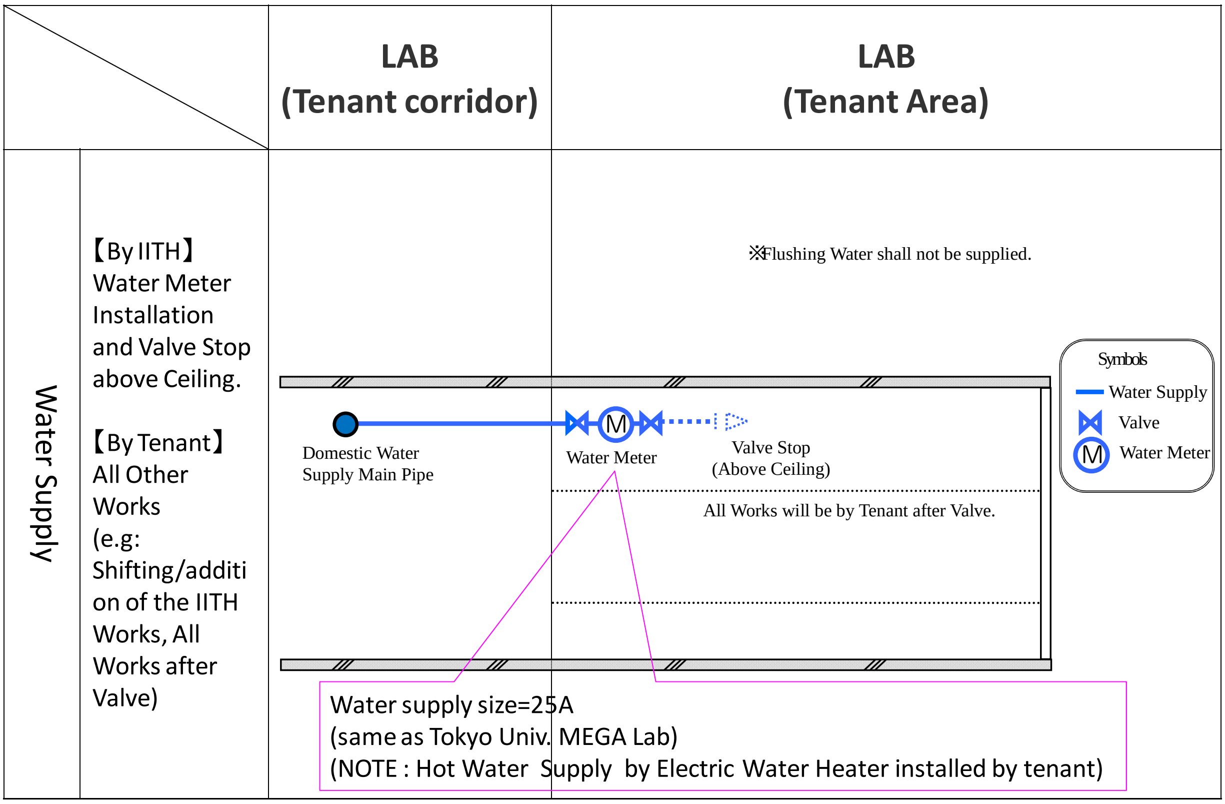


Figure 3.2.30 Mega Lab Scope of Work - 1

Mega Lab Water Supply Scope



Mega Lab Waste Water Scope

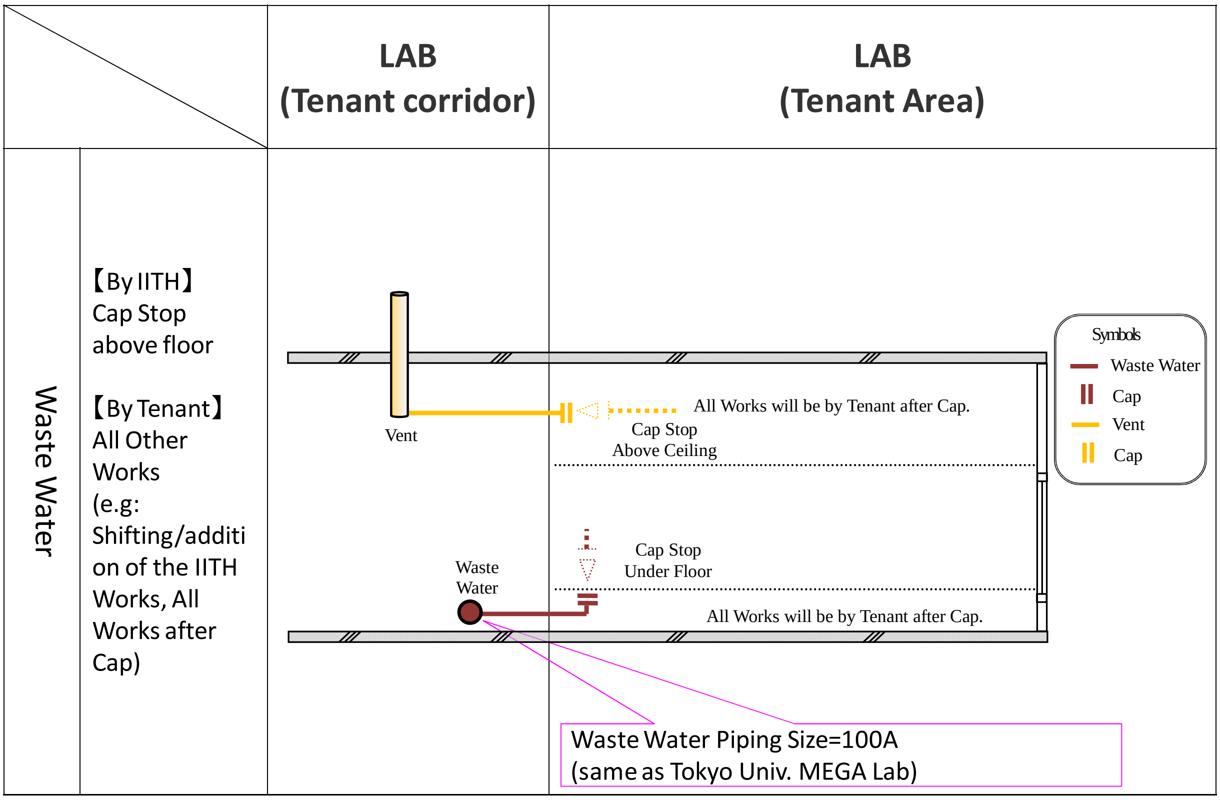
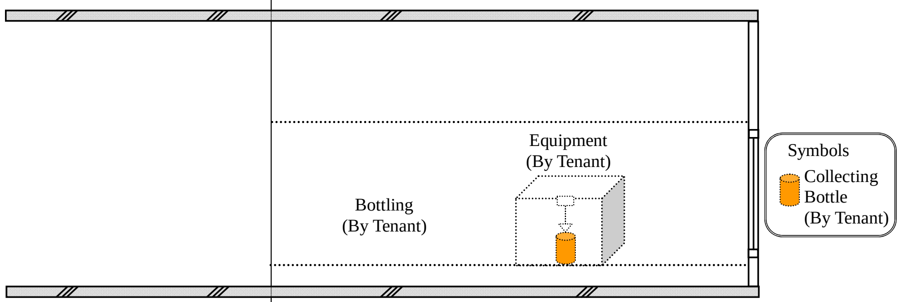


Figure 3.2.30 Mega Lab Scope of Work - 2

Mega Lab Special Waste Water Scope

		LAB (Tenant corridor)	LAB (Tenant Area)
Special Waste Water	【By IITH】 — 【By Tenant】 All Works (e.g:Collecting by Bottle)		



Mega Lab Firefighting Scope

		LAB (Tenant corridor)	LAB (Tenant Area)
Fire Fighting	【By IITH】 Installation by Law (Pre-Action Sprinkler) 【By Tenant】 Shifting/addition of Sprinkler Head, Fire Extinguisher, Special Fire Fighting		

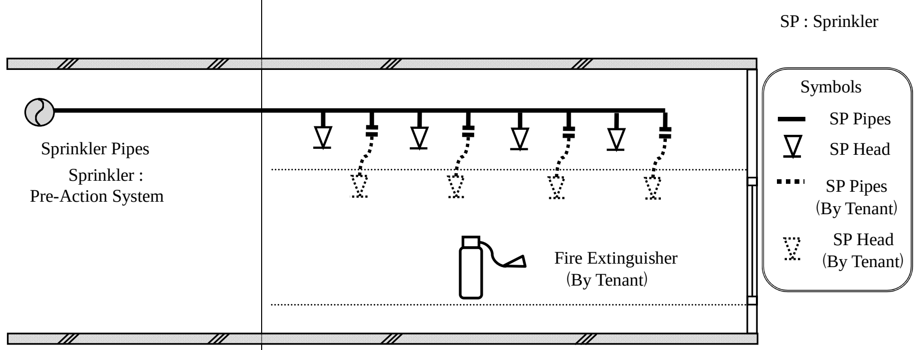
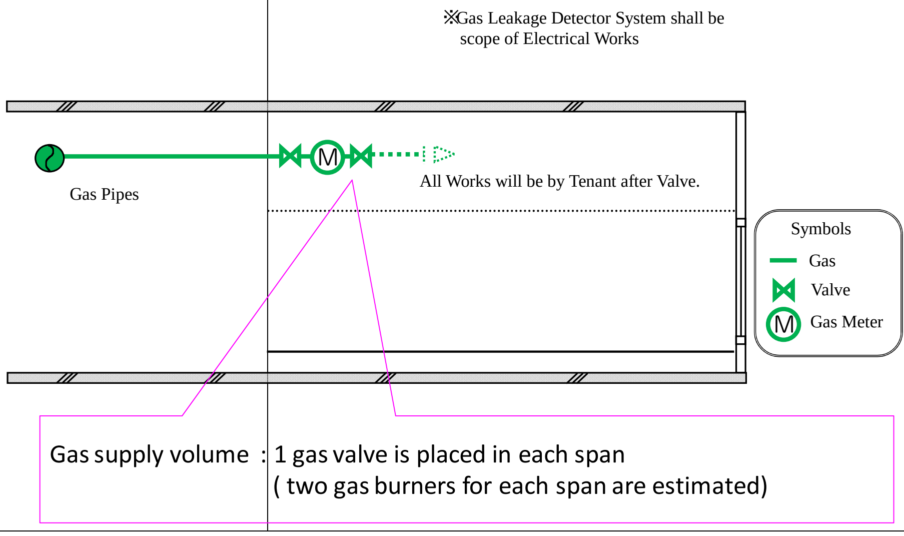


Figure 3.2.30 Mega Lab Scope of Work - 3

Mega Lab Gas Scope

		LAB (Tenant corridor)	LAB (Tenant Area)
Gas	【By IITH】 Gas Meter Installation and Valve Stop. 【By Tenant】 All Other Works (e.g: Shifting/addition of the IITH Works, All Works after Valve)		

Mega Lab Special Gas Scope

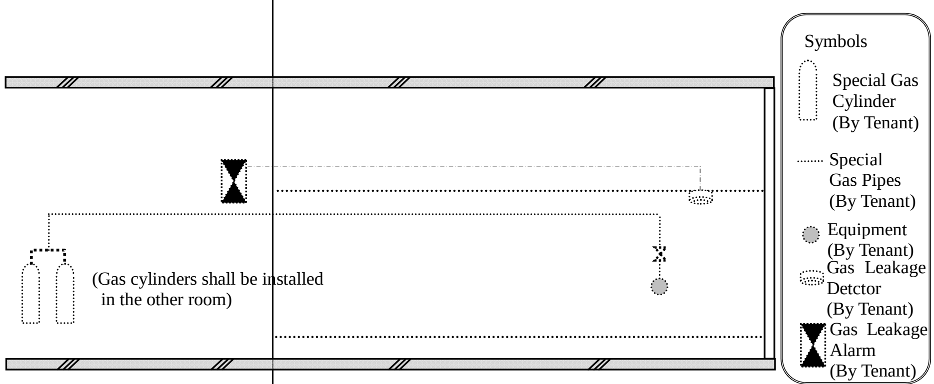
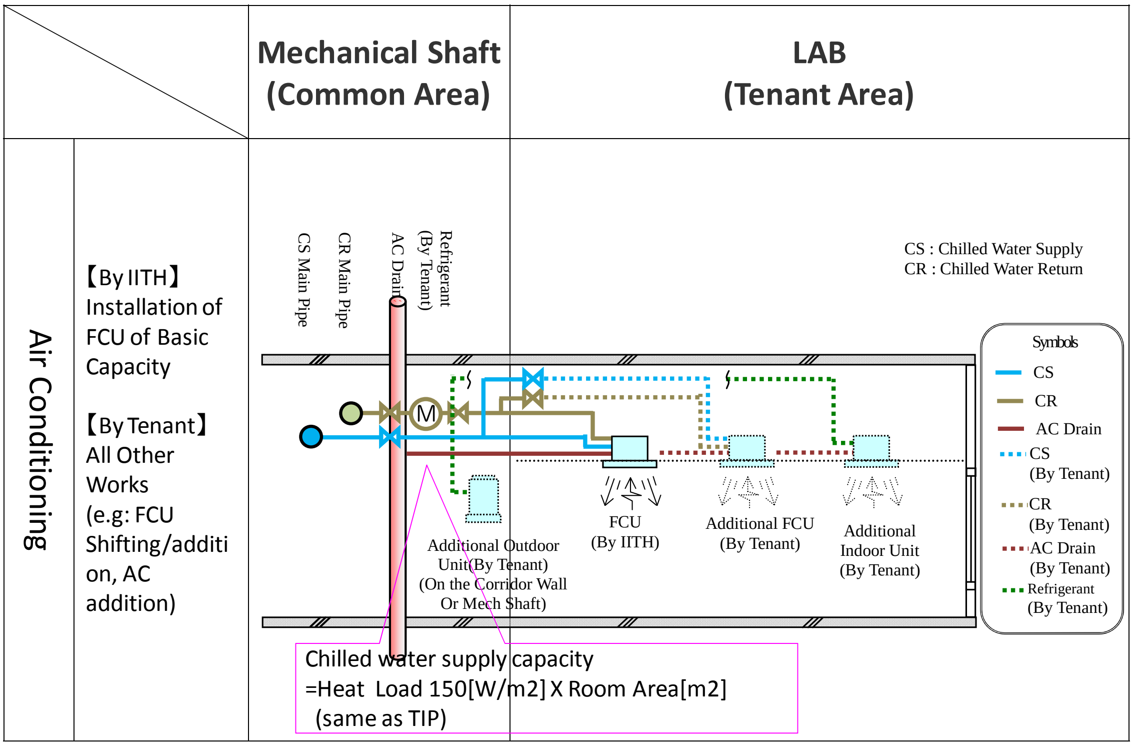
		LAB (Tenant corridor)	LAB (Tenant Area)
Special Gas	【By IITH】 — 【By Tenant】 All Works (e.g: Gas Sylinder, pipes, Pipe Connection, Gas Leakage Detctor, System, etc)		

Figure 3.2.30 Mega Lab Scope of Work - 4

ii) Wet Lab

Wet Lab Scopes of work are shown below

Wet Lab Air Conditioning Scope



Wet Lab Ventilation Scope

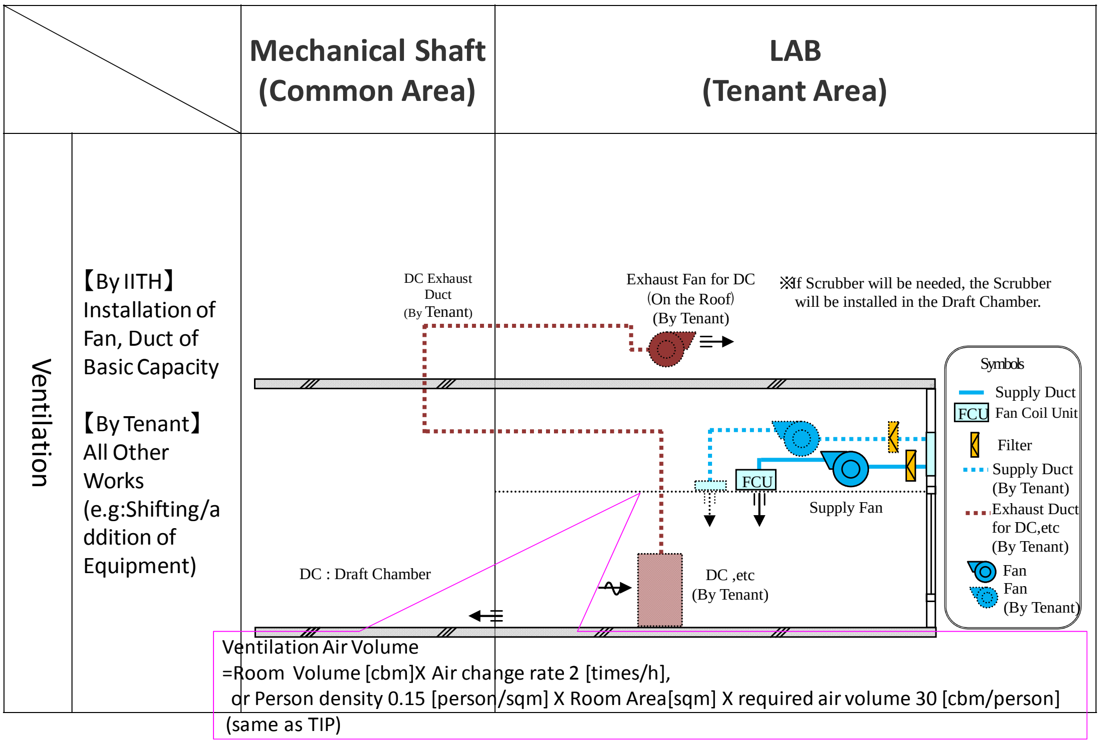
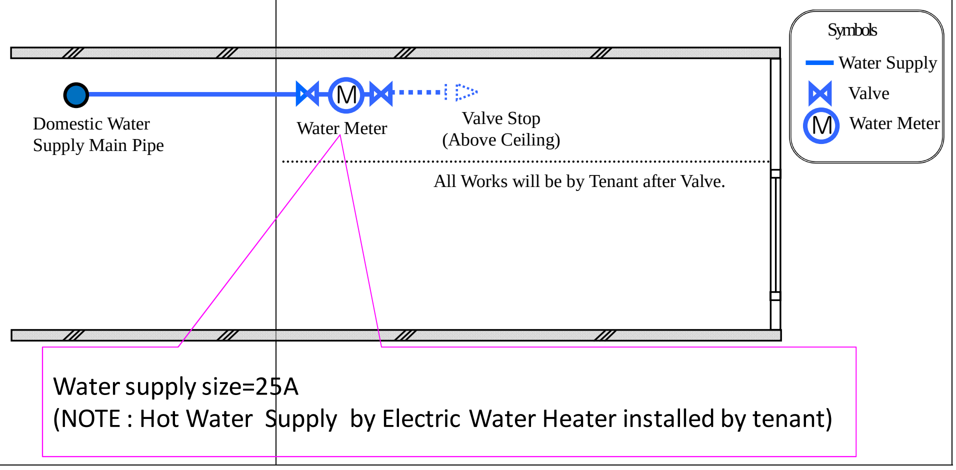


Figure 3.2.31 Wet Lab Scope of Work - 1

Wet Lab Water Supply Scope

		Mechanical Shaft (Common Area)	LAB (Tenant Area)
Water Supply	【By IITH】 Water Meter Installation and Valve Stop above Ceiling. 【By Tenant】 All Other Works (e.g: Shifting/addition of the IITH Works, All Works after Valve)		

Wet Lab Waste Water Scope

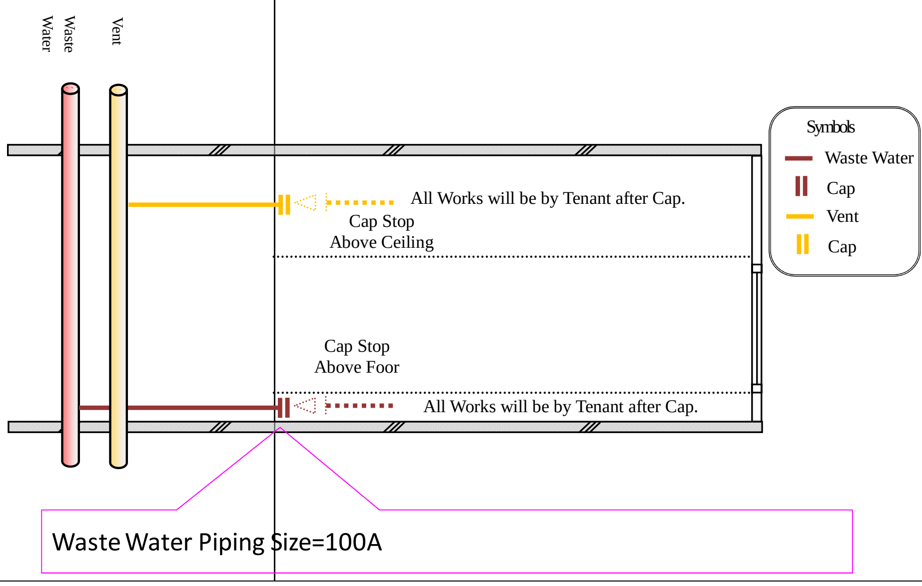
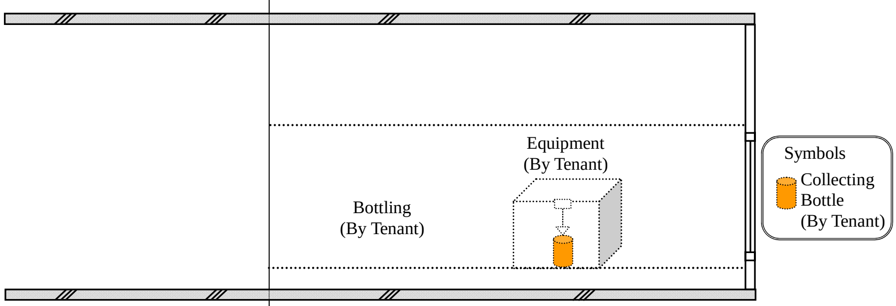
		Mechanical Shaft (Common Area)	LAB (Tenant Area)
Waste Water	【By IITH】 Cap Stop above floor 【By Tenant】 All Other Works (e.g: Shifting/addition of the IITH Works, All Works after Cap)		

Figure 3.2.31 Wet Lab Scope of Work - 2

Wet Lab Special Waste Water Scope

		Mechanical Shaft (Common Area)	LAB (Tenant Area)
Special Waste Water	【By IITH】 — 【By Tenant】 All Works (e.g:Collecting by Bottle)		

Wet Lab Firefighting Scope

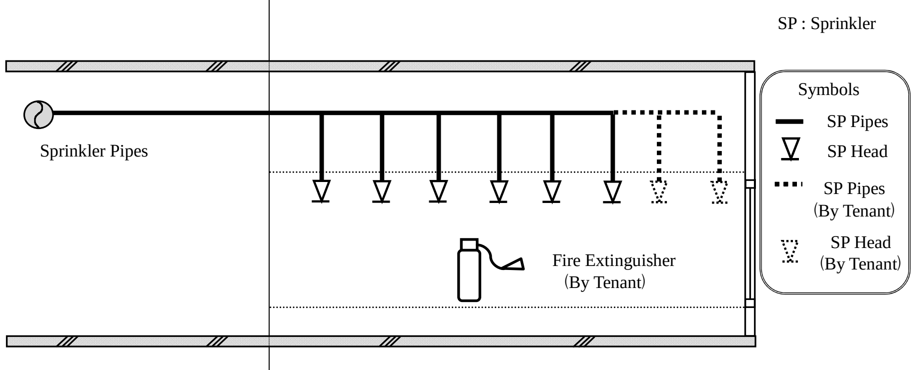
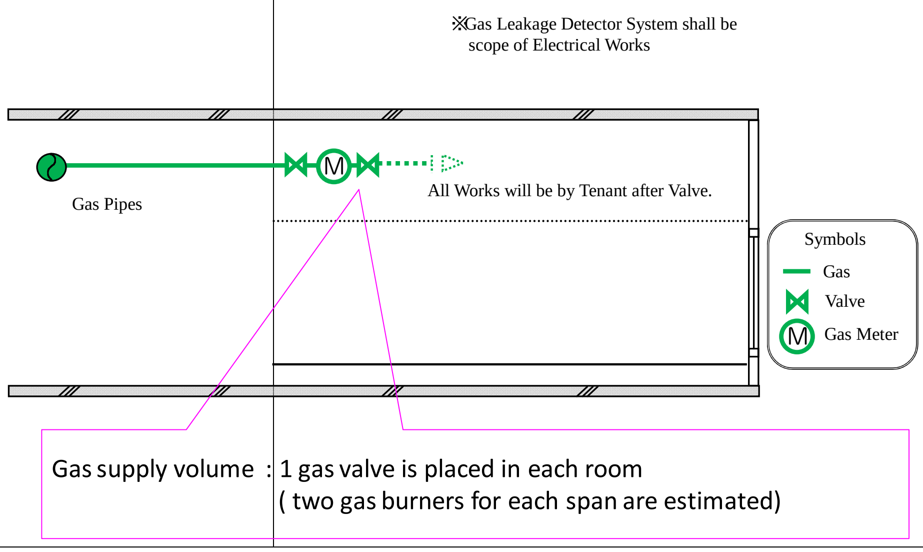
		Mechanical Shaft (Common Area)	LAB (Tenant Area)
Fire Fighting	【By IITH】 Installation by Law (Sprinkler) 【By Tenant】 Shifting/addition of Sprinkler Head, Fire Extinguisher, Special Fire Fighting		

Figure 3.2.31 Wet Lab Scope of Work - 3

Wet Lab Gas Scope

		Mechanical Shaft (Common Area)	LAB (Tenant Area)
Gas	【By IITH】 Gas Meter Installation and Valve Stop. 【By Tenant】 All Other Works (e.g: Shifting/addition of the IITH Works, All Works after Valve)		



Wet Lab Special Gas Scope

		Mechanical Shaft (Common Area)	LAB (Tenant Area)
Special Gas	【By IITH】 — 【By Tenant】 All Works (e.g: Gas Sylinder, pipes, Pipe Connection, Gas Leakage Detctor, System, etc)		

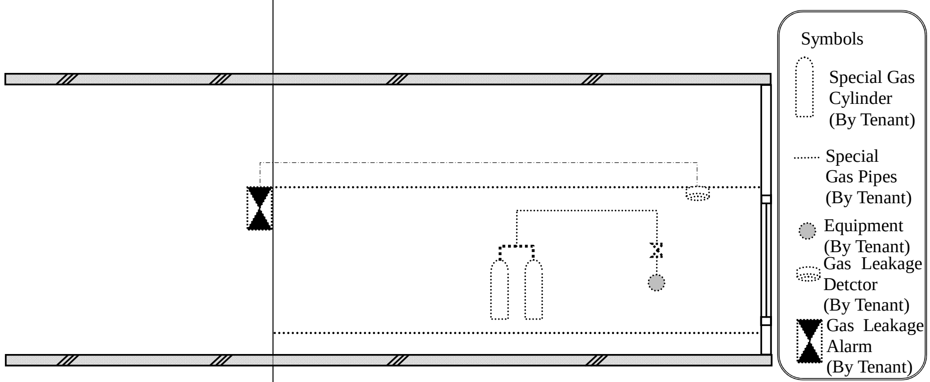


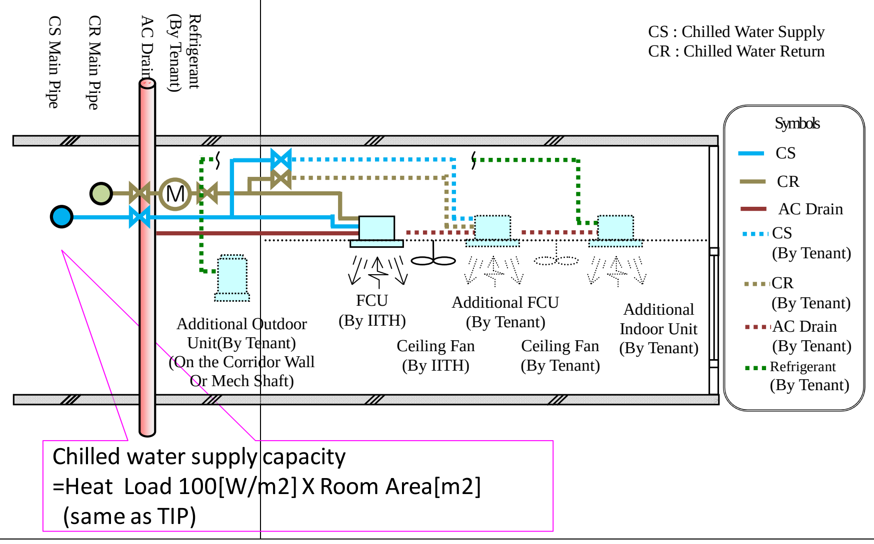
Figure 3.2.31 Wet Lab Scope of Work - 4

iii) Dry Lab

Dry Lab scopes of work are shown below.

Dry Lab Air Conditioning Scope

		Mechanical Shaft (Common Area)	LAB (Tenant Area)
Air Conditioning	【By IITH】 Installation of FCU of Basic Capacity 【By Tenant】 All Other Works (e.g: FCU Shifting/addition, AC addition)		



Dry Lab Ventilation Scope

		Mechanical Shaft (Common Area)	LAB (Tenant Area)
Ventilation	【By IITH】 Installation of Fan, Duct of Basic Capacity 【By Tenant】 All Other Works (e.g:Shifting/addition of Equipment)		

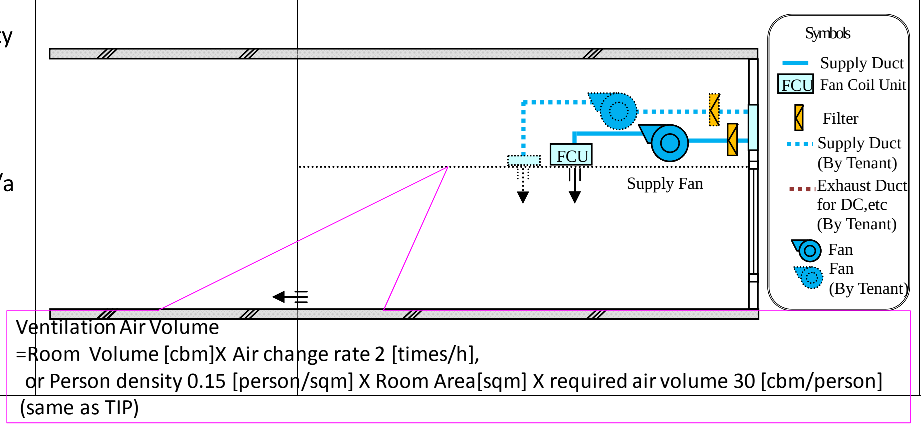
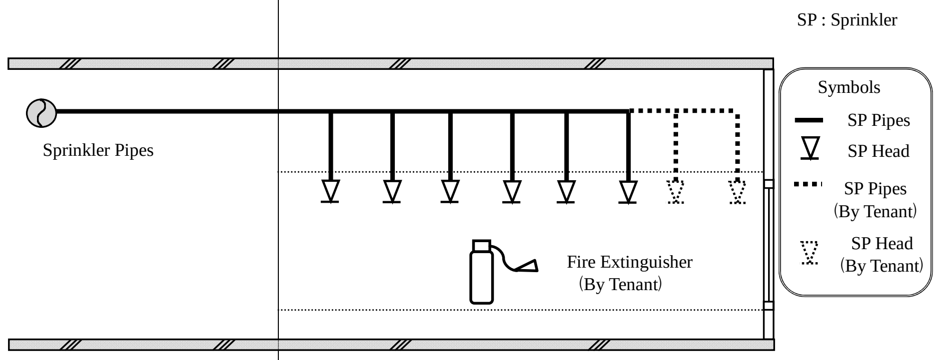


Figure 3.2.32 Dry Lab Scope of Work - 1

Dry Lab Firefighting Scope

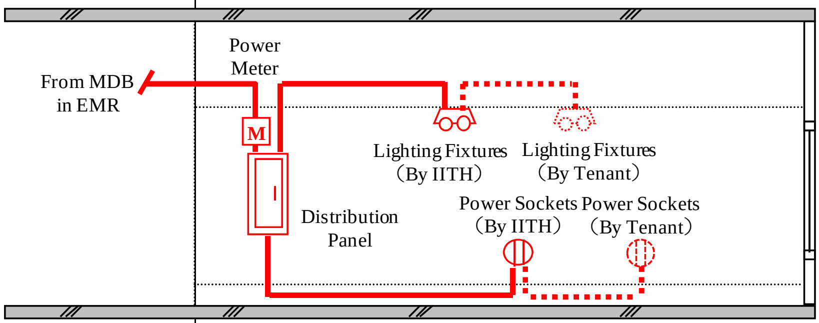
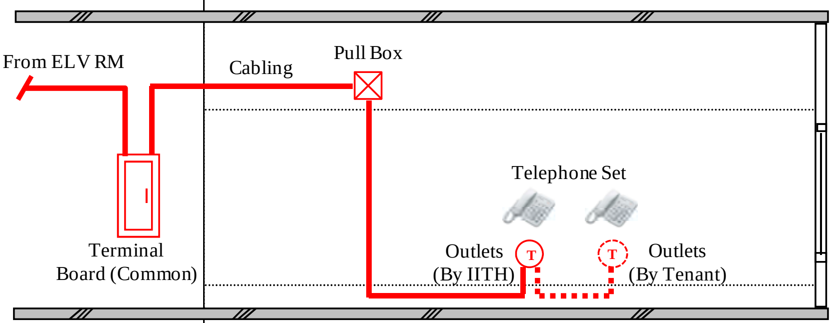
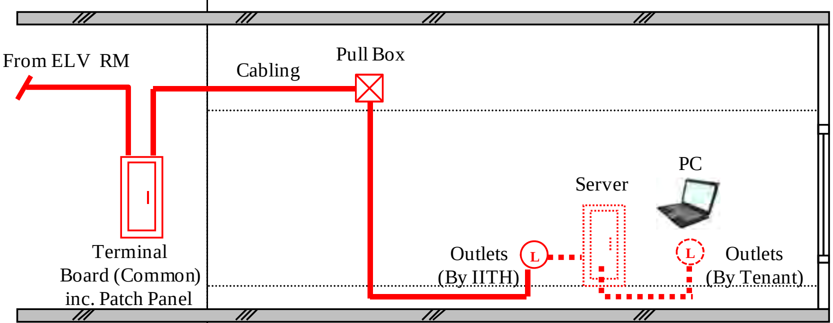
		Mechanical Shaft (Common Area)	**LAB (Tenant Area)**
Fire Fighting	【By IITH】 Installation by Law (Sprinkler) 【By Tenant】 Shifting/addition of Sprinkler Head Fire Extinguisher, Special Fire Fighting		

(Water supply, waste water, special waste water, gas and special gas are not equipped)

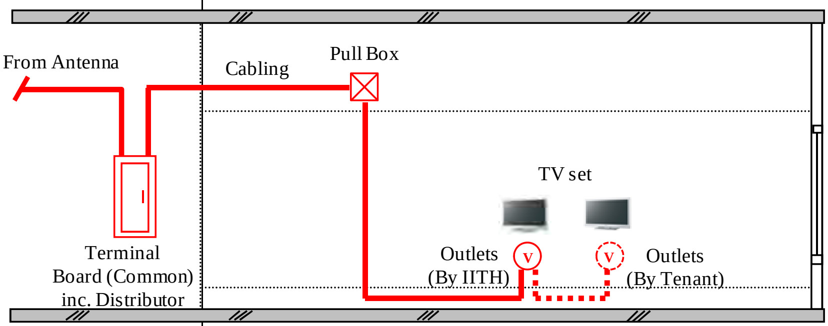
Figure 3.2.32 Dry Lab Scope of Work - 2

(b) Scope of Work

Figure 3.2.33 Scope of Work for DRY LAB／WET LAB／MEGA LAB OFFICE

		EPS (Commen Area)	LAB (Tenant Area)
Lighting / Power Socket	【By IITH】 -Distribution Panel and Power Meter -Installation of Lighting Fixtures and Switches of Basic Layout 【By Tenant】 -All Other Works (e.g: Lighting Fixtures , Receptacle Shifting/addition with additional partition)		
Telephone	【【By IITH】 -Pull Box and Outlets of Basic Layout in LAB 【By Tenant】 -All Other Works (e.g: Outlets Shifting/ addition with additional partition, Telephone Set)		
LAN	【By IITH】 -Pull Box and Outlets of Basic Layout in LAB 【By Tenant】 -All Other Works (e.g: Outlets Shifting/ addition with additional partition, Sever, PC)		

<table>
<tr><td></td><td></td><td>EPS
(Commen Area)</td><td>LAB
(Tenant Area)</td></tr>
<tr><td>Television</td><td>【By IITH】
-Pull Box and Outlets of Basic Layout in LAB

【By Tenant】
-All Other Works
(e.g: Outlets Shifting/ addition with additional partition, TV Set)</td><td colspan="2">
</td></tr>
<tr><td>Fire Alarm / Public Address</td><td>【By IITH
-Installation according to NBC

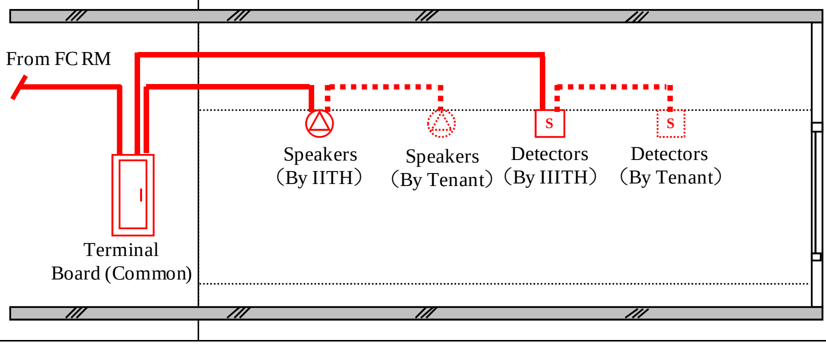
【By Tenant】
-Shifting/addition of Detectors and Speakers</td><td colspan="2">
</td></tr>
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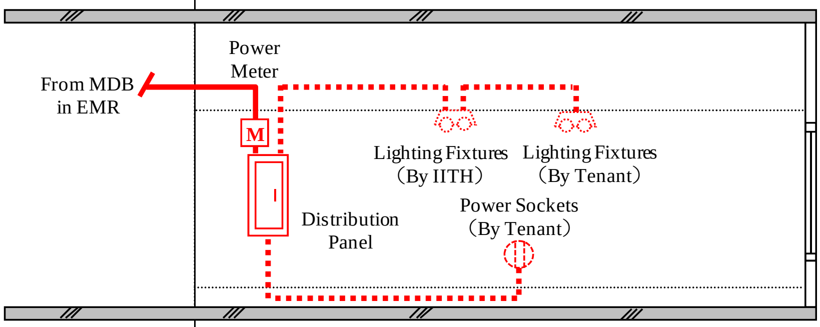
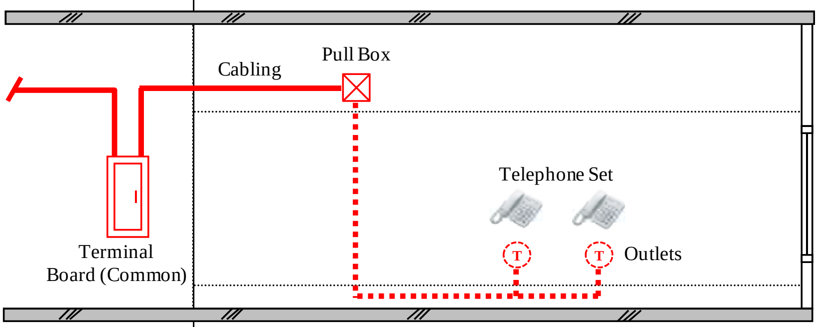
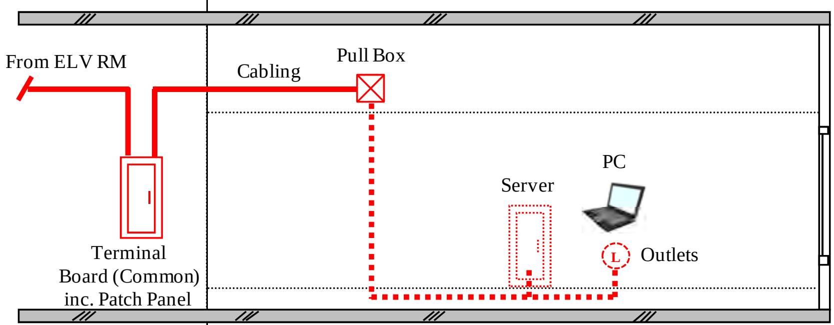
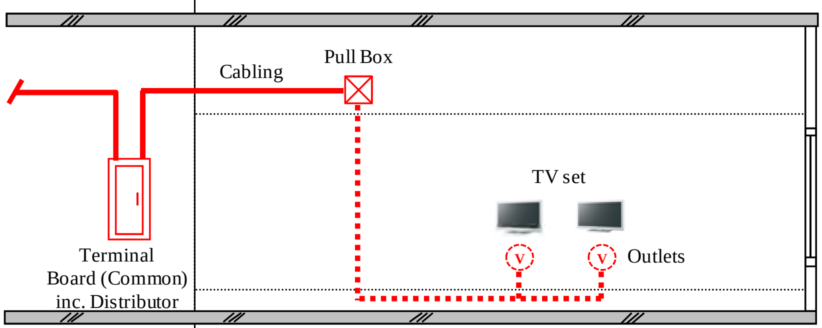
Figure 3.2.34 Scope of Work for MEGA LAB

<table>
<tr><th colspan="2"></th><th>EPS
（Commen Area）</th><th>LAB
（Tenant Area）</th></tr>
<tr><td>Lighting / Power Socket</td><td>【By IITH】
-Distribution Panel and Power Meter

【By Tenant】
-Installation of Lighting Fixtures and Switches</td><td colspan="2">
</td></tr>
<tr><td>Telephone</td><td>【By IITH】
-Pull Box in LAB
-Cabling to the Pull Box

【By Tenant】
-Change of Cabling from Terminal Board to the Pull Box
-All Other Works
(e.g: Installation of Outlets, Telephone Set)</td><td colspan="2">
</td></tr>
<tr><td>LAN</td><td>【By IITH】
-Pull Box in LAB
-Cabling to the Pull Box

【By Tenant】
-Change of Cabling from Terminal Board to the Pull Box
-All Other Works
(e.g: Installation of Outlets, Server, PC)</td><td colspan="2">
</td></tr>
<tr><td>Television</td><td>【By IITH】
-Pull Box in LAB
-Cabling to the Pull Box

【By Tenant】
-Change of Cabling from Terminal Board to the Pull Box
-All Other Works
(e.g: Installation of Outlets, TV Set)</td><td colspan="2">
</td></tr>
<tr><td>Fire Alarm / Public Address</td><td colspan="3">Same as DRY LAB／WET LAB／MEGA LAB OFFICE</td></tr>
</table>

3.3 Structural System

3.3.1 Design Policy

These buildings shall be designed to be safe against the long term load, earthquake load and wind load. It shall be designed basically according to the local code/standard, but the Japanese code will be considered at certain points of design for example to set limit value for beam deflection. The construction method shall be determined based on an available method on the site. The structural planning shall be reasonable and economical with due consideration given to the architectural planning.

3.3.2 Conditions for the Detailed Design assistance of Structure

- Following building code : NBC (National Building Code)
- Regional seismic criteria : Zone Ⅱ
- Concrete strength : M35, 35 N/mm^2 (by Cube test)
- Adopting creep factor : 1.6 (at the 28^{th} day strength)
- Type of structure : Reinforced concrete structure

3.3.3 Geotechnical Conditions

(a) Geotechnical Survey

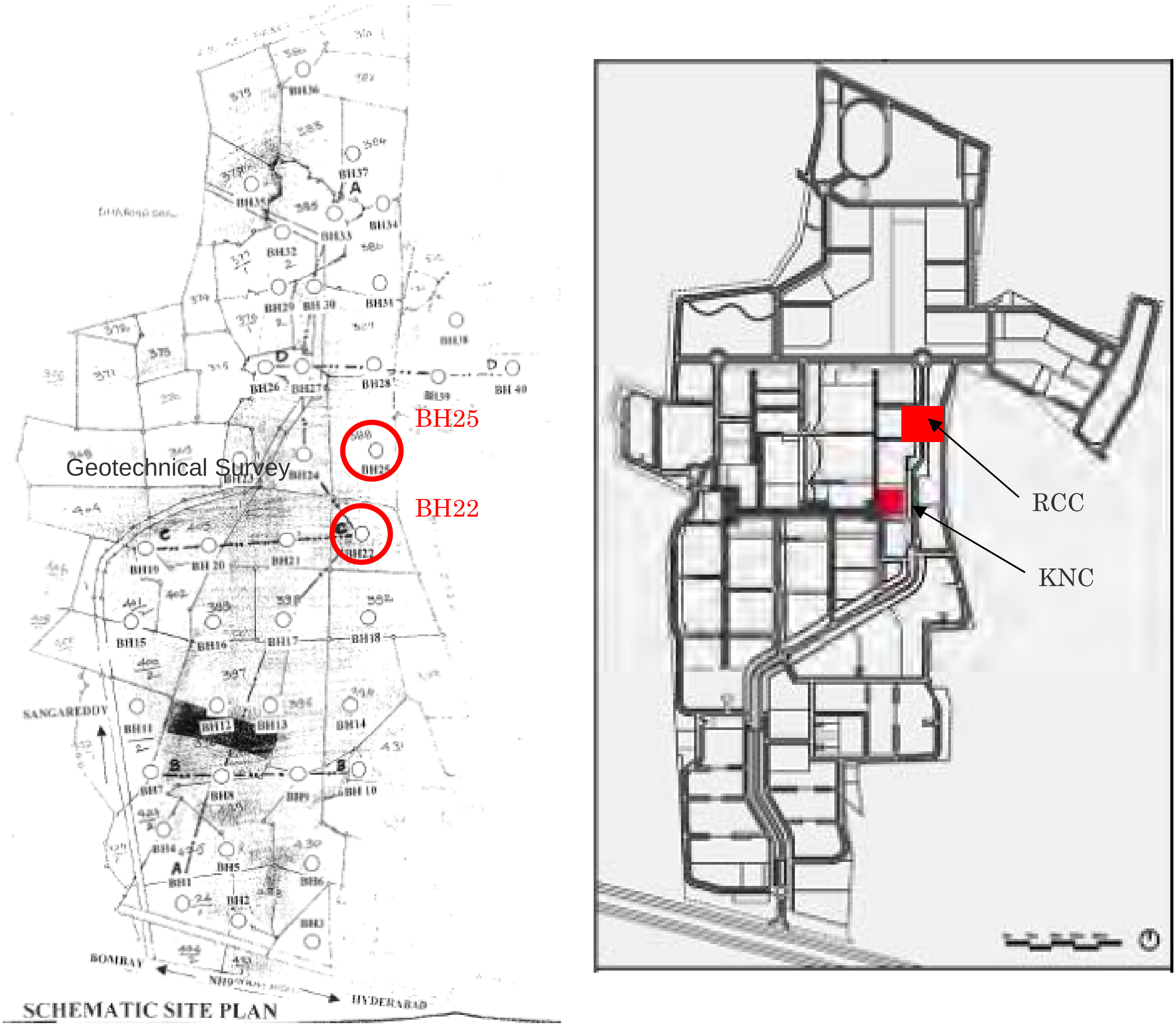


Figure 3.3.1 Campus Map and Ground Survey Position

Table 3.3.1 BH22 Ground Survey Results <KNC>

SOIL PROFILE — Project : S I for the Proposed Campus of IIT-H at Kandi Village in Medak District

B.H. Location : | Water Table : 17.0 m | Term. Depth : 30 m | B.H. No. : 22

N-Value *	Depth (m)	Soil Description	Grain Size Analysis: Gravel (%)	Grain Size Analysis: Sand (%)	Grain Size Analysis: Silt (%)	Grain Size Analysis: Clay (%)	Atterberg: Liquid (%)	Atterberg: Plastic (%)	In-situ: Density (g/cm³) #	In-situ: Water Cont (%)	Triaxial Test: Type	Triaxial Test: c (kg/cm²)	Triaxial Test: Φ
	0.0	Ground Level											
41	0.5	Dark Greyish Brown Clayey Silty Sand	0	56	31	13	30.6	17.8					
	1.0	Dark Greyish Brown Clayey Silty Sand with Gravels	2	55	30	13			2.01	3.10	CD	0.13	35
59/25 cms	2.0	Dark Greyish Brown Clayey Silty Sand with Gravels	8	63	20	9	NP	NP	2.16	2.89	DS	-	38
	2.5	Whitish / Yellowish Granite Based Weathered Rock		Sp.Gr.	2.64								
	3.0	Whitish / Yellowish Granite Based Weathered Rock											
	4.5	Whitish / Yellowish Granite Based Weathered Rock		Sp.Gr.	2.64								
	6.0	Whitish Grey Fissured & Fractured Rock											
	7.5	Whitish Grey Fissured & Fractured Rock		Sp.Gr.	2.68								
	9.0	Whitish Grey Fissured & Fractured Rock											
	10.5	Whitish Grey Granite Based Weathered Rock		Sp.Gr.	: 2.65								
	12.0	Whitish Grey Fissured & Fractured Granite Rock											
	15.0	Whitish Grey Fissured & Fractured Granite Rock		Sp.Gr.	: 2.68								
	18.0	Whitish Grey Fissured & Fractured Granite Rock											
	21.0	Whitish Grey Fissured & Fractured Granite Rock		Sp.Gr.	: 2.68								
	24.0	Whitish Grey Fissured & Fractured Granite Rock											
	27.0	Whitish Grey Fissured & Fractured Granite Rock		Sp.Gr.	: 2.70								
	30.0	Whitish Grey Fissured & Fractured Granite Rock											
		* N Values Observed											
		# : Natural Bulk Density											

Table 3.3.2 BH25 Ground Survey Results <RCC>

SOIL PROFILE			Project : S I for the Proposed Campus of IIT-H at Kandi Village in Medak District										
		B.H. Location :	Water Table : N.E.				Term. Depth : 10 m				B.H. No. : 25		
N-Value *	Depth (m)	Soil Description	Grain Size Analysis				Atterberg		In-situ		Triaxial Test		
			Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Liquid (%)	Plastic (%)	Density (g/cm³) #	Water Cont (%)	Type	c (kg/cm²)	φ
	0.0	Ground Level											
51/18 cms	0.5	Dark Reddish Brown Clayey Silty Sand with Gravels	5	50	36	9	31.7	18.7	2.13	7.40	CD	0.12	35
	1.0	Dark Reddish Brown Clayey Silty Sand with Gravels	4	54	34	8							
	2.0	Dark Whitish / Reddish Brown Clayey Silty Sand with Gravels	4	60	29	7	NP	NP					
	3.0	Whitish / Greyish Brown Granite Based Weathered Rock		Sp.Gr.	: 2.65								
	4.5	Whitish / Greyish Brown Granite Based Weathered Rock											
	6.0	Whitish / Greyish Brown Granite Based Weathered Rock		Sp.Gr.	: 2.65								
	7.5	Whitish / Greyish Brown Granite Based Weathered Rock											
	9.0	Whitish / Greyish Brown Granite Based Weathered Rock		Sp.Gr.	: 2.66								
	10.0	Whitish / Greyish Brown Granite Based Weathered Rock											
		* N Values Observed # : Natural Bulk Density											

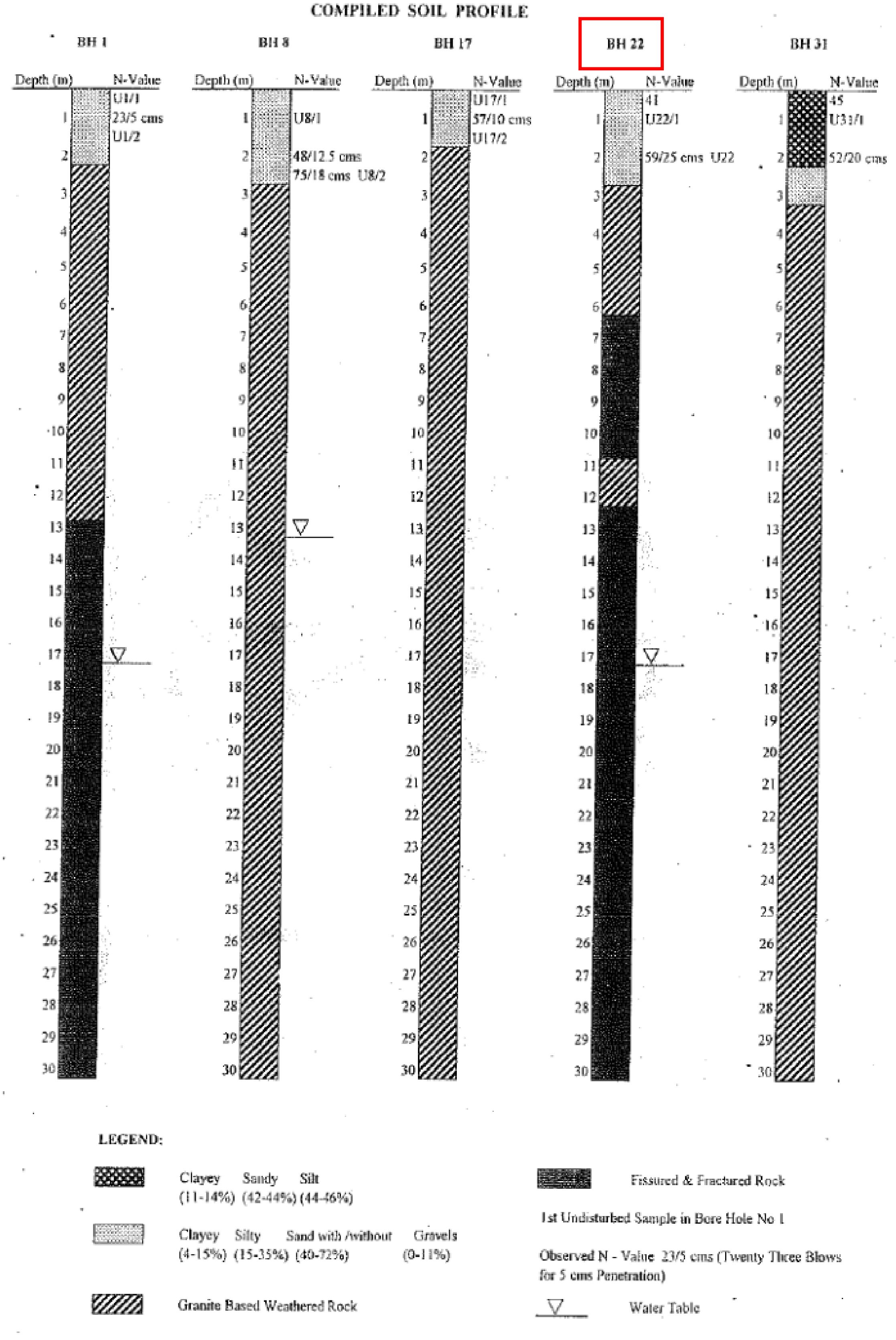


Figure 3.3.2 Completed Soil Profile

(b) Consideration of Geotechnical Investigation Report

The results of SPTs (Standard Penetration Test) on the geotechnical investigation report for this project show that the conditions at GL -2.5～3 m include a strong soil layer composed of weathered rocks with a high N value. Therefore, it is recommended to have a direct foundation system and set the bottom of foundation level in GL-2.5～3m. However, the additional geotechnical investigation considering the layout planning is necessary for the following reasons:

The number of tests was limited and one for each building site is not enough.

The report has no N values indicated in the results of many of BHs (boreholes) and the soil layer strengths are not clear.

The underground water level at the site for KNC is about GL-17 m from the result of BH22. The result of BH25 shows that no underground water was observed in the site of RCC.

(c) Additional Bore locations

Considering the ongoing construction projects, such as the academic buildings and hostels, the bedrock levels of each site are not consistent. IITH shall execute boring tests for both KNC and RCC. These results shall be taken into consideration during the CD phase. Discussions between IITH and the local structure consultants determined that bores shall be located every 50 meters. The borehole locations are shown in the diagrams below. These results must be confirmed at the Construction Design Stage and the Local Consultant who is responsible for the Construction Design must review the structural design of the foundations accordingly.

Figure 3.3.3 KNC Borehole Locations

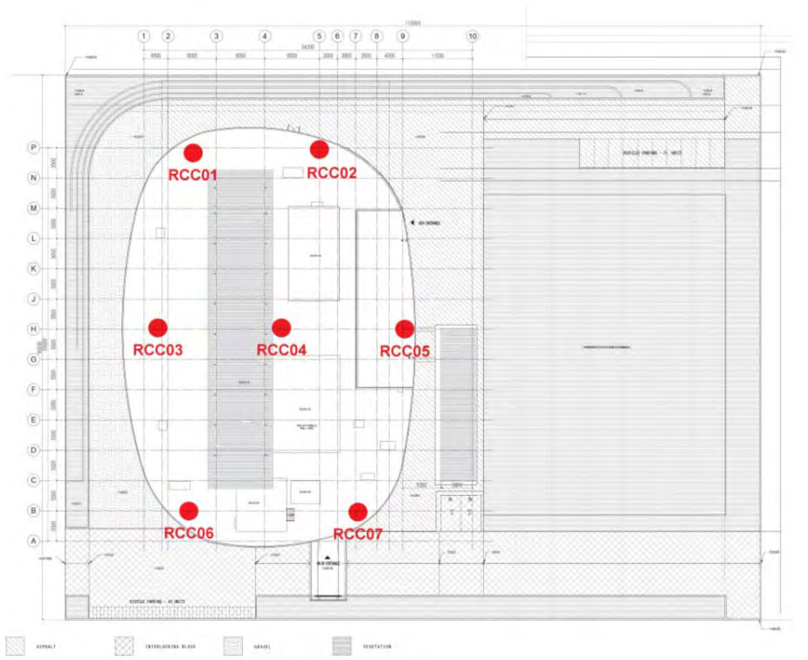


Figure 3.3.4 RCC Borehole Locations

3.3.4 Foundation Design

The recommended foundation system by the geotechnical investigation report is shown below. The foundation system is the independent footing system (direct foundation system). The bottom of the foundation is 2 m from the ground level, and the soil bearing capacity is 25ton/m². Therefore, the supporting soil layer has enough strength to support this building by the direct foundation system.

CALCULATIONS FOR ALLOWABLE BEARING PRESSURE FOR COLUMN FOUNDATIONS

Soil Properties (Ref. IS : 6403)
Borehole Properties (BH 32)

Depth of foundations	D	=	200 cm
Width of foundation	B	=	150 cm
Angle of shearing resistance	ϕ	=	32°
Cohesion	C	=	0.16 kg/cm²
Natural density	γ	=	1.90 g/cm³
Submerged density	γ_b	=	1.00 g/cm³
Bearing Capacity Factors	N_c	=	27.30 N_q = 16.55 N_γ = 20.54

Safe bearing capacity (under submerged conditions)

$$q_b = \frac{1}{3}\left(\frac{2}{3}\cdot c\cdot N_c + \gamma_b\cdot D\cdot\left(N_q - 1\right) + 0.5\cdot\gamma_b\cdot B\cdot N_\gamma\right)$$

$$q_b = 2.52 \text{ kg/cm}^2$$

Settlement Criterion (Ref IS : 8009)

N	=	N - value (Average)	=	50
R_w	=	water table correction factor	=	0.5
F_d	=	depth factor = [1+0.2D/B]	≤	1.2
D	=	depth of foundation	=	2.0 m
B	=	width of footing	=	1.5 m

Substituting the above values in the equation below we get bearing pressure for an allowable settlement of 25 mm

$$q_s = 0.35\cdot(N-3)\cdot\left(\frac{B+0.30}{2\cdot B}\right)^2\cdot R_w\cdot F_d$$

$$q_s = 3.55 \text{ kg/cm}^2$$

Allowable Bearing Pressure

The lower value of the allowable bearing pressure shall be adopted. Therefore, adopt an allowable bearing pressure of :

q_a = 2.5 kg/cm² i.e. 25 tons/m²

Note : ***q_a is a NET VALUE, Weight of backfill etc. need not be added to the loading except in case of filling above original Ground Level.***

3.3.5 Structural Framing Concept

(a) KNC

This is the library building with a square shaped plan of 58.3 m×56.0 m. It consists of 4 floors and the floor heights are between 3.7 m to 5.4 m. The building consists of double storey height spaces and they are connected together with void space to provide continuous space flow throughout the building. The height of this building is 26.9 m measuring from GL to the top of the highest girders of its sloping-framed roof. This building is a Reinforced Concrete (RC) rigid frame structure. The main span is 8.4 m to 13.8 m (which are the spans for the roof frame). To support the main library space called "stepped open access bookshelves area" on the 1st floor, small sized columns are required between the main columns because of its large weight. The short direction span under the stepped open access bookshelves area is 4.2 m. This building has 3 remarkable features as described below. These architectural design features greatly affect the structural design of the building.

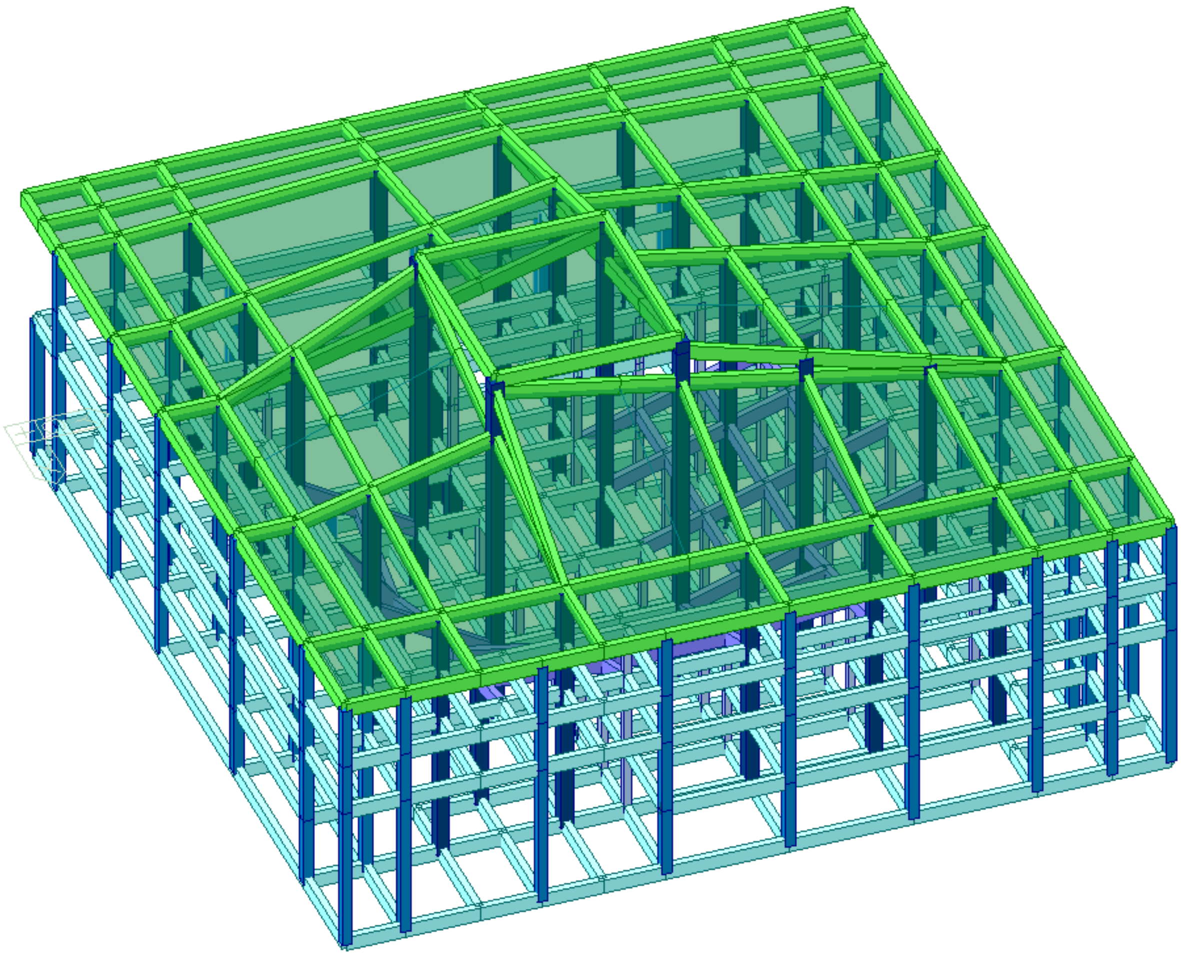


Figure 3.3.5 Framing drawing of KNC

(i) STEPPED OPEN ACCESS BOOKSHELVES AREA

The stepped open access bookshelves area is the main library space located in the center of the building. It is a grand open library divided by book shelves and its floor levels are gradually changed by via ramps and stairs connecting from the 1st to 2nd floors. Bookshelves are placed on each floor level.

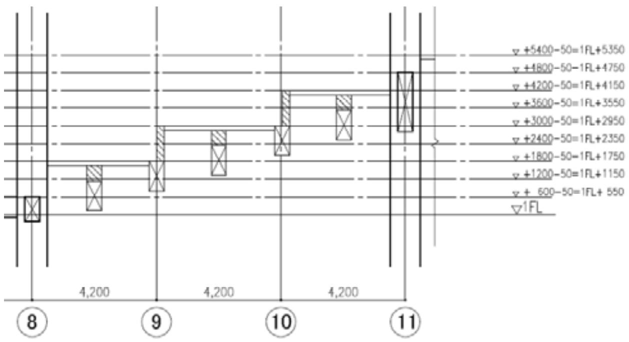
Visitors will experience being surrounded by books from toe to head while standing at the lowest level of stepped open access bookshelf area. On the highest level of step open bookshelf, visitor will experience the generous triple height space with the unique roof framing above.

The challenge of making the stepped floors is that the floor levels change by 600 mm or 1200 mm in the range of 2.1 m or 4.2 m and it requires a lot of upward lump concretes to adjust various floor levels. It causes the floor heavier by adding extra weigh on top of large prospect load imposed by library function.

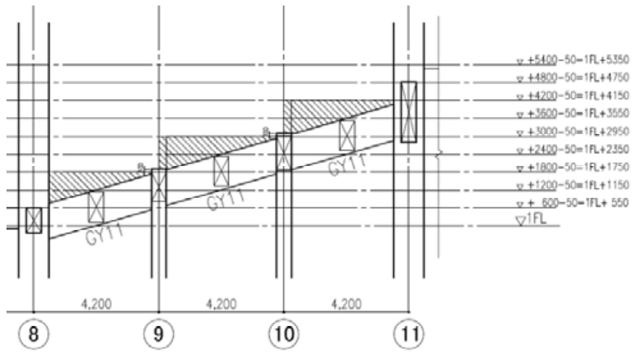
The basic concept to make this stepped floor is the following:

- The girders are sloped and straightly connected the 1st floor to 2nd floor.
- making the reinforced bars of the girders go straight through the small sized columns
- The secondary beams are horizontal.
- The slabs are supported by the upward lump concrete on the beams.

By taking this concept, the beams and columns are kept stable.. At the same time, the upward lump concrete are reduced and the dead loads are kept lower. Besides, the arch space under the stepped floor can be kept as an important design aspect.



Framing Elevation on Grid F



Framing Elevation Grid G

Figure3.3.6 Framing Elevation <KNC>

(ii) RC ARCH WALLS

In the ground floor and 1st floor, the massive concrete arch walls are under the main frame. This is an architectural design feature for the space around the cafeteria and building façade. They have various lengths and heights by location.

The RC arch wall is 500 mm-thick, which is the same width as the girder and column width. It is quite thick and affects the stiffness and strength of the frame. To evaluate these arch walls properly is an important task for a structural calculation.

(iii) ROOF

The roof frame of this building has the height (thickness) of 7.9 m. It consists of a flat roof at the center, 4 Hyperbolic parabolic Shell (HP) planes, and accessible flat roof along the peripheral.

Considering the construction aspect, the entire roof framing system including HP shells will be made of in-situ concrete. The 6.3 m long cantilever structure is used in the west side of the roof. Pre-stressed beams are used to keep the depth small.

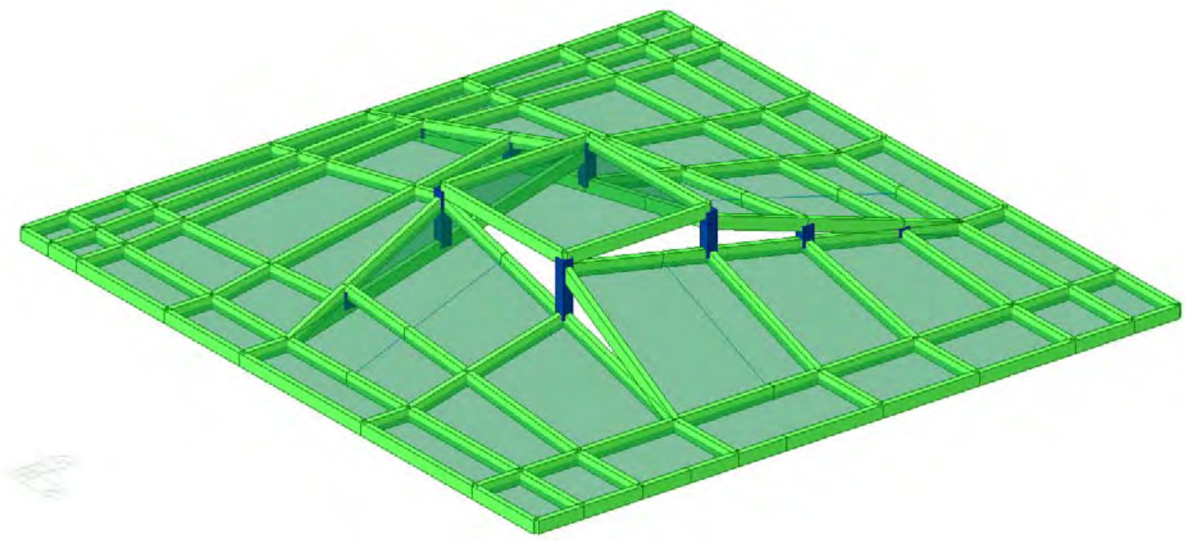


Figure 3.3.7 Framing Drawing of the roof

(b) RCC

This building is a rigid frame structure with shear walls. It has floor plan similar to oval shape and the dimension of the whole structure is 49 m by 70 m long. The span is five meter in north-south axis and twelve meters (maximum) for east-west axis.

The building consists of five storey's and a penthouse on roof. Each storey height is 4 to 4.5 meters where laboratories and office are placed on each floor. On the ground floor, parts of the floor are 2.3 meters lower where the 10.3 meters story height Mega Labs are placed.

The long spanned girders are 900 mm depth, and shall be pre-stressed where the slab load is heavy in certain parts of building, such as Wet Labs and roof garden. The columns are mainly 800 mm by 800mm; which shall be sufficient enough to bear a buckling length of 10.3 meters high.

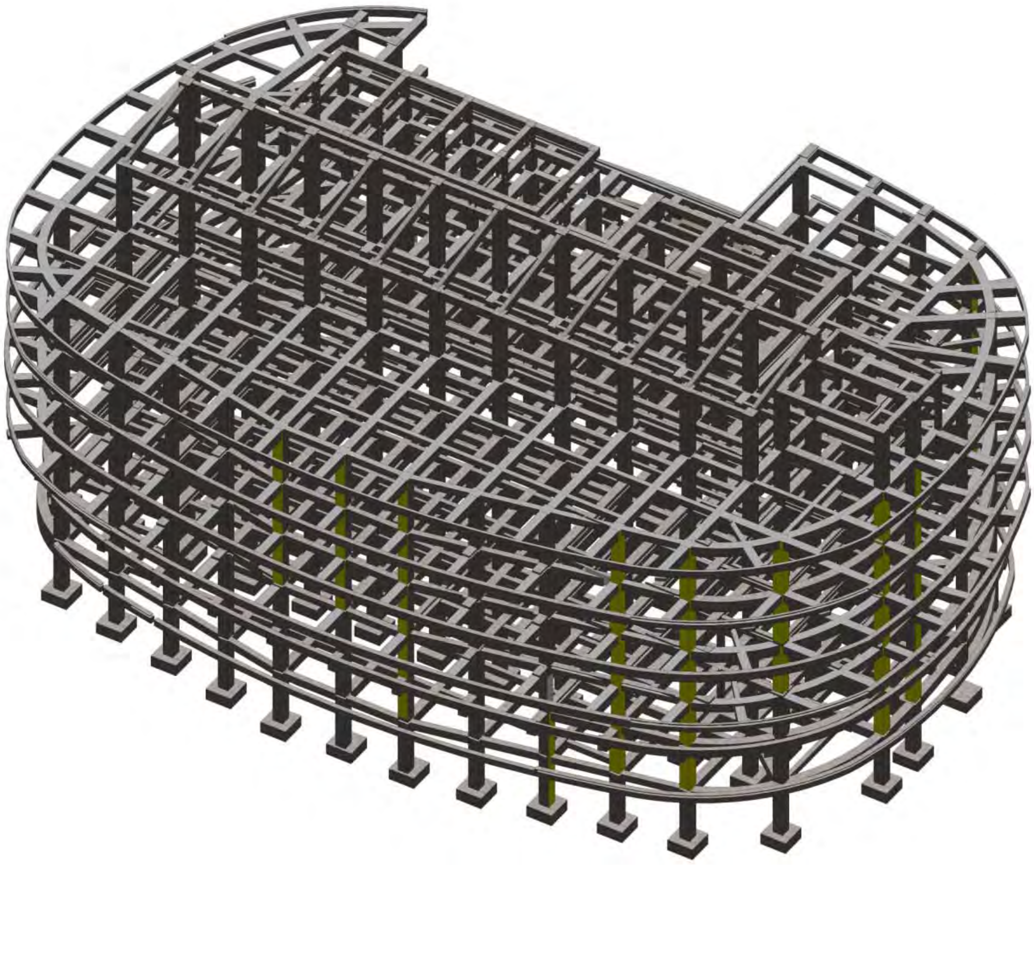


Figure 3.3.8 Framing Drawing of RCC

3.3.6 Design Load

(a) Loading Condition

The superimposed live load (floor load) is set according to the NBC as shown below. Appendix D shows color diagram of imposed live load. It is deemed safe enough as (or that) it is larger than the one according to Japanese code.

(b) Imposed live load

The imposed live loads are shown in below. The areas of the loads are indicated in Appendix D.

Table 3.3.3 Imposed Live Load for Rooms

Room		Live Load (N/㎡)	Remarks
KNC	OPEN SHELF	6,000	NBC,　2.2 ≧ h　6,000 N/m2 h ＞ 2.2　6,000+2,000×（h-2.2）N/m2
	ARCHIVE	9,600	
	READING ROOM	4,000	(with separate storage)
	GROUP STUDY ROOM	4,000	
	MEDIALITERACY	4,000	
	AUDIOVISUAL ROOM	5,000	
	CAFETERIA	4,000	
	ENTRANCE HALL	4,000	
	ADMINISTRATION OFFICE	4,000	
	CORRIDOR, STAIR	4,000	
	WC	2,000	
	KITCHEN	3,000	
	STORAGE	5,000	
	TOP ROOF	750 1,500	(inaccessible, as to 0°≦Gradient≦10°) (accessible)
	MACHINE ROOM	10,000	
	MINI KITCHEN	3,000	
RCC	MEGA LAB	15,000	Shall be determined by concerning machine weight, floor finishing such as raised floor system and future possible usage changes.
	WET LAB	10,000	
	DRY LAB	7,000	
	SLOPE TO RECIEVEING DOCK	7,500	Concerning trucks and cargo weight。
	OFFICE, LOUNGE	4,000	
	MEETING ROOM	4,000	
	CORRIDOR, STAIRCASE	4,000	
	BALCONY	4,000	
	FLAT ROOF (accessible)	1,500	NBC , (0°≦Gradient≦10°)

(c) Fixed Load for KNC

(i) Fixed Load <KNC>

GFL					
SLAB LEVEL	SLAB THICKNESS		THICKNESS(mm)	SPECIFIC GRAVITY (N/mm*㎡)	N/㎡
CAFETERIA, ENTRANCE HALL					
FL-150	t=200	STONE	20	30	600
		MORTAR SETTING BED	30	20	600
		RADIENT COOLING SYSTEM	100	24	2400
			TOTAL		3600
ADMINISTRATION OFFICE					
FL-50	t=200	STONE	20	30	600
		MORTAR SETTING BED	30	20	600
			TOTAL		1200
AUDIOVISUAL ROOM					
FL-50	t=200	STONE	20	30	600
		MORTAR SETTING BED	30	20	600
			TOTAL		1200
STORAGE					
FL-0	t=150	FINISHING			100
			TOTAL		100

1FL-3FL					
SLAB LEVEL	SLAB THICKNESS		THICKNESS(mm)	SPECIFIC GRAVITY (N/mm* ㎡)	N/㎡
OPEN SHELF, STEPPED OPEN SHELF					
FL-50	t=150	STONE	20	30	600
		MORTAR SETTING BED	30	20	600
			TOTAL		1200
ARCHIVE					
FL-0	t=150	FINISHING			100
			TOTAL		100
READING ROOM, GROUP STUDY ROOM					
FL-50	t=150	STONE	20	30	600
		MORTAR SETTING BED	30	20	600
			TOTAL		1200

WC						
	FL-350	t=150	STONE	20	30	600
			MORTAR SETTING BED	30	20	600
			SAND BED FOR TUBES	300	20	6000
					TOTAL	7200
KITCHEN						
	FL-350	t=150	STONE	20	30	600
			MORTAR SETTING BED	30	20	600
			SAND BED FOR TUBES	300	20	6000
					TOTAL	7200
CORRIDOR						
	FL-50	t=150	STONE	20	30	600
			MORTAR SETTING BED	30	20	600
					TOTAL	1200

RF	SLAB LEVEL	SLAB THICKNESS		THICKNESS (mm)	SPECIFIC GRAVITY (N/mm*㎡)	N/㎡
ROOF						
	FL-0	t=150	LIQUID APPLIED MEMBRANE WATER PROOFING			100
					TOTAL	100

GF-RF	SLAB LEVEL	SLAB THICKNESS		THICKNESS(mm)	SPECIFIC GRAVITY (N/mm*㎡)	N/㎡
STAIR						
	FL-50	t=250	STONE	20	30	600
			MORTAR SETTING BED	30	20	600
			STEPS	AVERAGE 100	25	2500
					TOTAL	3700

(ii) Fixed Load＜RCC＞

GFL	SLAB LEVEL	SLAB THICKNESS		THICKNESS (mm)	SPECIFIC GRAVITY (N/mm*㎡)	N/㎡
Mega Lab			(*) INDICATES FINISHINGS TO BE DONE BY TENANTS			
	FL-2300	t=250	RAISED FLOOR (*)	2600		2500

		ADDITIONAL CONCRETE WIRE WITH WELDED MESH (*)	100	25	2500
		ASPHALT MEMBRANE (*)	10	15	150
		STEEL TROWELED MORTAR	10	24	240
			TOTAL		5150
ENTRANCE HALL, CORRIDOR					
FL-50	t=250	GRANITE: t30	30	29	870
		SETTING BED: t20	20	24	480
			TOTAL		1350
MEGA LAB OFFICE					
FL-50	t=250	CARPET TILE	0	24	0
		CABLE TRUNKING SYSTEM (MORTAR: t50)	50	24	1200
			TOTAL		1200

1FL-4FL SLAB LEVEL	SLAB THICKNESS		THICKNESS(mm)	SPECIFIC GRAVITY (N/mm*㎡)	N/㎡
DRY LAB					
FL-50	t=150	CARPET TILE	0	24	0
		CABLE TRUNKING SYSTEM (MORTAR t50)	50	24	1200
			TOTAL		1200
WET LAB（2F）		(*) INDICATES FINISHINGS TO BE DONE BY TENANTS			
FL-450	t=150	RAISED FLOOR (*)	350		2000
		ADDITIONAL CONCRETE WITH WELDED MESH (*)	100	25	2500
		ASPHALT MEMBRANE (*)	10	15	150
		STEEL TROWELED MORTAR	10	24	240
			TOTAL		4890
WET LAB（3F、4F）		(*) INDICATES FINISHINGS TO BE DONE BY TENANTS			
FL-350	t=150	RAISED FLOOR (*)	350		2000
		STEEL TROWLED	10	24	240

		MORTAR			
				TOTAL	2240
TOILET, SHOWER					
FL-350	t=150	SAND STONE t=20	20	24	480
		SETTING BED t=30	30	24	720
		SAND BED FOR TUBES	300	25	7500
				TOTAL	8700
BALCONY					
FL-200	t=150	GRANITE: t30	30	29	870
		SETTING BED :t20	20	24	480
		CONCRETE OVERLAY t=100 to 150	125	25	3125
		ASPHALT MEMBRANCE	10	25	250
				TOTAL	4725

4F SLAB LEVEL	SLAB THICKNESS		THICKNESS(mm)	SPECIFIC GRAVITY (N/mm*㎡)	N/㎡
TERRACE					
FL-450	t=150	CONCRETE OVERLAY t=100 to 300	200	25	5000
		ASPHALT MEMBRANE	10	25	250
				TOTAL	5250

RF SLAB LEVEL	SLAB THICKNESS		THICKNESS(mm)	SPECIFIC GRAVITY (N/mm*㎡)	N/㎡
ROOF					
FL-0	t=150	CONCRETE OVERLAY t=100 to 300	200	25	5000
		ASPHALT MEMBRANE	10	25	250
				TOTAL	5250

3.4 Electrical System

3.4.1 Design Policy

- The design of the mechanical facilities shall be compliant with the NBC and, laws and regulations on fire-fighting specified by the Central Government. Its contents shall also be in accordance with the standard specifications for public works construction specified by the Central Government.
- The design contents shall satisfy the criteria for the acquisition of a four-star rating in the environmental impact assessment standards, the GRIHA.
- The environmental impact assessment standards will be followed in the selection of equipment and construction materials and in the development of the mechanical facility design. The mechanical facility design will be developed in such a way to minimize the cost of maintaining the facilities through the use of easy-to-maintain and multi-purpose equipment and systems, and with consideration given to the reduction of energy consumption.

3.4.2 Conditions for the Detailed Design assistance of Electric Facilities

The typical standards of electrical system in India which shall be applied in IITH projects are as below.

- NBC (National Building Code of India - 2005)
- ECBC （Energy Conservation Building Code）
- IS（International Electro technical Commission）
- IEC (International Electrotechnical Commission)
- BS (British Standard)

3.4.3 Electrical Equipment Overview

(a) Power supply facilities

Electric power will be supplied to the KNC and the RCC from the substation on the campus (part of the infrastructure work). In the M/P in which the power transmission routes are shown, the transmission lines extend to the KNC along a route from the northeastern side of the site and to the RCC along a route from the southwestern side. The power from the two different sources (3φ3W415V), the mains and emergency electricity supply, will be transmitted from the substation to the KNC and the RCC through two discrete transmission lines. The emergency electricity will be generated by emergency generators installed on the campus. The capacity allocated to the emergency electricity is approximately 40 % of the capacity of the mains electricity. In addition, photovoltaic power generation systems with an output capacity of approximately 10 kW each will be installed in the KNC and the RCC to reduce mains energy consumption. The following figures show conceptual diagrams of the electric power supply facilities in the campus as a whole. The pillars boxes will be installed on the site boundaries of the KNC and the RCC and the wiring within the sites from the distribution pillars will be included in the project scope of the work.

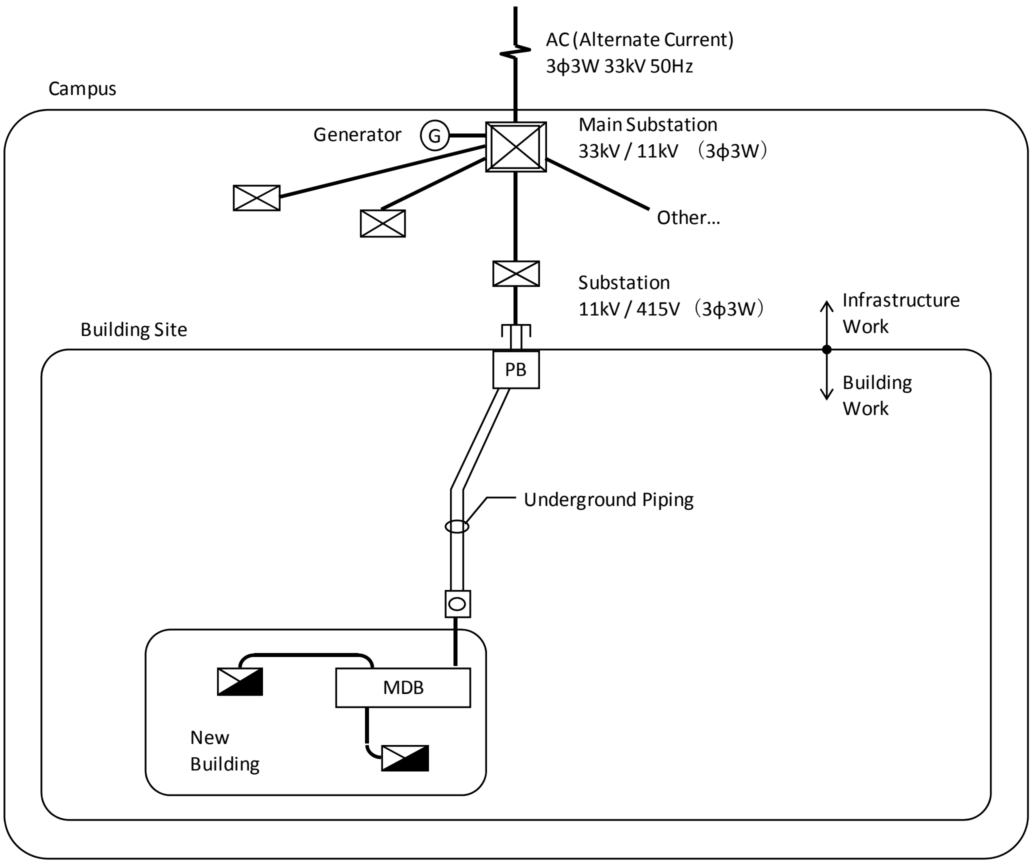


Figure 3.4.1 Overall Electric Power Supply Facilities Plan

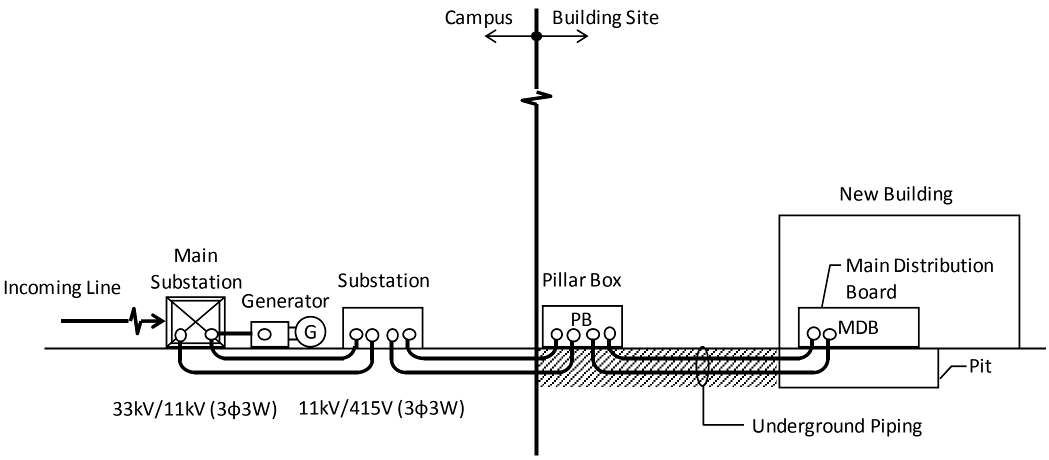


Figure 3.4.2 Electric Power Supply Facilities Cross-Section

A low-voltage switchboard will be installed in the electric machine room (EMR) of the building, and power from the substation will be fed to the board. Storage batteries will be installed in the room as a backup power source for some of the lighting fixtures during times of power failure. An uninterrupted power supply (UPS) will also be installed in the room as a backup power source for such equipment as the fire alarm control panel, the public address system amplifier, security monitors and telephone switchboard.

The electric power will be supplied to the buildings by installing low-voltage trunk lines between the low-voltage switchboard and breaker panels installed throughout the entire building. In principle, a low-voltage trunk line from the electric machine room will be laid horizontally in the upper side of the common area and go up then vertically in electric pipe shafts (EPS). The following figure shows the conceptual diagram of the power supply in the KNC and the RCC.

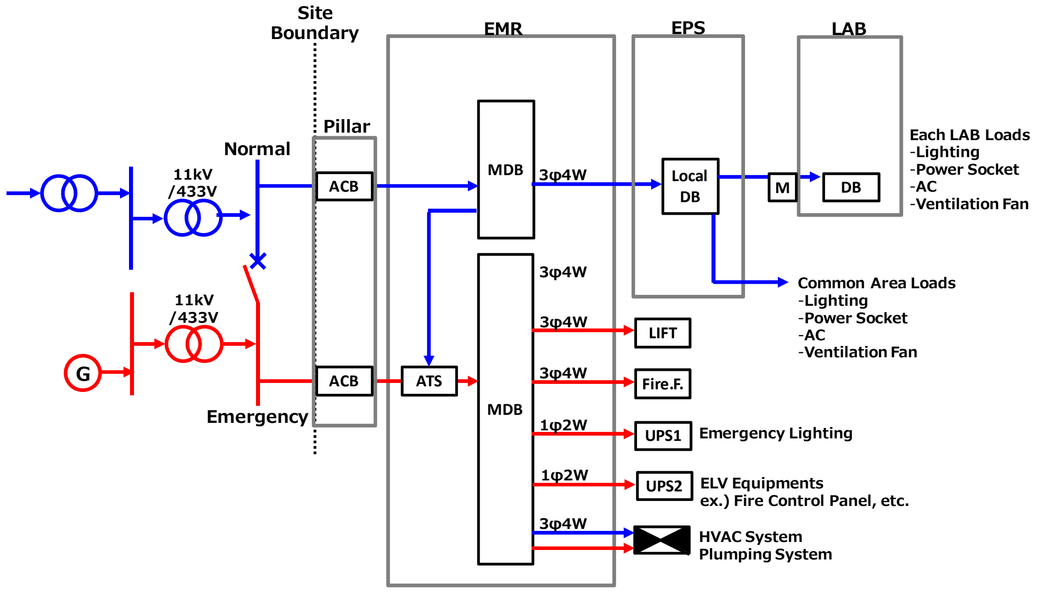


Figure 3.4.3 Power Supply in the KNC and the RCC

(b) Lighting and wall sockets

While lighting will mainly be installed by means of fluorescent light fixtures, high-efficiency long-life Light-Emitting Diode (LED) fixtures will be used wherever they can reduce energy consumption. In the lighting design, the NBC provisions on luminance will be used as the standard for the luminance setting. The lighting fixtures shall comply with the lighting power densities stipulated in ECBC. Manual switches will be used to turn indoor lights on and off. Automatic switches activated by motion sensors will be used in the toilets and locker rooms in order to save energy. And, automatic schedule control in addition to manual switches will be used in the common area, corridors and so on.

One-phase 240 V power will be provided at the wall sockets. Two-round-pin sockets will be installed on the walls. In addition to general purpose sockets for vacuum cleaners, etc., sockets for audio-visual equipment and electric heaters will be installed.

In the RCC, distribution panels with power meters will be installed in each laboratory to measure electric power consumption for payment, because the laboratories are rental space. The following tables show the lighting plan for main rooms in the KNC and the RCC.

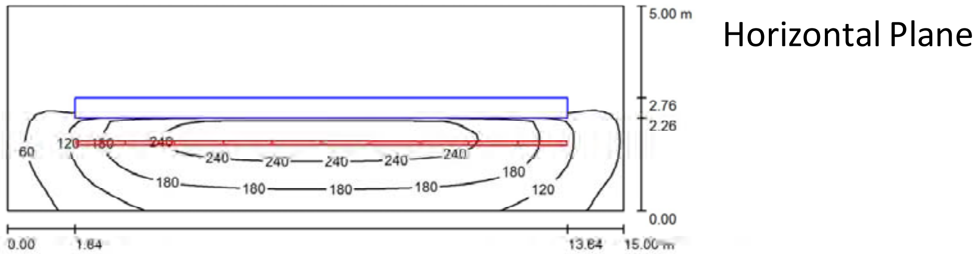
Table 3.4.1 Lighting Plan for Main rooms in the KNC

Room Name	Illuminance	Lamp	Fixture Type	Switching
Administration RM	300 lx	Fluorescent	Ceiling Recessed Type	Local Switch
Group Study /Reading RM	300 lx	Fluorescent	Ceiling Recessed Type	Local Switch
Open Shelf (for Whole)	100 lx	Metal Halide	Flood Light	Local Switch and Automatic Control
Open Shelf (for Shelf)	150 lx (Vertical)	Fluorescent	Line Light	Local Switch and Automatic Control
Hall at 1st FL	100 lx	Metal Halide	Blacket Light	Local Switch and Automatic Control
Corridor (with Ceilng)	100 lx	LED	Down Light	Local Switch and Automatic Control
Corridor (without Ceilng)	100 lx	LED	Foot Light	Local Switch and Automatic Control
WC	150 lx	LED	Down Light	Automatic by Occupancy
Mini Kitchen	150 lx	LED	Down Light	Automatic by Occupancy
Storage	100 lx	Fluorescent	Ceiling Mounted Type	Local Switch
Machine RM	150 lx	Fluorescent	Ceiling Mounted Type	Local Switch

Table 3.4.2 Lighting Plan for Main rooms in the RCC

Room Name	Illuminance	Lamp	Fixture Type	Switching
Lab	300 lx	Fluorescent	Suspended Type	Local Switch
Meeting RM	300 lx	Fluorescent	Ceiling Recessed Type	Local Switch
Hall	150 lx	LED	Down Light	Local Switch and Automatic Control
Corridor (Outer Perimeter)	100 lx	Fluorescent	Indirect Lighting	Local Switch and Automatic Control
Corridor (Inside)	100 lx	LED	Down Light	Local Switch and Automatic Control
WC	150 lx	LED	Down Light	Automatic by Occupancy
Mini Kitchen	150 lx	LED	Down Light	Automatic by Occupancy
Storage	100 lx	Fluorescent	Ceiling Mounted Type	Local Switch
Machine RM	150 lx	Fluorescent	Ceiling Mounted Type	Local Switch

In the lighting plan, the luminance distribution figures are made for confirmation. The next figures show the luminance distribution for the bookshelf in the KNC and Dry Lab in the RCC.



Height of Room: 6.000 m, Mounting Height: 3.275 m, Light loss factor: 0.80

Values in Lux, Scale 1:108

Surface	ρ [%]	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0
Workplane	/	92	4.04	264	0.044
Floor	20	67	2.97	198	0.045
Ceiling	50	11	5.90	15	0.560
Walls (4)	30	29	3.29	121	/

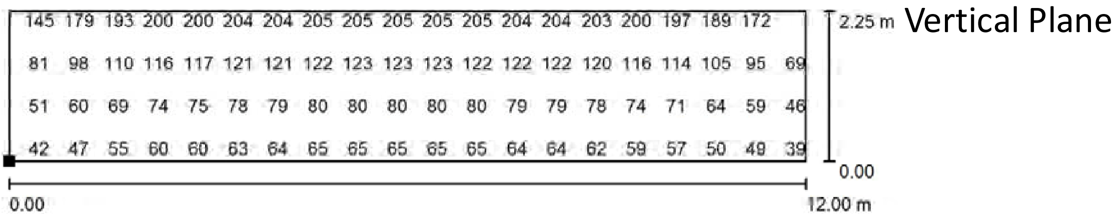
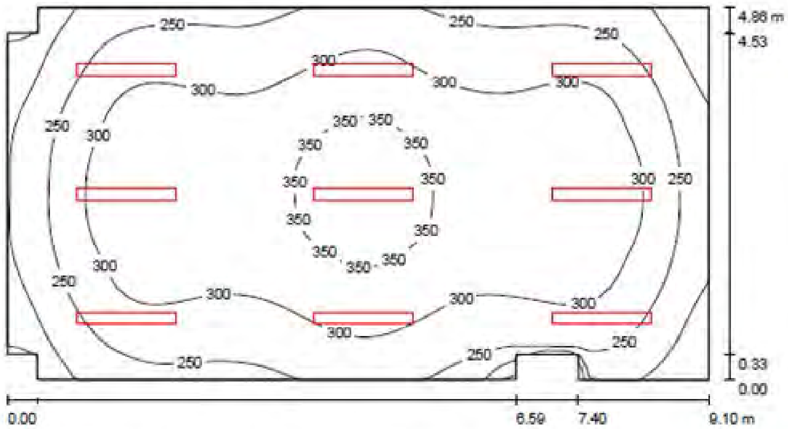


Figure 3.4.4 Luminance Distribution for Bookshelf in the KNC



Height of Room: 3.750 m, Mounting Height: 3.400 m, Light loss factor: 0.80

Values in Lux, Scale 1:66

Surface	ρ [%]	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0
Workplane	/	289	150	377	0.519
Floor	20	235	139	297	0.592
Ceiling	30	80	45	124	0.568
Walls (12)	20	209	43	1084	/

Workplane:
Height: 0.850 m
Grid: 64 x 32 Points
Boundary Zone: 0.000 m

Figure 3.4.5 Luminance Distribution for Dry Lab in the RCC

(c) Telephone and LAN Facilities

Communication lines in the KNC and the RCC will be connected to the intra-campus communication network as components of the network. The M/P, depicting the power transmission routes, shows the communication lines extend to the KNC along a route from the south-eastern side of the site and to the

RCC along a route from the north-eastern side. Main distribution frames (MDF) will be installed in the extra low voltage room in the KNC and the RCC to connect communication lines from the communication network to communication lines in the buildings.

A communication system will be developed that integrates telephone communication and LAN systems. Optical fiber cable will be used to connect the MDFs to the patch panels installed. The CAT6e LAN cable will be used to connect the patch panels and information outlets in rooms.

(d) Communal TV reception facilities

Antennas will be installed on the roofs of the buildings. The signal received by the antennas on the coaxial cable will be connected to the television outlets in rooms by way of terminal boards installed evenly through the buildings. The following figure shows conceptual diagrams of telephone/LAN/communal TV reception facilities in the KNC and the RCC.

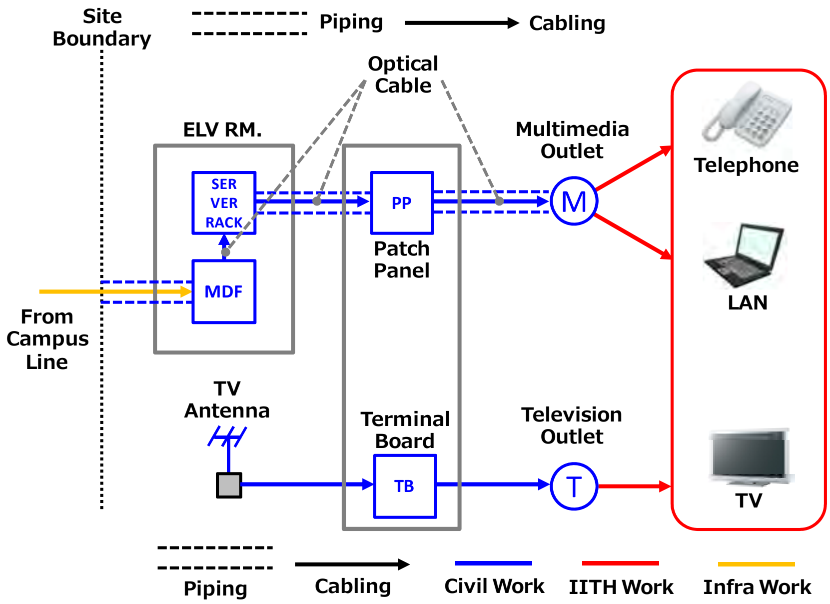


Figure 3.4.6 Diagram of Telephone/LAN/Communal TV Reception Facilities

(e) Public address system

Public address equipment will be installed in both the KNC and the RCC for emergency or service announcements to the entire building. The main public address equipment including amplifiers will be installed and used in the Fire Control Room in each building.

(f) Automatic fire alarm system

Fire alarm facilities will be installed in the buildings in accordance with the NBC of India. The control panels will be installed and monitored in the Fire Control Room in each building. Smoke detectors will be used as the main fire sensors.

(g) Video monitoring system

Monitoring cameras will be installed in both the RCC and the KNC for enhanced security. Monitoring devices will be installed in the Fire Control Room in each building to monitor and record images. Cameras will be installed in public spaces including the entrances and corridors.

(h) Lightning arresters

The lightning arrester facilities will be designed in accordance with the NBC India. A system of roof conductors will be used for most of the arresters. Copper rods will be used as the ground electrodes.

(i) Ground systems

An independent grounding system with various types of ground electrodes will be used in the project. Designs for three types of grounding systems will be developed for lightening arresters, power equipment and light electrical equipment.

(j) Intelligent Building Management system : IBMS

IBMS will be designed for control various system comprehensively. The next figuree shows conceptual diagrams of IBMS.

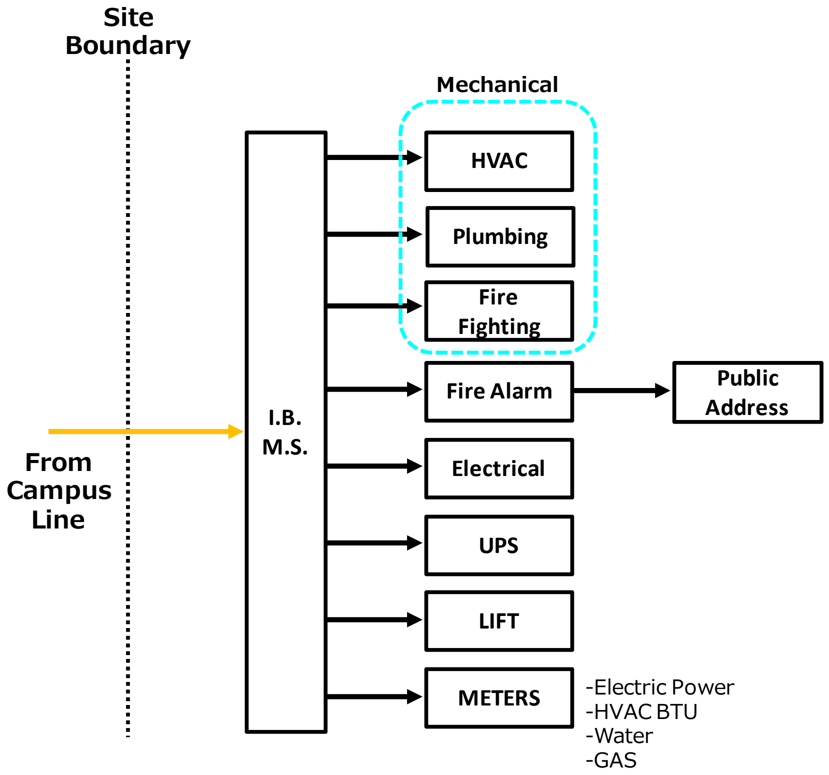


Figure 3.4.7 IBMS Concept Diagram

3.5 HVAC SYSTEM

3.5.1 Design Concept

- Attention will be paid to the provision of a high efficiency mechanical systems for energy use reduction complying with Indian environmental standards GRIHA and ECBC.
- To aim for the four-star acquisition of GRIHA
- To get the GRIHA points comprehensively with the building design, the choice of construction materials, operation and maintenance, etc.

3.5.2 REFERENCE STANDARDS

The typical standards of HVAC system in India which shall be applied to IITH projects are as below.

- Relevant standards of the American Society of Heating, Refrigeration & Air Conditioning Engineers (ASHRAE)
  ASHRAE 62.1-2007.
  ASHRAE 90.1-2004.
- Duct construction standards as per relevant IS Codes and the Sheet Metal & Air Conditioning Contractors Association (SMACNA) standards
- National Building Code of India- 2005.
- Indian Society of Heating, Refrigeration & Air Conditioning Engineers (ISHRAE) Weather Design Data.

3.5.3 BASIS OF DESIGN

● Site location	: HYDERABAD, ANDHRA PRADESH.
● Outside Condition	
Summer	106 °F (41.1 °C) Dry Bulb , 78 °F (25.6 °C) Wet Bulb
Monsoon	85 °F (29,4 °C) Dry Bulb, 81 °F (27.2 °C) Wet Bulb
● Inside Condition	
General room	25°C Dry Bulb ± 2 °C, RH around 50% (no control on RH)
Archive Room	25°C Dry Bulb ± 2 °C, RH 25% ± 5%
● Height of RCC building	(refer to the architectural drawings)
Pit floor	2.50 mtrs (except tank and machine room)
Ground floor	4.00 mtrs
First floor	4.00 mtrs
Second Floor	4.50 mtrs
Third Floor	4.50 mtrs
Fourth Floor	4.50 mtrs
● Height of KNC building	(refer to the architectural drawings)
Pit floor	3.10 mtrs (except tank and machine room)
Ground floor	5.00 mtrs

First floor	5.40 mtrs	
Second Floor	3.70 mtrs	
Third Floor	4.40 mtrs	(only seminar room : 6.40 mtrs)

- Glass Height — As per design
- Lighting Load — 1.5 W/sq.ft.
- Equipment Loads

[KNC]		
Audiovisual RM	5.6 W/sq.ft	(60 W/sqm)
Office	2.8 W/sq.ft	(30 W/sqm)
General RM	0.9 W/sq.ft	(10 W/sqm)
ELV RM	46.5 W/sq.ft	(500 W/sqm)
[RCC]		
Mega Lab	27.9 W/sq.ft	(300 W/sqm)
Wet Lab	13.9 W/sq.ft	(150 W/sqm)
Dry Lab	9.3 W/sq.ft	(100 W/sqm)
Office	2.8 W/sq.ft	(30 W/sqm)
General RM	0.9 W/sq.ft	(10 W/sqm)
ELV RM	46.5 W/sq.ft	(500 W/sqm)

- Fresh Air — As per ASHRAE 62.1-2007 (7.5 cfm/ person + 0.18 cfm/ sqft)
- Wall Aerated blocks — U = 0.35 Btu / Hr Sq ft°F (for reference)
- Wall — U = 0.12 Btu / Hr Sq ft°F (for reference)
- Exposed Glass — U Value - 0.3 Btu/hr sq.ft °F (for reference)

  Shading Coefficient - 0.2 (for reference)
- Ventilation Requirements

Toilets	Exhaust @ 15 ACPH
Mechanical Plant Room	Exhaust @ 15 ACPH

3.5.4 Air Conditioning System

For both KNC and RCC, the chilled water at 6.7 degrees should be supplied from the chiller plant installed in the water chiller. The temperature of the primary chilled water should be 6.7 degrees for the chilled water supply (CS) and 13.7 degrees for the chilled water return (CR) with a temperature difference of 7 degrees.

The chilled water is received through the heat exchanger in the primary chilled water facility in the mechanical room. After this, the chilled water shall be supplied to AHUs and FCUs. The temperature of the secondary chilled water shall be CS 7.7 degrees, and CR 12.7 degrees with a temperature difference of 5 degrees. The diagram for the chilled water supply system and scope of work is shown as below.

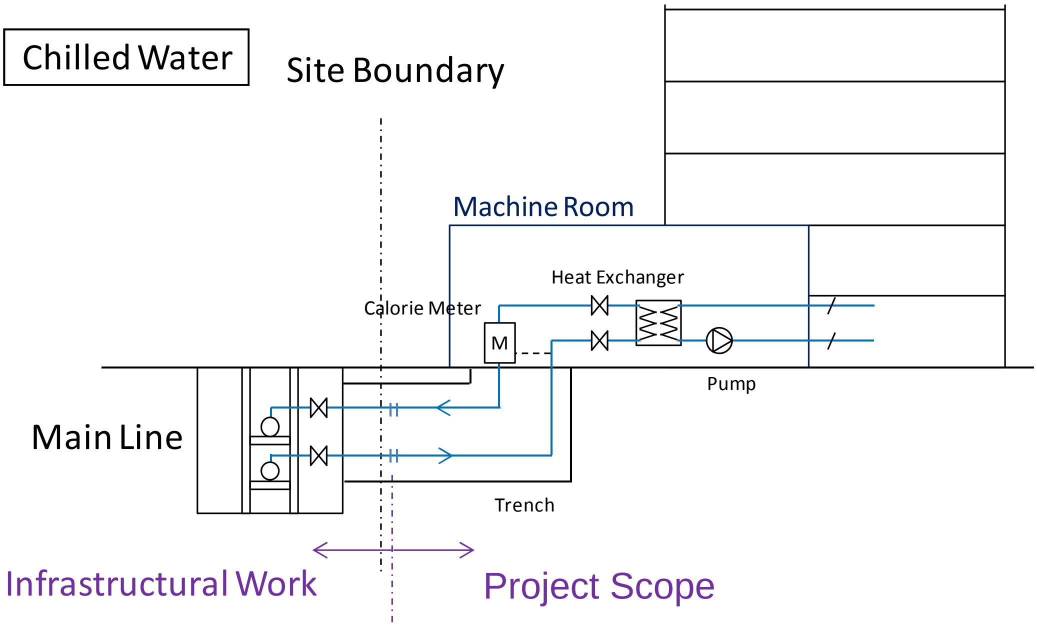


Figure 3.5.1 Heat Source Scope and System Diagram

3.5.5 HVAC Plan

The exterior air and interior temperature/ humidity conditions are shown below. Since the temperatures are high throughout the year cooling only systems are to be selected.

Table 3.5.1 Exterior Temperature/Humidity Air Conditions

Room	Temperature(DB)	Temperature(WB)	Absolute Humidity	Relative Humidity	Specific enthalpy
Outdoor	39.2 ℃	22.6 ℃	10.2 g/kg	23.1 %	65.6 kJ/kg
Remarks	･Outdoor air conditions is by ECBC.				

Table 3.5.2 Interior Temperature/Humidity Air Conditions

Facility	Room	Temperature [℃]	Humidity [%]	AC System
KNC	Stepped Open Shelf	25	Not controlled	AHU (Floor Supply System)
	Entrance Hall Cafeteria Reading RM(GF)	25	Not controlled	AHU (Floor Supply + Floor Chilled Water System)
	Audiovisual RM Office Reading RM Study RM	25	Not controlled	FCU
	Archive	25	25	DX Unit (for Constant temperature and Humidity type)
RCC	Wet Lab Dry Lab Office Meeting RM Seminar RM Conference RM	25	Not controlled	FCU
	Mega Lab	- (Out of Scope)	- (Out of Scope)	By Tenant

(a) KNC

The air conditioning system for the open access bookshelves area and the entrance hall is to be a single duct system, which is suitable for large spaces. Rooms with high ceilings such as the entrance hall and the open shelf will have occupied zone air conditioning with floor diffusers for efficient energy usage. A radiation air conditioning system will be installed at the entrance hall by the under-floor chilled water piping. No water cooling system will be installed in the open access bookshelves area to prevent water leakage accidents. The system type, wind speed and number of diffusers will be considered in order to maintain a uniform air stream.

The archive room requires a constant temperature and humidity, therefore, a floor standing DX Unit (constant temperature and humidity type) shall be installed in this room. The DX Unit will be powered by a generator. FCUs shall be installed for the other rooms. The figure below shows an example of under floor air distribution system equipments.

Figure 3.5.2 Under Floor Air Distribution System Example

(b) RCC

The individual laboratory rooms are expected to have differing operational schedules. They will be provided with individual FCU systems for each room for flexible operation. Since each laboratory is to be leased to tenants, the fan coil units in each laboratory will be designed with standard capacity for each tenant. Requests from tenants will be met by placing diversion valves in cold water piping and providing expansion room for extra equipment and piping ducts routes..

The scope of work for air conditioning in the Mega Lab is shared until the chilled water branch and after that point, all air conditioning systems will be included under the individual tenant's scope of work.

The high efficiency HVAC system is designed by installing the ceiling fans at Dry Labs and offices as well as natural ventilation system in order to reduce the HVAC energy usage during the mild seasons.

3.5.6 Ventilation System

The ventilation system is prepared to exhaust smells, heat, dust, humidity, CO_2, fumes and other indoor pollution materials and to provide outdoor fresh air to maintain the quality of indoor air environment. Lab fumes that are smelly and dangerous are to be discharged with individual ventilation exhausts to keep smells from entering the general ventilation systems.

(a) KNC

The open access bookshelves area and entrance hall will be provided with single duct air conditioning systems with forced mechanical ventilation. Spaces with differing operational schedules such as reading rooms, audiovisual rooms and offices will be provided with individual ventilation systems together with air supply fans for lean and flexible operation. The ventilation systems for habitable rooms will also incorporate draft air systems, which are commonly used in India.

(b) RCC

Since individual laboratories are expected to have differing operational schedules, they will be provided with individual ventilation systems with air supply fans for lean and flexible operation. Also, the ventilation systems for habitable rooms will incorporate with draft air systems. Since each laboratory is to be leased to tenants, the FCUs in each laboratory will be designed with standard capacity for each tenant. Requests from tenants will be met by providing expansion room for extra equipment and piping duct routes.

The scope of ventilation work in the Mega Lab is shared until the wall opening or connecting ducts and after that, all ventilation systems will be included under the individual tenant’s scope of work.

3.6 PLUMBING AND FIRE-FIGHTING SYSTEM

3.6.1 DESIGN POLICY

To apply the mechanical equipment system with high energy performance as well as

- To meet the standards and code such as GRIHA and ECBC , harmony with the local climate characters,
- To achieve GRIHA 4 star rating
- To design system considering maintenance and operation aspects

3.6.2 REFERENCE STANDARDS

The typical standards of plumbing and fire-fighting system in India which shall be applied in IITH projects are as below.

- NBC India- 2005.
- Codes & Design Guidelines.
- American Society of Plumbing Engineers (ASPE)
- International Plumbing Code- 2003
- Uniform Plumbing Code of India – 2008
- ECBC-2008

3.6.3 BASIS OF DESIGN

Site location :HYDERABAD, ANDHRA PRADESH.

Height of RCC building (refer to the architectural drawings)

Pit floor	2.50 mtrs (except tank and machine room)
Ground floor	4.00 mtrs
First floor	4.00 mtrs
Second Floor	4.50 mtrs
Third Floor	4.50 mtrs
Fourth Floor	4.50 mtrs

Height of KNC building (refer to the architectural drawings)

Pit floor	3.10 mtrs (except tank and machine room)
Ground floor	5.00 mtrs
First floor	5.40 mtrs
Second Floor	3.70 mtrs
Third Floor	4.40 mtrs (only seminar room : 6.40 mtrs)

3.6.4 Water Supply System

A separate city water system and treated effluent water system are supplied to each project site. Potable water will be supplied from the city water system while grey water for treated effluent will be used for flushing toilets, watering of landscaping and water for the cooling towers. According to Indian design standards, receiving water tanks are to be designed for 100% of daily supply needs. Receiving water tanks and terrace water tanks for the Project facilities are to be concrete tanks with sufficient space for inspection and maintenance.

Since the supply side water pressure for RCC and KNC has been confirmed to be 40mH, the water is lifted up to the gravity/receiving water tank directly and distributed by gravity. The water pressure of upper floor will be small. Therefore, the water for the upper floor will be supplied by a booster pump. The scope of work for primary and secondary water supply systems, including water supply system diagrams and calculations for water supply requirements, are shown below.

The demarcation of the scope of works for primary and secondary water supply systems is shown below.

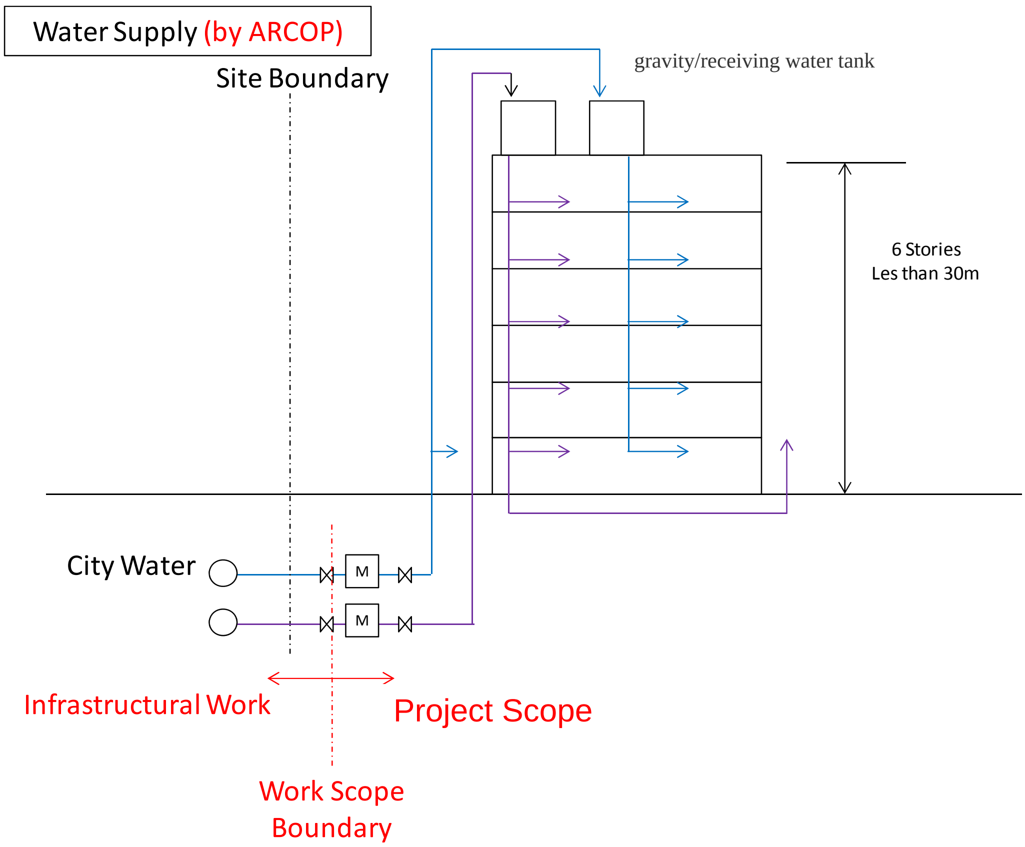


Figure 3.6.1 Water Supply Scope of Work

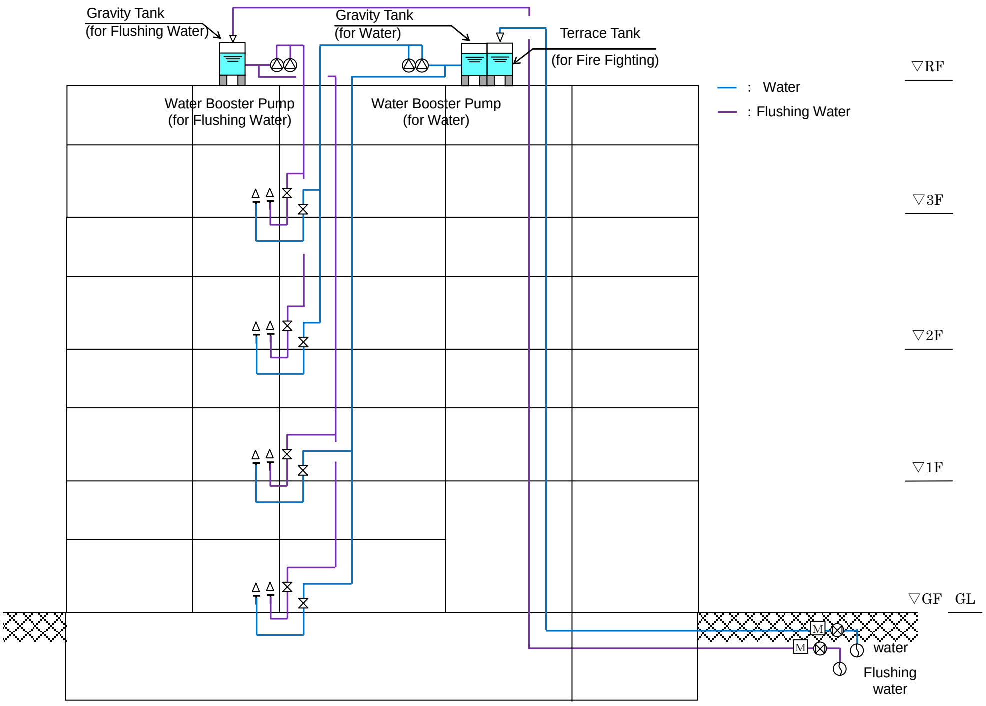


Figure 3.6.2 Water Supply Diagram for KNC

Table 3.6.1 Water and Hot water Consumption for KNC

□Water supply quantity calculation KNC

Zone	Room Name	Person			Average consumption unit			Usage time	Maximum	Peak
		Area [㎡]	Person density [P/㎡]	Number of person [P]	Average unit [ℓ/P・day]	Domestic Water ratio	Flushing water ratio	[h]	hourly flow rate	flow rate
café	Cafeteria	20 seats	1 rotation	20	70	70%	30%	5	2.0	3.0

□Hot Water supply quantity calculation

Zone	Room Name	Hot Water ratio	Water supply quantity [ℓ/day]	Hot Water quantity [ℓ/day]	Usage time [h]	Maximum hourly flow rate	Peak flow rate
café	Cafeteria	50%	980	490	5	2.0	3.0

Zone	Room Name	Hot Water supply quantity								Remark
		Day consumption[m3/day]		Average hourly consumption[m3/h]		Maximum hourly hourly consumption[ℓ/h]		Peak flow[ℓ/min]		
		Hot Water		Hot Water		Hot Water		Hot Water		
café	Cafeteria	1.0		0.2		7		20		
Sub total		1.0	0.0	0.2	0.0	6.5	0.0	19.6	0.0	
Total		**1.0**	**0.0**	**0.2**	**0.0**	**6.5**	**0.0**	**19.6**	**0.0**	
			1.0		**0.2**		**6.5**		**19.6**	

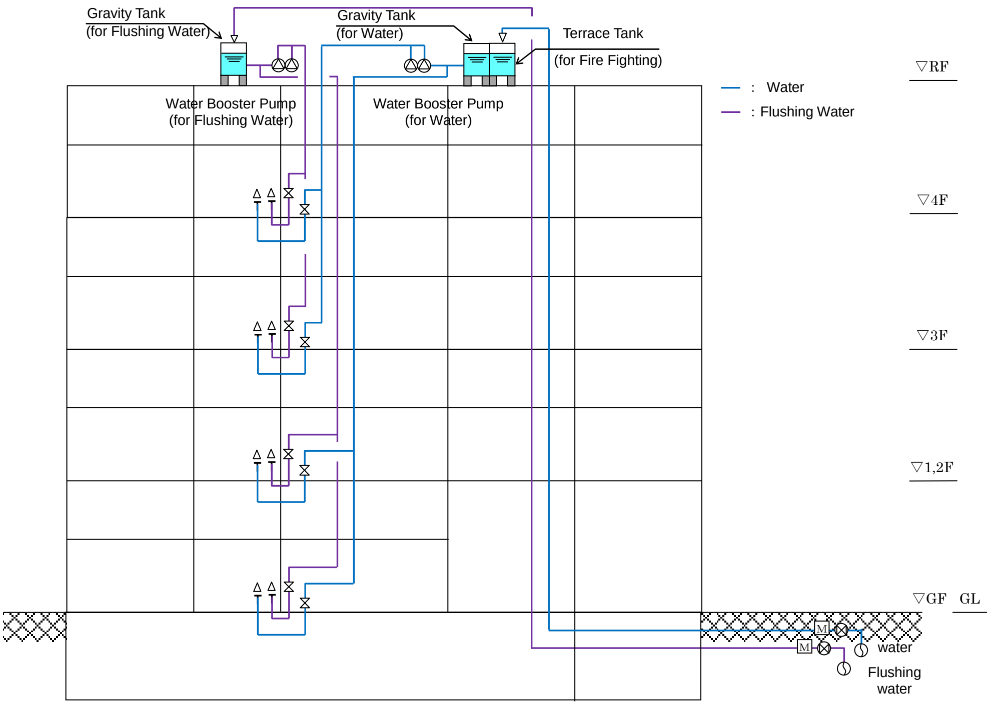


Figure 3.6.3 Water Supply Diagram for RCC

Table 3.6.2 Water and Hot Water Consumption for RCC

☐Water supply quantity calculation RCC

Zone	Room Name	Person: Area [m²]	Person: Person density [P/m²]	Person: Number of person [P]	Average consumption unit: Average unit [ℓ/P･day]	Average consumption unit: Domestic Water ratio	Average consumption unit: Flushing water ratio	Usage time [h]	Maximum hourly flow rate	Peak flow rate	Remark
Researcher	dryLAB	10 persons/room	16 rooms	160	45	30%	70%	6	2.0	2.0	Changed as per NBC, 2005, part-9, page 19, table 1
Researcher	wetLAB	10 persons/room	30 rooms	300	45	30%	70%	6	2.0	2.0	Changed as per NBC, 2005, part-9, page 19, table 1
Water for reseach	wet LAB			300	50	100%	0%	6	2.0	2.0	
Researcher	MegaLAB	950	0.15	143	45	30%	70%	6	2.0	2.0	Changed as per NBC, 2005, part-9, page 19, table 1
Water for reseach	wet LAB			143	50	100%	0%	6	2.0	2.0	
Student	SeminerRM		Total seats→	220	45	30%	70%	6	2.0	3.0	Changed as per NBC, 2005, part-9, page 19, table 1
Office staff	office	400	0.15	60	45	30%	70%	8	2.0	2.0	Changed as per NBC, 2005, part-9, page 19, table 1

Zone	Room Name	Water supply quantity: Day consumption[m3/day] Domestic Water	Day consumption[m3/day] Flushing water	Average hourly consumption[m3/h] Domestic Water	Average hourly consumption[m3/h] Flushing water	Maximum hourly consumption[ℓ/min] Domestic Water	Maximum hourly consumption[ℓ/min] Flushing water	Peak flow[ℓ/min] Domestic Water	Peak flow[ℓ/min] Flushing water	Remark
Researcher	dryLAB	2.2	5.0	0.4	0.8	12	28	24	56	
Researcher	wetLAB	4.1	9.5	0.7	1.6	23	53	45	105	
Water for reseach	wet LAB	15.0	0.0	2.5	0.0	83	0	167	0	
Researcher	MegaLAB	1.9	4.5	0.3	0.7	11	25	21	50	
Water for reseach	wet LAB	7.1	0.0	1.2	0.0	40	0	79	0	
Student	SeminerRM	3.0	6.9	0.5	1.2	17	39	50	116	
Office staff	office	0.8	1.9	0.1	0.2	3	8	7	16	
make-up water for cooling tower		7.7	0.0	1.0	0.0	24.1	0.0	24.1	0.0	
Sub total		41.8	27.8	6.6	4.6	212.1	151.8	416.6	342.1	
Total		**41.8**	**27.8**	**6.6**	**4.6**	**212.1**	**151.8**	**416.6**	**342.1**	

☐Water tank quantity calculation ※Tank capasity ratio shall be 0% of day consumption. ※Gravity tank capasity ratio shall be 100% of day consumption.

Water tank (m^3)		Water gravity tank (m^3)		Flushing water tank (m^3)		Flushing water gravity tank (m^3)		Fire fighting tank (m^3)		Fire fighting terrace tank (m^3)	
Capacity		Capacity		Capacity		Capacity		Capacity		Capacity	
0		**42**		**0**		**28**		**166**		**40**	

Changed as dom & flushing tanks are located on terrace not on under ground

As discussed in meeting 16m3 cooling tower req added in FF tank

☐Make-up water consumption calcuration for each MEGALab

MEGALab HEAT LOAD	300	W/m²	(based on supposed chilled water load demand)
MEGALab AREA	937.36	m²	
MEGALab COOLING WATER CAPACITY	281,208	W	80 RT
deg reference	5	deg	
cooling water flow	804	L/min	

Make-up water for cooling tower

cooling water flow	804	L/min			
make-up water ratio			Average hourly consumption		
	0.02			965	L/h
summary				965	L/h
Average hourly consumption	965	L/h			
Maximum hourly consumption	1,448	L/h	Maximum hourly flow rate	1.5	
Peak flow	24	L/min	Usage time	8	h(assumption)
Day consumption	7,721	L/d	receiving time	1	（h)
			tank quantity	1,448	L

Calculation results

Day consumption	7,721	L/day
Average hourly consumption	965	L/h
Maximum hourly consumption	1,448	L/h（Maximum hourly flow rate：1.5）
Peak flow	24	L/min（peak flow rate：1）
tank quantity	1,448	L(receiving time：1hour)

☐Hot Water supply quantity calculation RCC

Total no of persons	% of persons using shower	No of persons using shower	Average consumption unit: Average unit [ℓ/day]	Average consumption unit: quantity [ℓ/day]
600	10	60	50	3,000

As discussed in meeting considered out of 600 persons 10% will use shower & at hot water consumption of 50lit/day.

3.6.5 Waste Water System

The soil water pipe and general waste water pipe inside the building should be separated.

They should be connected outside the building footprint.

Storm water is discharged into the common drainage system around the sites. The drainage system will be separated for soil water and general sewage and this practice is common locally. The demarcation of the scope of works for primary and secondary drainage systems are shown below.

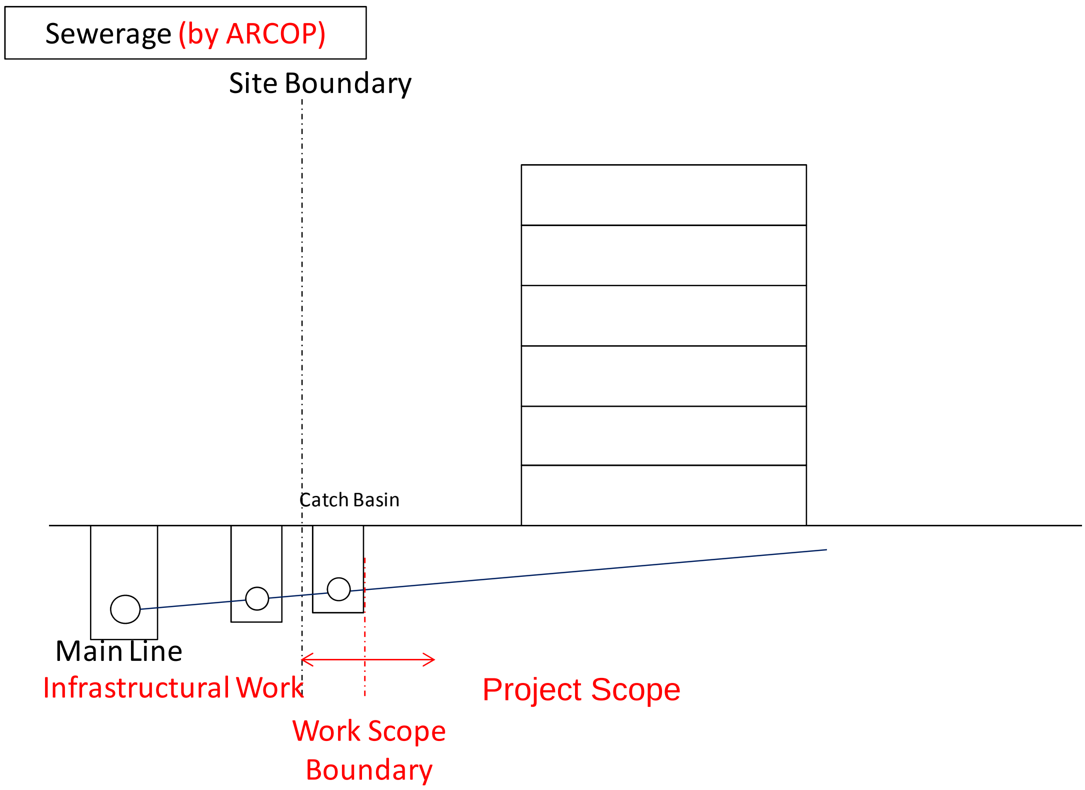


Figure 3.6.4 Soiled /Storm Water Drainage Discharge Scope

3.6.6 Fire Fighting System

The firefighting system shall be required depending on the classification, size and height of the building based on NBC.

Both RCC and KNC must be provided with sprinkler systems and indoor hydrant systems. Separate fire fighting pumps are required for the sprinkler system, the indoor hydrant system, the Jockey for the sprinkler system, the jockey for the indoor hydrant system and the stand-by system giving a total of 5 separate fire-fighting pumps. Furthermore, a fire-fighting pump for each vertical pipe of the indoor hydrant system must be provided on the roof as a stand-by unit.

Since the supply side water pressure for both RCC and KNC has been confirmed to be 40mH, water can be elevated to the roof firefighting auxiliary tank integrated into the structure through a direct connection to the primary water supply system. The fire fighting water tank will be above ground structural tanks. Fire fighting water tanks and auxiliary tank capacities for RCC are 150m3 and 40m3 respectively . The fire fighting water tank will be above ground structural tanks. Fire fighting water tanks and auxiliary tank capacities for KNC are 100m3 and 40m3 respectively by law. The Fire Fighting System Diagram is shown below.

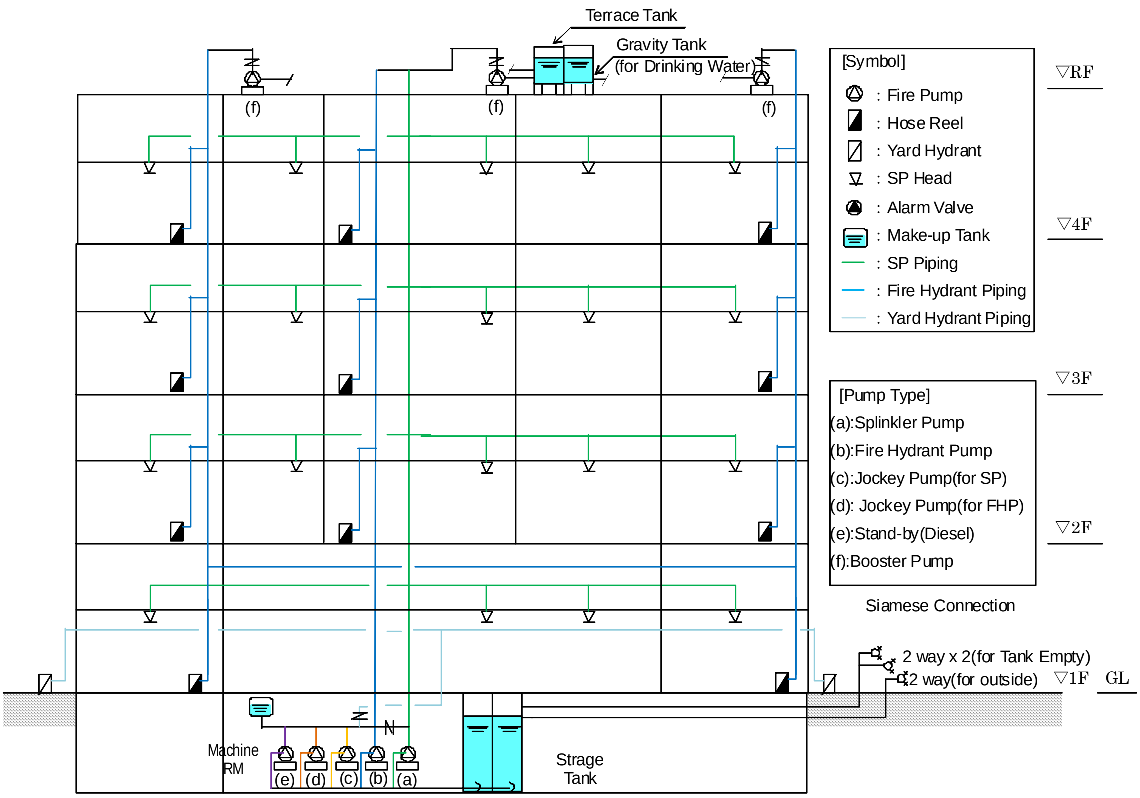


Figure 3.6.5 Firefighting System Diagram

The fire fighting system in the archive room of KNC shall be considered carefully for protecting the very important documents. In order to prevent water leakage accidents, FM-200 system, a dry mist fire protection system or pre-activated sprinkler system shall be installed in the archive room. The table below shows the initial/ running cost and maintenance comparison of possible fire fighting system at the archive room. Considering easier maintenance and reasonable budget, dry mist fire protection system shall be applied based on the discussion with IITH.

The main stepped open access bookshelves area is a very large space with no dividing walls Therefore, a typical fire fighting system cannot be applied in this area. Based on the local fire fighting regulations, instead of using fire rated walls, water curtain system shall be installed in order to divide safety areas. The figure below shows the fire protected areas divided by water curtains in the stepped open bookshelves area.

Table 3.6.3 Comparison of Fire Fighting Systems of KNC Archive Room Options

Si. No.	Comparison Parameters	Water Mist System. (System 1)	FM 200 System (System 2)	Double Interlock Preaction System. (System 3)
1	Cost (Supply + Installation) in Rs.	10,687,500	50,00,000	25,00,000
2	Maintenance Cost	The maintenance cost required to maintain the pumps and accessories is same as system-3 and it is very negligible	Maintance cost for this system is considerably higher than system 1 & 3	The maintenance cost required to maintain the pumps and accessories is same as system-1 and it is very negligible
3	Space (dimensions in mtrs)	4 X 3 X 3 (L X W X H)	2 X 2 X 3 (L X W X H)	1 X 0.75 X 2 (L X W X H)
4	Merits	1. Running cost is less. 2. Environmental friendly. 3. Very effective in fire suppression. 4. Periodically testing can be done. 5.The books or stored data will not get dimaged due to water mist system when it is activated for fire fighting.Water droplets are in micron size and they do not dimage the books	1. Less capital cost as compared to system 1	1. Less capital cost as compared to system 1 and system 2. 2. Running cost is less. 3. Peridiocally testing can be done. 4. Environmental friendly.
5	Demerits.	1. Very High capital cost as compared to system 1 and system 2.	1. There can be some minor damages to the books due to FM200 or similar gas. 2. Even in case of small fire 100% gas will be released , and this needs to refilled completely. Also in government system, there will be a tendering system and the lead time will be more for ordering the same during that duration there is no protection to the area. 3. High refilling cost. 4. Periodically testing is not possible.	1. There will be a damage to the books stored in soft / hard format due to use of water in sprinkler system

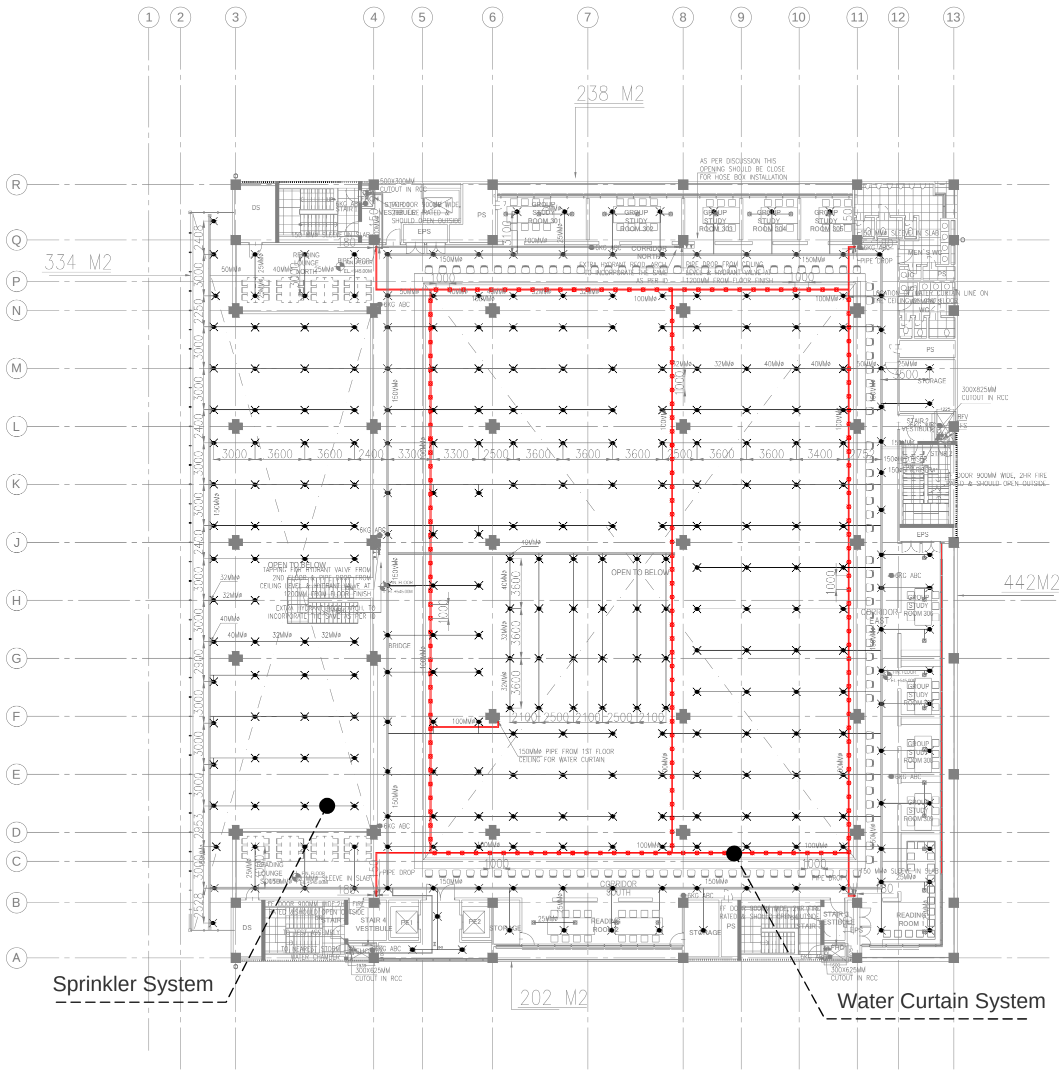


Figure 3.6.6 Fire Proteced Areas Divided with Water Curtains of KNC

Stepped Open Access Bookshelves Area

CHAPTER 4

COST ESTIMATION REVIEW

Chapter 4 COST ESTIMATION REVIEW

4.1. Cost Estimation Review

For this project, the construction cost shall be estimated based on the CPWD, not the BOQ (Bill of Quantity) following the local practice. Items not listed on CPWD were based on local construction market prices during the discussion with IITH in December 2012（MD on IITH Phase 2）.

However, based on the UoT's presentation held on October 14, 2013 at UoT Kashiwa Campus with IITH, the KNC project was expanded from the scheme submitted for MD phase 2. (Total floor area 7,150m2 ⇒8,290m2 , Height 15m ⇒ 23.4m).

For this phase, the cost estimation shall be done based on the architectural drawings as well as CPWD standard unit prices. Items not listed on CPWD were adjusted through local consultants. On the other hand, MEP works were calculated using a rate based on the total area and building types. The academic buildings and hostel construction costs shall be referred to as well.

Table 4.1.1 Cost Estimation

		KNC	RCC
December 2012 Budget Estimation	Building Cost ①	Rs 475,029,805	Rs 444,073,989
	Exterior Work ②	Rs 30,083,031	Rs 52,032,600
	Sub Total ①+②=③	Rs 505,112,836	Rs 496,106,589
	IITH Tennant Work ④	Rs -10,648,050	Rs -35,493,150
	Total ③ - ④	Rs 494,464,786	Rs 460,613,439
October 2014 DD Cost Estimation	Building Cost	Rs 483,429,030	Rs 427,402,193
	Exterior Work	Rs 12,106,116	26,696,342
	Total	**Rs 495,535,146**	**Rs 454,098,535**
	Difference (2012-2014)	Rs 1,070,360	Rs -6,514,904

As for the KNC, it is slightly higher than the budget estimation back in December 2012. However, the total estimation shall drop during the construction bidding due to packaging as well as RCC's cost estimation was dropped. The total cost estimation came out with Rs-5,444,544. It is within the total budget.