

DOCUMENTS INCLUDED

1- ARCHITECTURE PORTFOLIO (selected works)

2- SDI FINAL REPORT

3-WORKING DRAWING PORTFOLIO

4- CERTIFICATES



ARCHITECTURE
PORTFOLIO

2019 - 2023

DISHITA GOEL

DISHITA GOEL

STUDENT OF ARCHITECTURE



EDUCATION

2019 - Present	● RV College of Architecture Bangalore, Karnataka	Bachelor's of Architecture
2017 - 2019	● P. Obul Reddy Public School Hyderabad, Telangana	CBSE
2013 - 2017	● Pawar Public School Mumbai, Maharashtra	ICSE
2007 - 2013	● P. Obul Reddy Public School Hyderabad, Telangana	CBSE
2005 - 2007	● Euro Kids Hyderabad, Telangana	CBSE

LANGUAGE

	UNDERSTAND	TALK
English	●	●
Hindi	●	●
Telugu	●	●

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Address : IndusCrest Apartments, Ramchandrapuram, Osman
Nagar Rd, Sangareddy, Telangana - 500019

ABOUT ME

I am currently pursuing my Bachelor's Degree from RV College of Architecture, Bangalore, Karnataka.

Architecture to me is more than just making buildings, but about designing unique and pleasing experiences for the user. Through this maze of development as an architecture student, I have tried to keep myself open to new thoughts and ideas to further increase my creativity.

WORKSHOPS

2022	Study of relevance of Vedic Vaastu - Shastra in contemporary architecture	Certified course
2021	Alternate Building Materials and Technologies Foam concrete Rammed Earth Bamboo furniture workshop	Hands - on workshop Hands - on workshop Hands - on workshop
2022	Bamboo Design Workshop	Hands - on workshop
2022	Hafele Design Workshop	Hands - on workshop
2022	Facade Design for Architects Workshop - kaarwan	Certified course
2021	The Complete AutoCAD 2018-21 Course - Udemy	Certified course
2020	A complete course on Blender	

SOFTWARES

Auto CAD	● ● ● ● ● ●
SketchUp	● ● ● ● ● ○
Rhino	● ● ● ● ● ○
Revit	● ● ● ○ ○ ○
Blender	● ● ● ● ○ ○
V-Ray	● ● ● ○ ○ ○
Lumion	● ● ● ○ ○ ○
Enscape	● ● ● ○ ○ ○
Design Builder	● ● ● ○ ○ ○
Climate Consultant	● ● ● ○ ○ ○
Relux	● ● ○ ○ ○ ○
Q Gis	● ● ○ ○ ○ ○

Adobe Photoshop	● ● ● ● ● ●
Adobe Illustrator	● ● ● ● ● ○
Adobe InDesign	● ● ● ● ○ ○
Keynote	● ● ● ● ● ●
Canva	● ● ● ○ ○ ○
Google Suites	● ● ● ○ ○ ○
Microsoft Office	● ● ● ○ ○ ○

TECHNICAL ABILITIES

Hand Drafting
Model Making
Sketching
Digital Rendering
Illustration

DOCUMENTATION

2022	Socio - cultural Aspect of Church Street Bangalore, Karnataka
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EXTRA - CURRICULAR

Member of Marketing Team -KALPA RVCA
To reach out to students and college community while creating an overarching image for the magazine theme through competitions and activities

Student Co-ordinator- ONSITE-INSIGHTS , RVCA

Serjeant-at-arms, ROTRACT CLUB , RVCA

NSS Camp-SCHOOL BELL

Creating better learning environment for underprivileged students, Makali

Member of Merchandise Club -DIMENSIONS 14 , RVCA

Designed logos for US-based Companies

COMPETITIONS

Solar Decathlon India

Finalist

Transparence 17.0 Interior

Participated

Tiny House Design

Participated

Archmello - The Habitat 2.0

Participated

RMZ Design Contest

Participated

ELECTIVES

Visual Communication

Environment Responsive Architecture

Alternate Building Materials & Technologies

Design of High Rise Buildings

WORK EXPERIENCE

Studio Dusk

Bangalore, Karnataka

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THE MARKET
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GURUKUL

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07

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COVID Museum

04

GATEWAY TO
JOURNEYS

Urban Transit Hub

06

WORKING
DRAWING

Mixed-use Building

01

THE MARKET PLACE

Johnson Market, Bangalore, Karnataka

Market Place Design

Semester 07

Studio Mentors : Debasree Pal | Aziz Rajani | Salila Vanka | Shalini Prakash



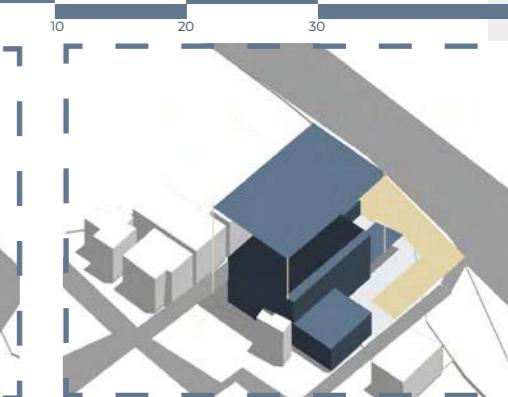
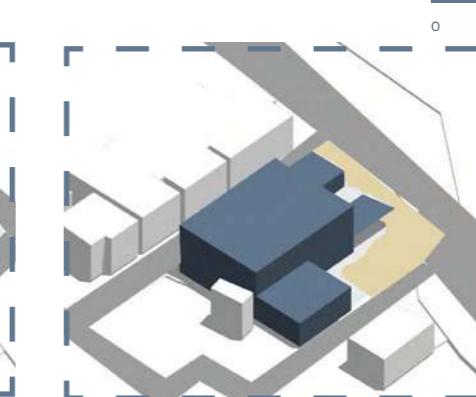
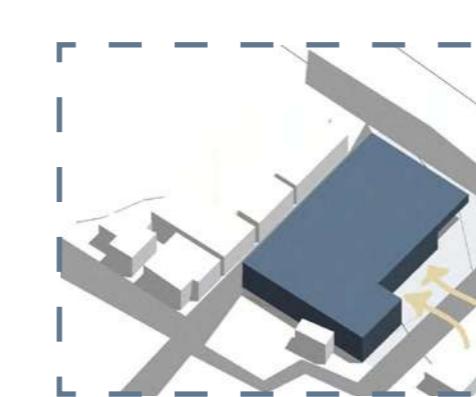
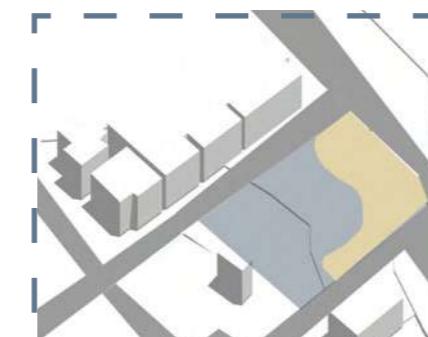
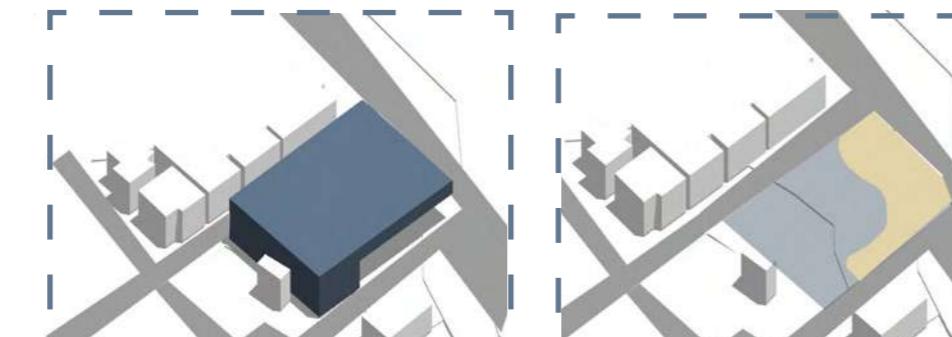
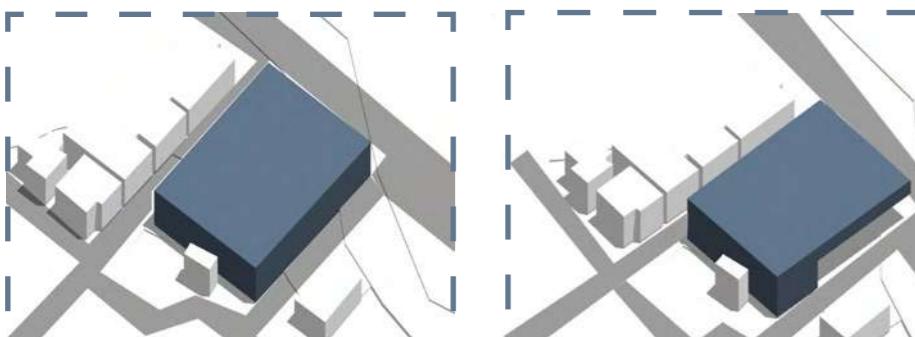
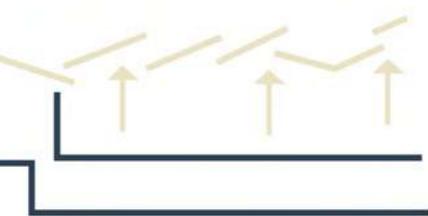
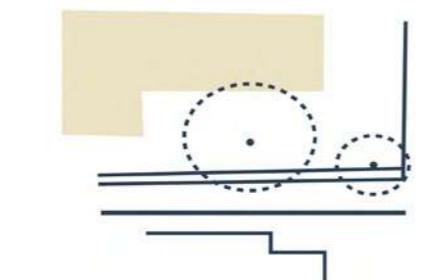
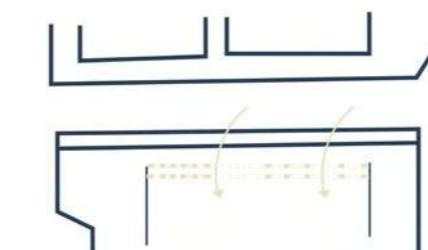
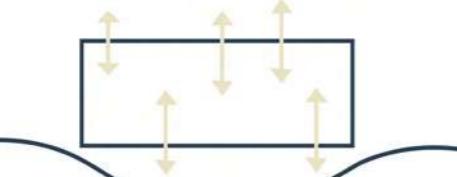
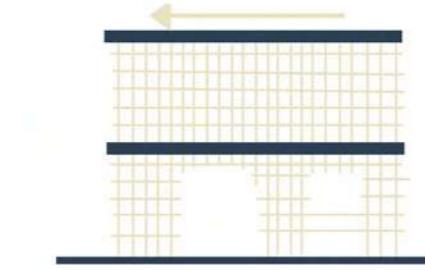
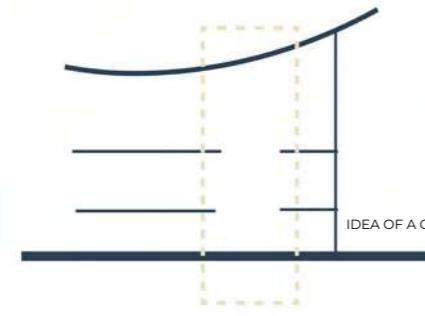
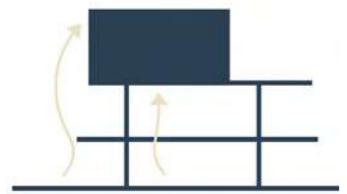
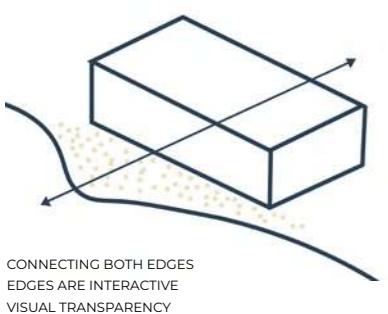
Design of an urban market building in Bangalore as an exercise in space-making in the public realm.

Area : 4500 sq.m

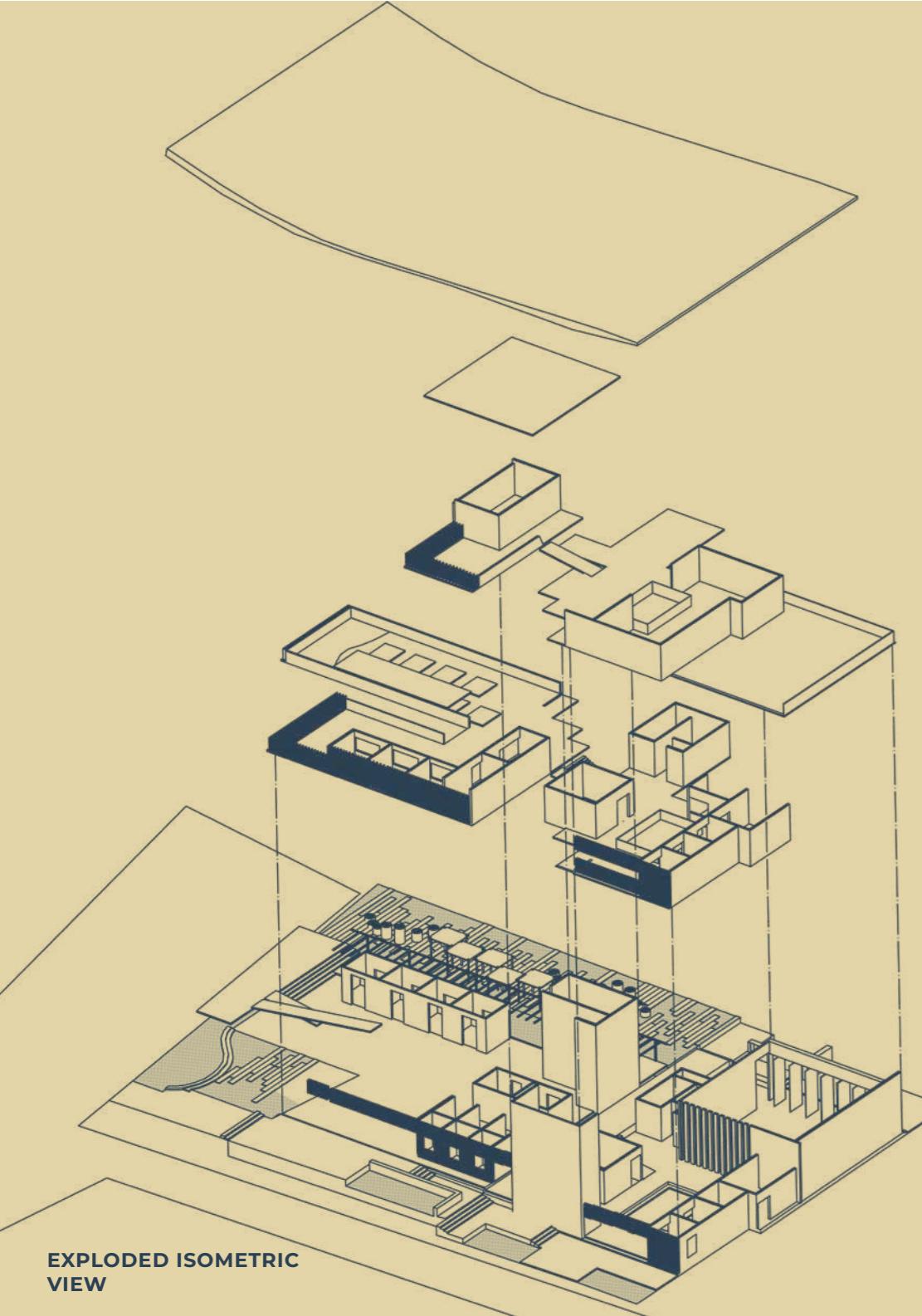
The project relooks into the needs of the community and the shopkeepers and incorporates them on the site by being versatile in nature.

To promote more interactions, the site is left porous and pathways are created so that people experience multiple spaces.

All the functions and spaces are linked in a manner such that the whole projects looks like one complete building . The market is designed in such a way that the market opens on to the streets surrounding the site letting people freely enter and leave the market. On the northern facade , wooden sticks (ECOWOOD) are used which modulate themselves in such a manner that they become openings at some places, shop fronts at some and as a facade at the remaining places.







01 Site showing built and unbuilt spaces
Urban park and public spaces

GROUND FLOOR PROGRAMS

- Meat market
- Urban Park
- Vegetable Market
- Community Gathering Space
- Refreshment Shops

02 FIRST FLOOR PROGRAMS

- Meat market
- Refreshment Shops
- Flea Market

03 SECOND FLOOR PROGRAMS

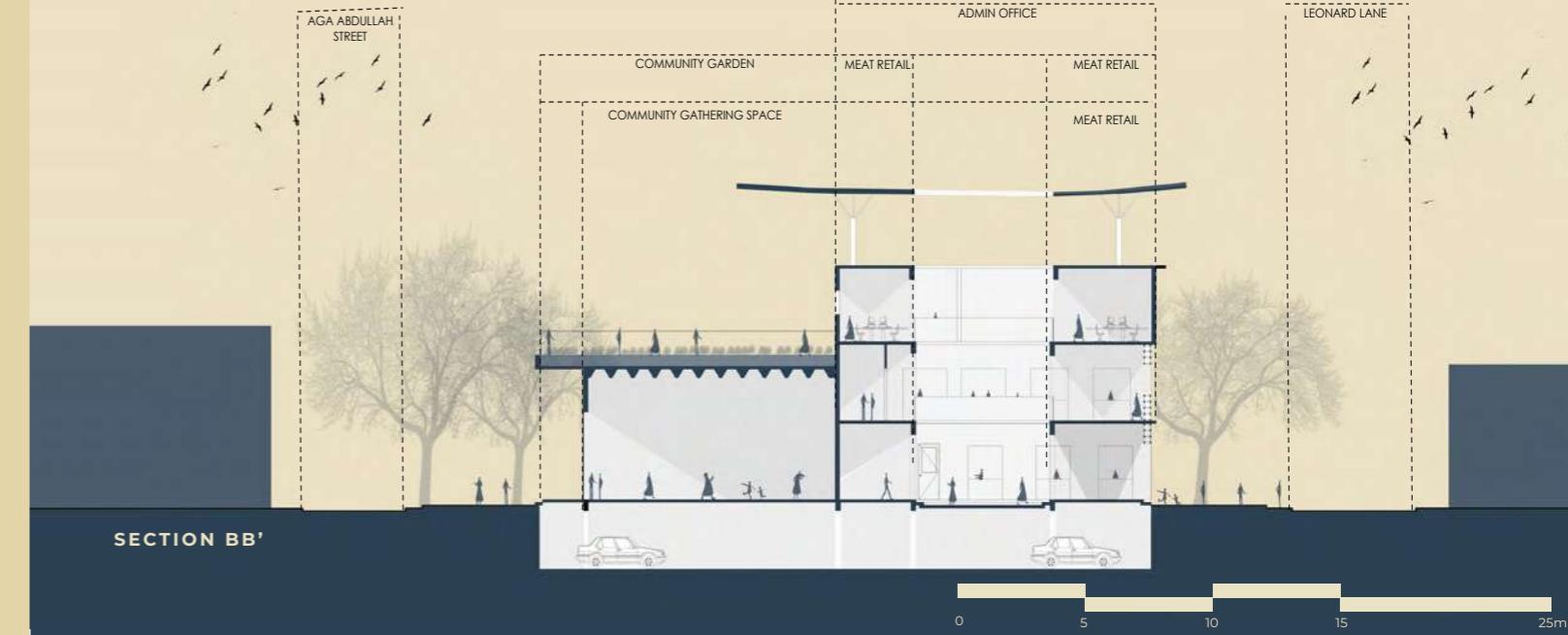
- BWSSB Office
- E - ware Office
- Admin Office

04 Roof added as a canopy , to give the market the feel of an open market

0 5 10 15 25



VIEW OF THE GREENERY INTEGRATED WITH THE WOODEN FACADE ON THE FIRST FLOOR



0 5 10 15

02

LOCAL ROOTS

MG Road, Bangalore, Karnataka

COVID Museum

Semester 03

Studio Mentors : Madhuri Rao | Smaran Mallesh | Meera Vasudev | Deepa Suriyaprakash

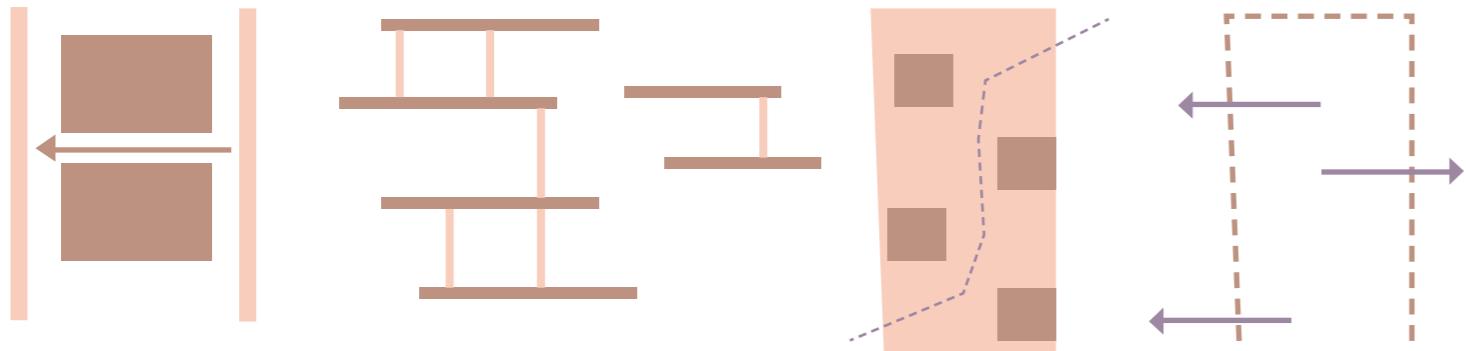
Design of a museum by taking into consideration any one aspect of the Covid - 19 pandemic.

Area : 500 sq.m

The COVID-19 pandemic and its aftermath, has forced us to rethink our lifestyles and health once again, with a renewed focus on oral traditions passed down from generation to generation.

The main aim of the museum is to create a space for interaction and human activity. A place where people get to know about what people did with respect to nourishment during the pandemic. A place where people learn about various traditional cuisines, learn how to cook them, learn about organic farming. A place where people get to know about the advantages of traditional cookwares and how the traditional cookwares were a hit during the pandemic.



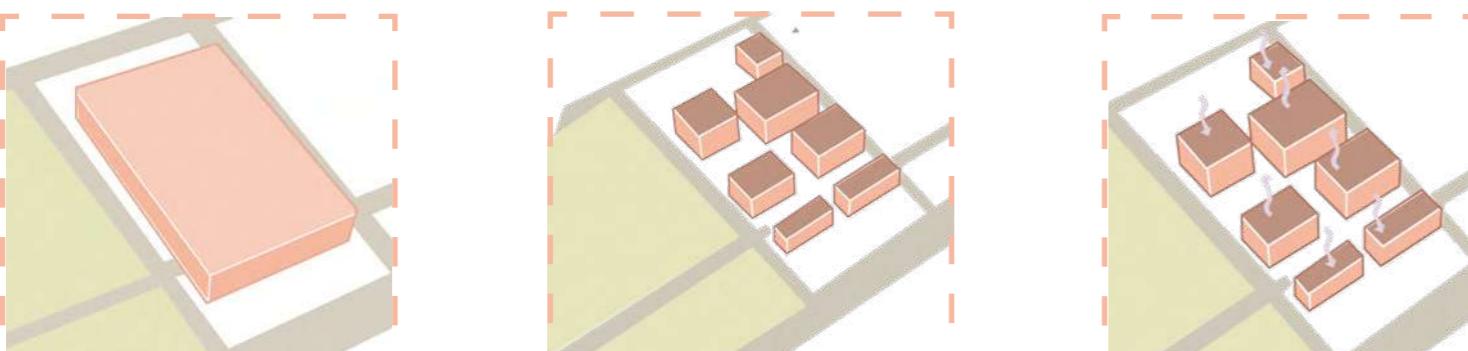


Toilet acts a thoroughfare between 83rd street and road which leads to chinnaswamy stadium

Idea of a grid where the horizontal lines act as the main system

Fluid path connecting the various spaces and the streets

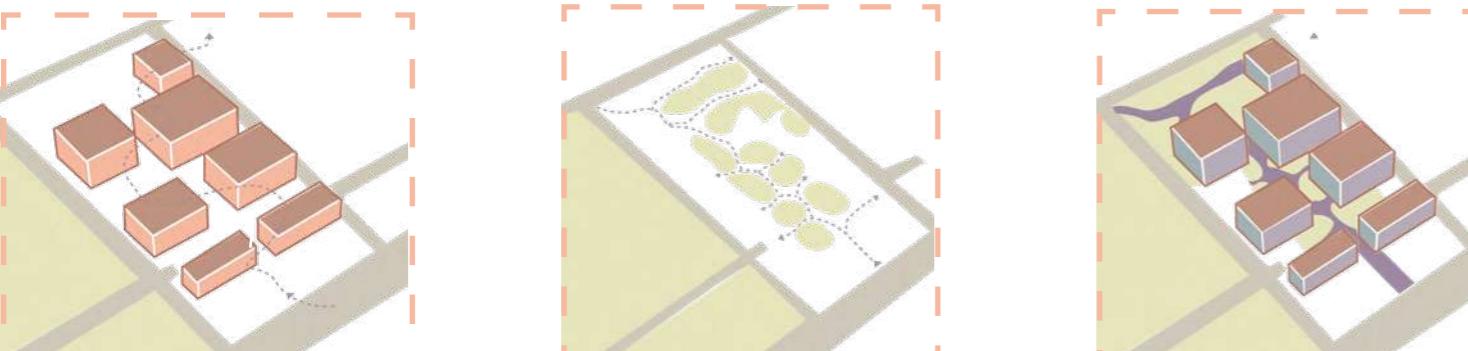
Jail wall at certain places to give a view of the outside



Placing the block on site

Breaking the bigger volume into smaller volumes keeping the idea of grid

Changing the volume of the masses based on the functionality of each block

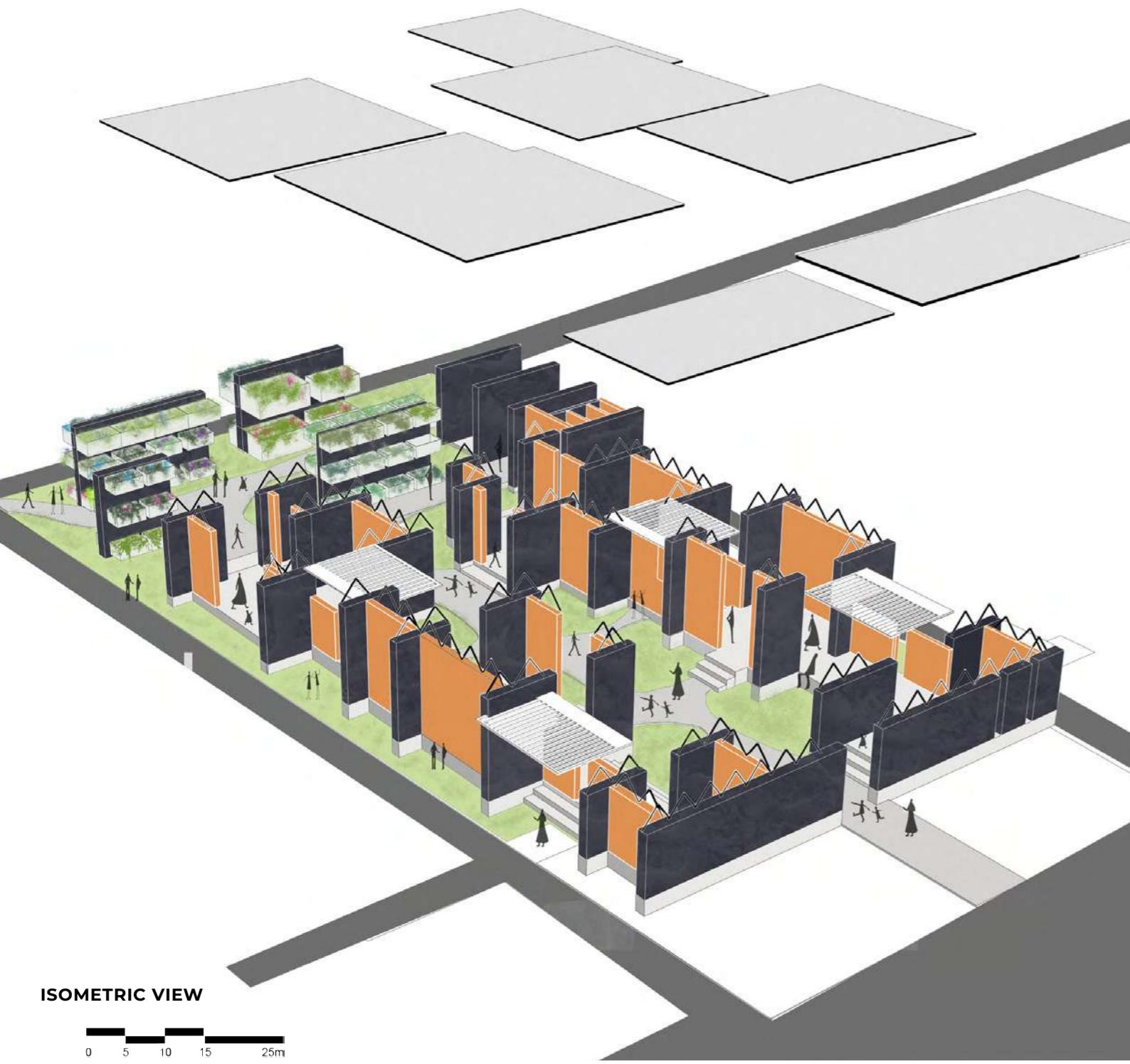


Connecting the various functions through a spine

The spine is designed in such way that it passes through organic gardens which are present in the site

Changing the materiality of the walls to give the users different experience







PERMANENT GALLERY



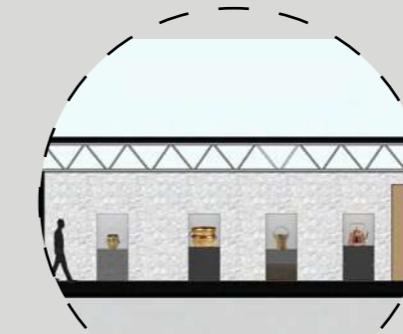
ORGANIC GARDEN



SECTION AA'



TEMPORARY GALLERY



PERMANENT GALLERY

0 5 10 15 25m

03

GURUKUL

Ramnagara, Karnataka

Educational Building

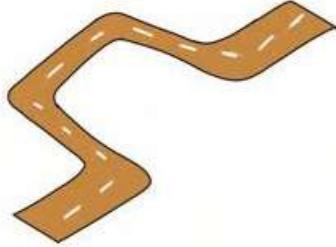
Semester 08

Studio Mentors : Phaniran Phingali | Minni Shastry | Ramya Ramakrishnan



Area : 1000 sq.m

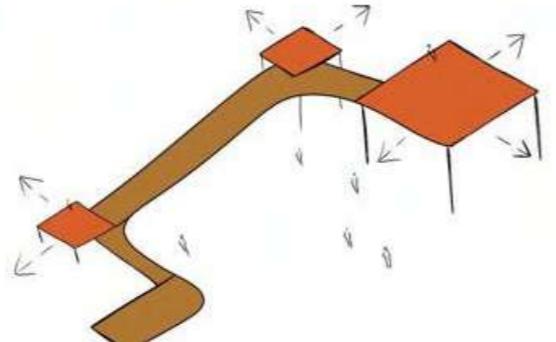
GURUKUL is a net zero, green educational center that takes learning back to its roots and brings back the traditional and sustainable way of learning and living. A place that helps in the exchange of knowledge between both, teachers and students. These principles come forward through the spaces of learning as well, when the architecture is made as a response to the site and the nature drives the built form. Vertical grouping makes for healthier peer dynamics as well as help minimize comparison in the mind of the learner as well as the adult. The physical activity programme at school includes activities that stimulate sensorial and motor development, cooperative games, pre-participation tasks to develop specific skills. The school creates an ambiance that nurtures the student's creative and aesthetic abilities, all the while incorporating an appreciation for nature.

**RAMPS**

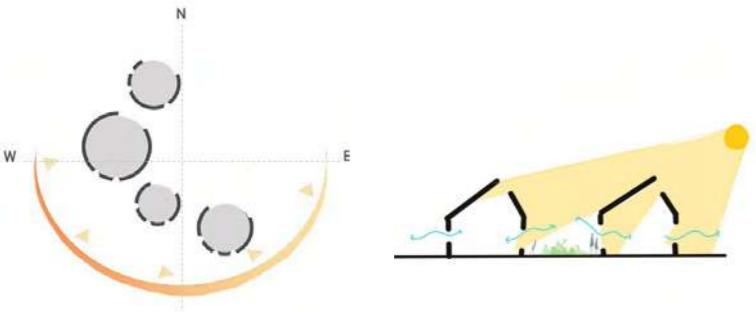
Allows people of different abilities to access different levels of pedestrian network easily

**SPACES IN BETWEEN**

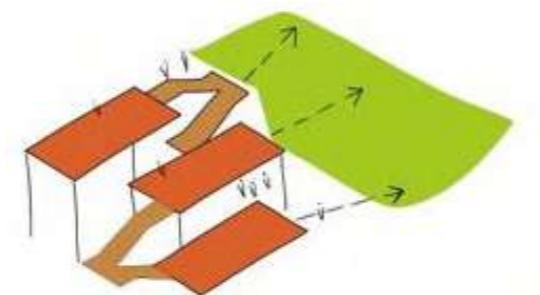
Interesting spaces in between the ramps, paths area created

**MULTI LEVEL PLATFORMS**

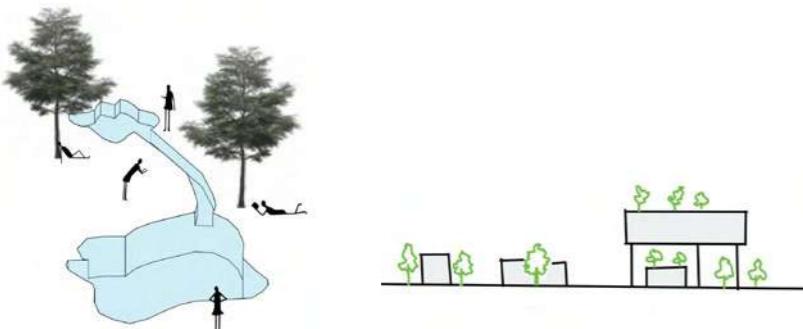
Larger platforms established across different levels of platforms to take advantage of the height while keeping spaces on the ground level free and usable.



Buildings oriented along EW, with max openings towards north

**PROGRAM LAYERING**

Interweaving the programs on different elevations to work with each other- platform providing shading from sun and rain to lower levels

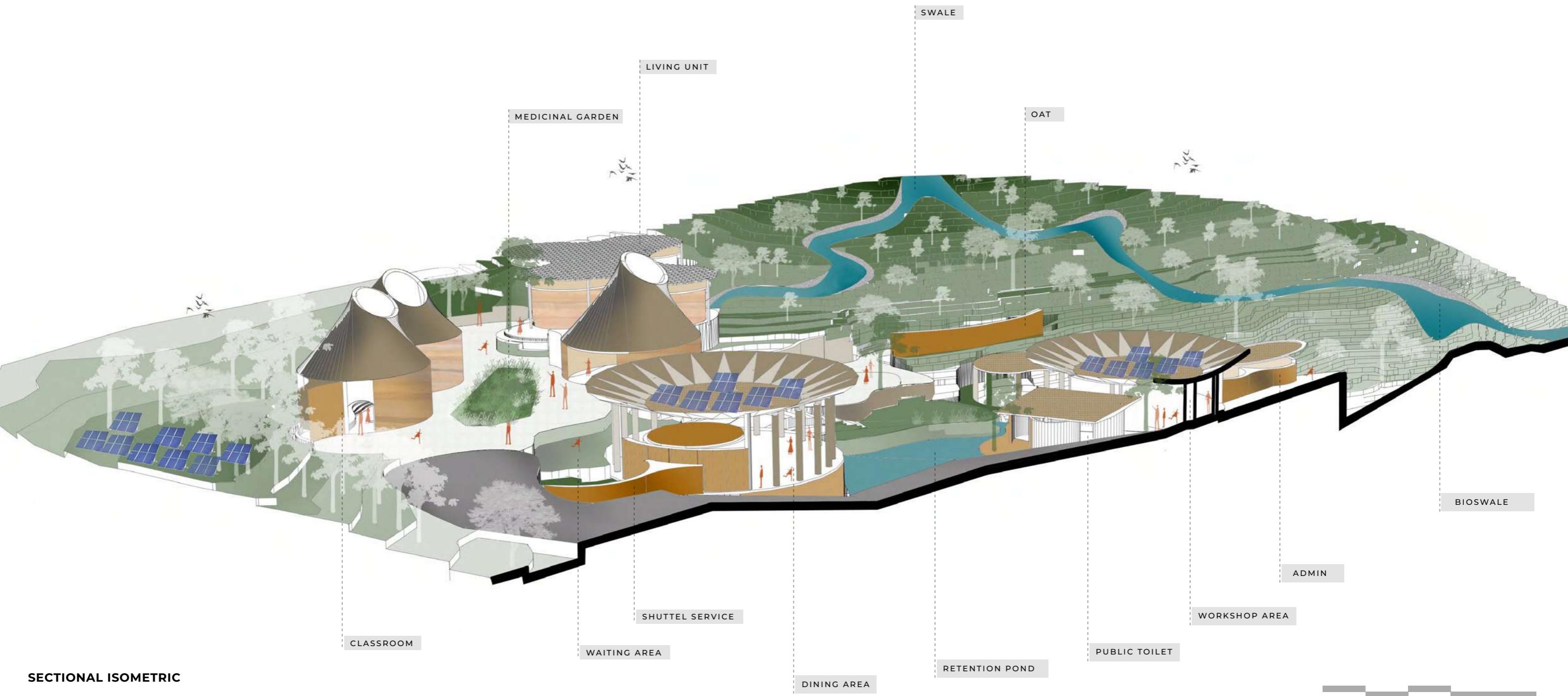


Swales and bio retention ponds help in cleaning the water and act as landscape features

**INCLUSIVITY**

In order to bring various diverse age groups, interests and communities together, complementing, the already existing programs across the site will strengthen the network





SECTIONAL ISOMETRIC

0 5 10 15 25m



SECTION AA'



POND AT THE CENTER FROM WHERE ALL BUILDINGS HAVE A VIEW TOWARDS IT.



ENTRANCE TO THE ADMIN AREA



CLASSROOMS AROUND MEDICINAL GARDENS



DORM UNIT FOR CHILDREN

04

GATEWAY TO JOURNEYS

Bangalore, Karnataka

Urban Transit Hub

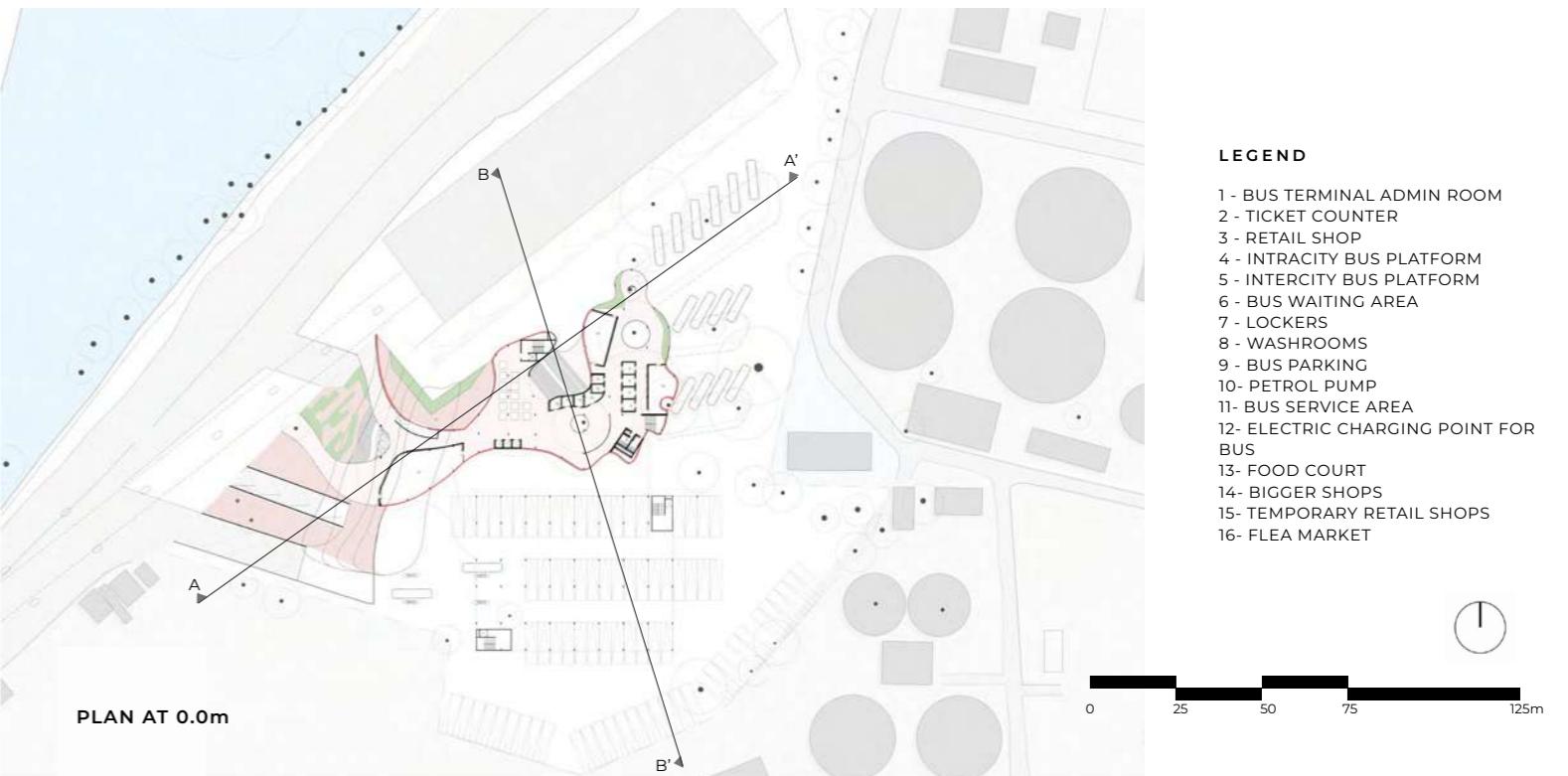
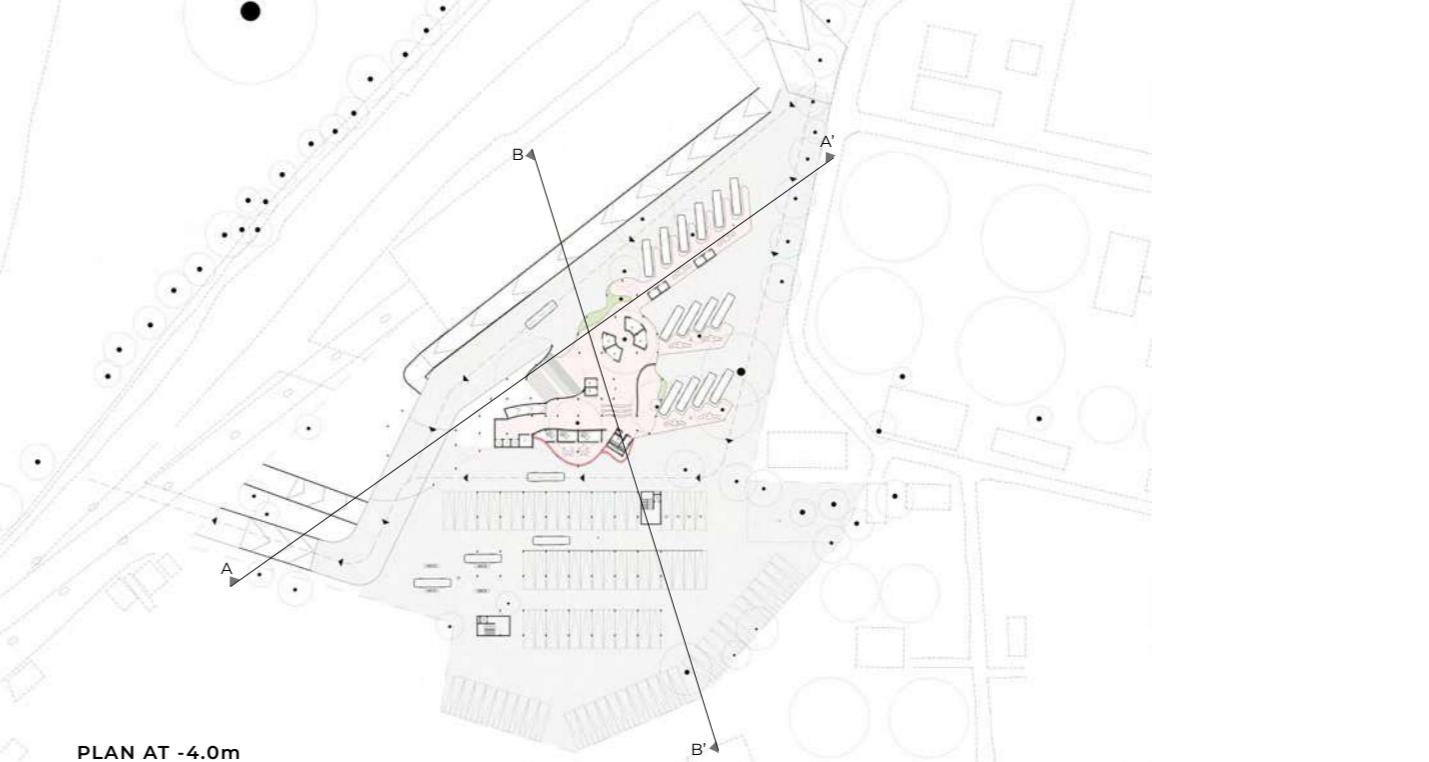
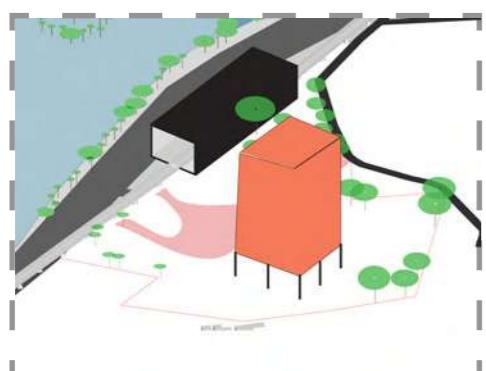
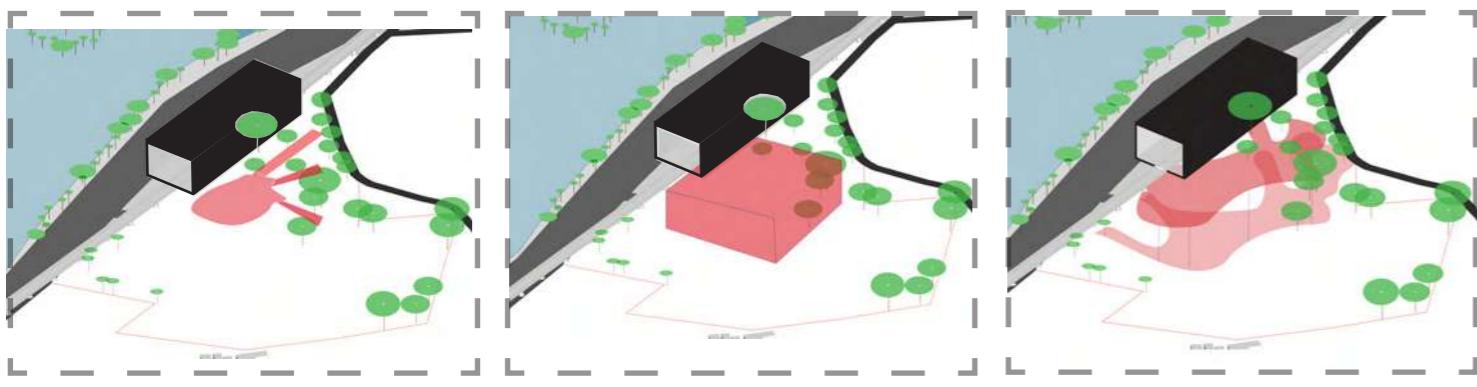
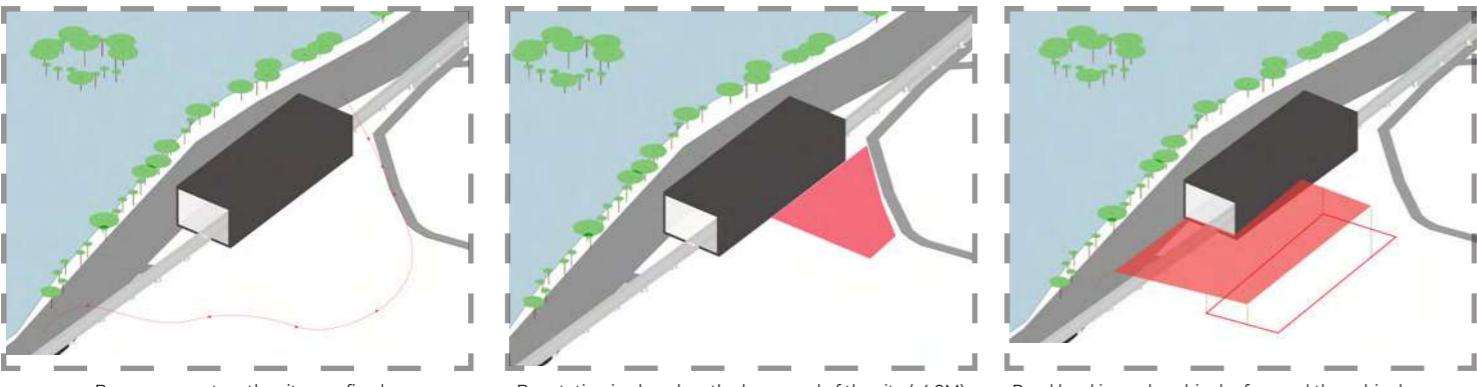
Semester 08

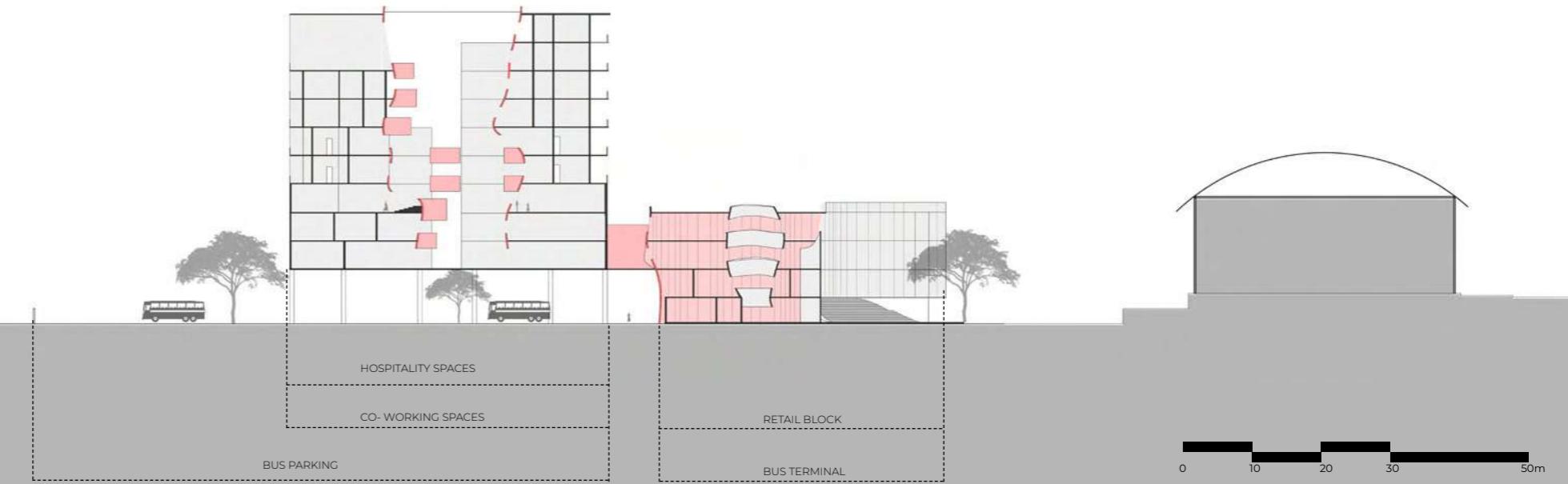
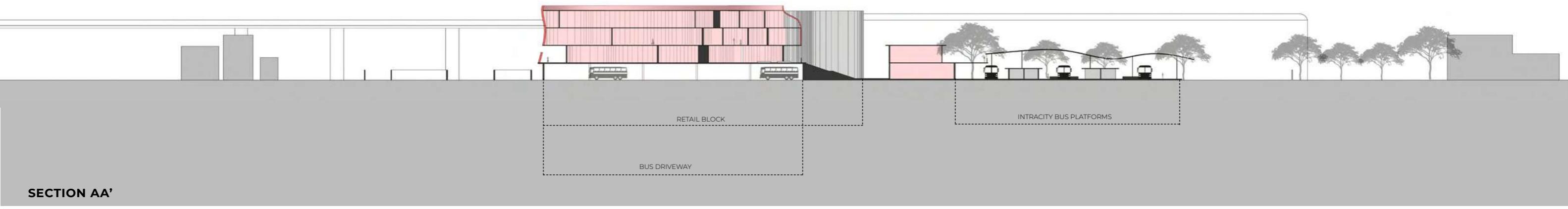
Studio Mentors : Hiranmayi S | Ajinkya K | Shalini M.O | Vaidehi R

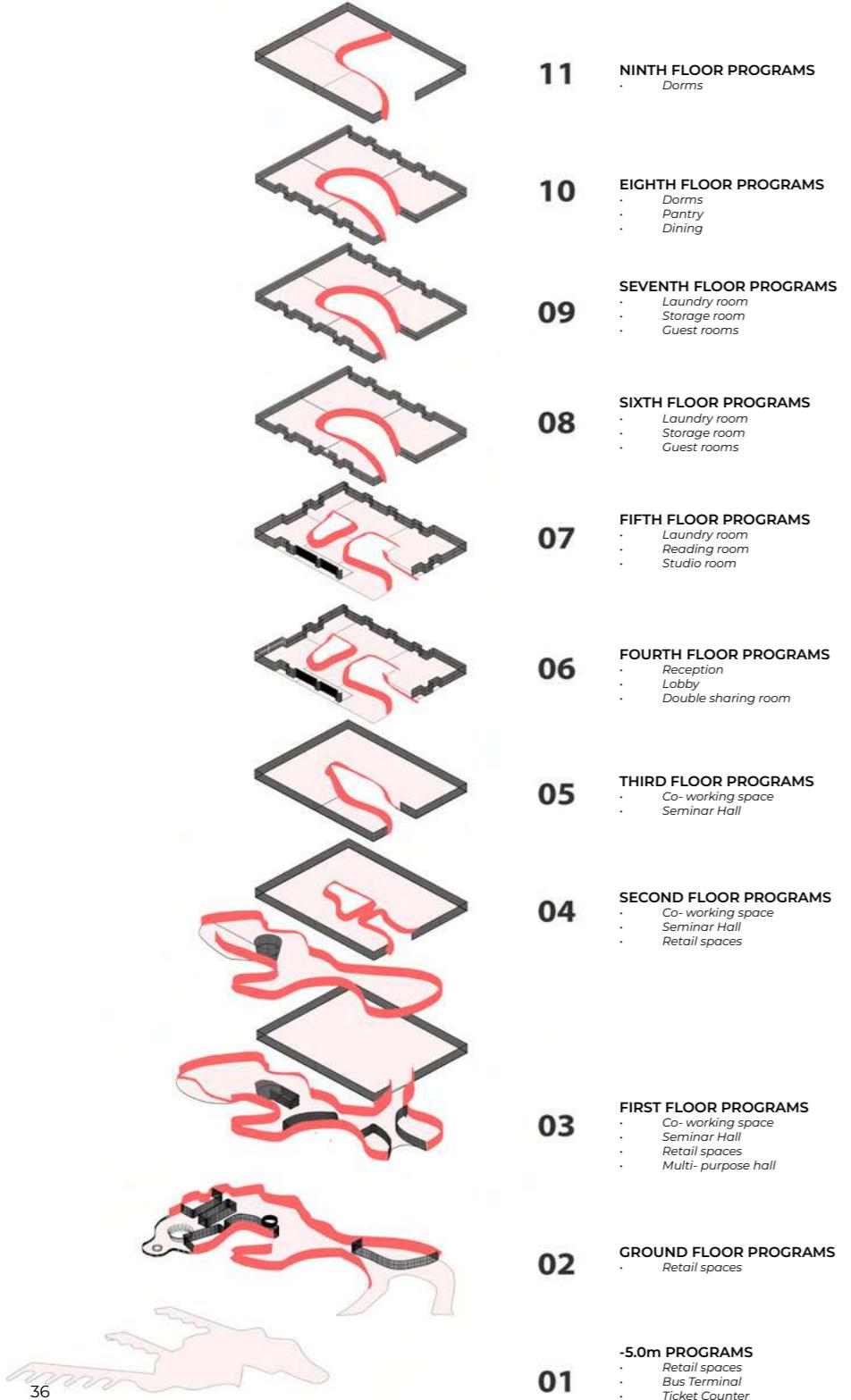


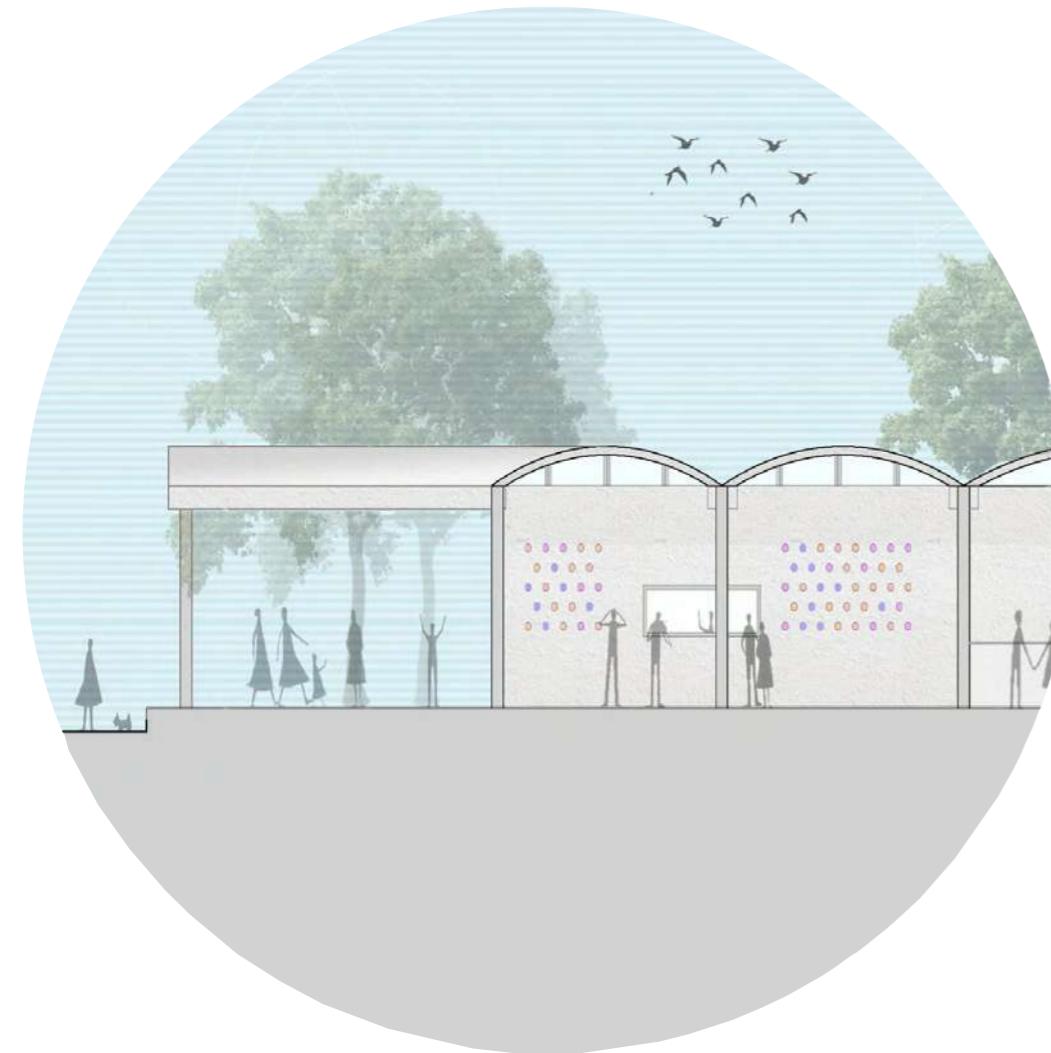
Area : 47000 sq.m

The Transit Hub at Kengeri is an innovative architectural project designed to serve as a central transportation hub in the bustling city of Kengeri. Located strategically at a prominent intersection, this transit hub aims to provide a seamless and efficient experience for commuters while revitalizing the surrounding urban environment. The Kengeri Urban Transit Hub aims to redefine transportation infrastructure by seamlessly integrating multiple modes of transit(bus and metro), prioritizing passenger comfort and safety, and enhancing the overall urban experience. It serves as a vibrant and dynamic hub that connects people, communities, and opportunities, contributing to the sustainable development of Kengeri.









R A S O I

Sirohi, Sheogarj, Rajasthan

Public Space

Semester 05

Studio Mentors : Pedaparthi Shweta | Gouthama DM

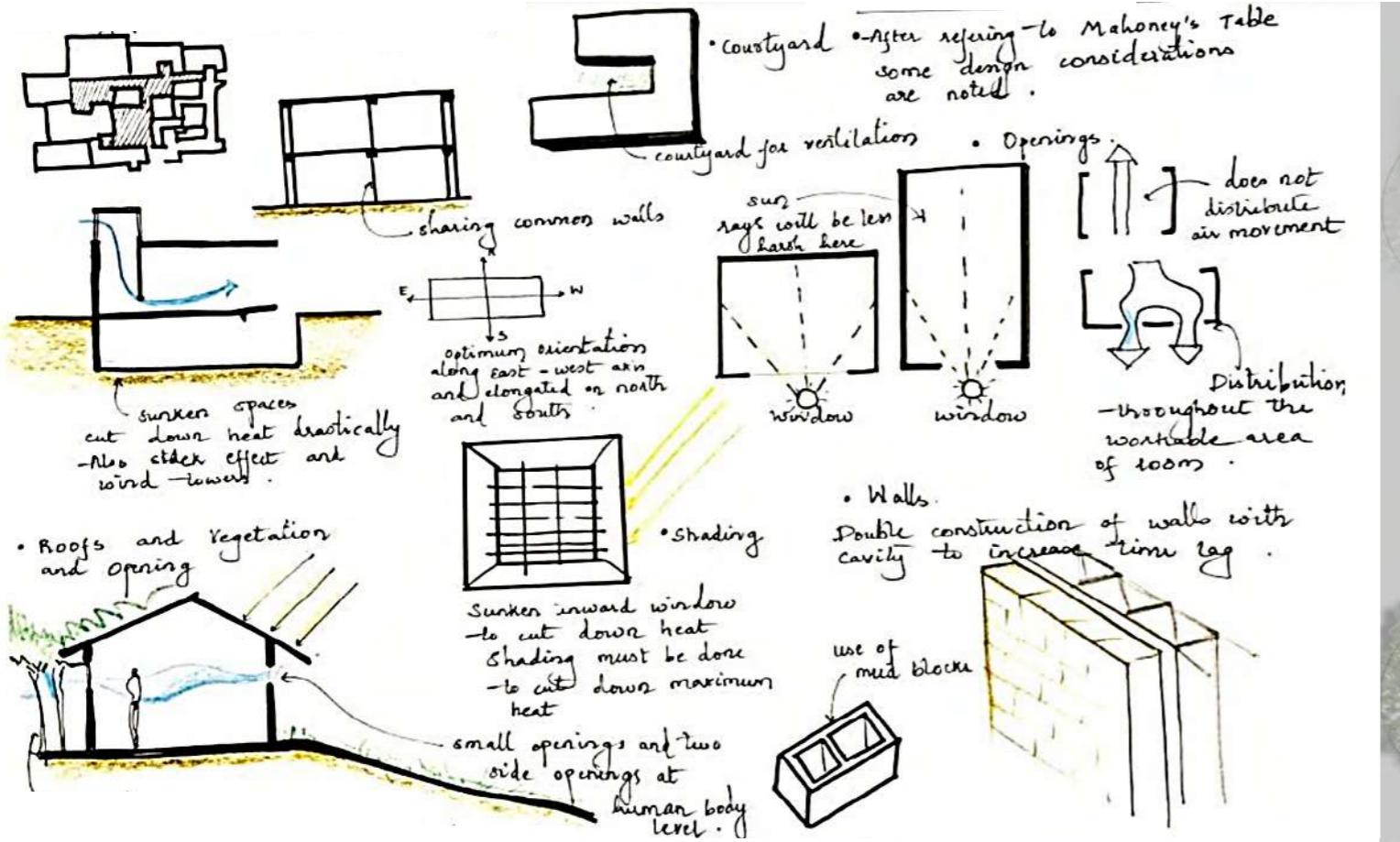
This studio attempts to look at alternate / unconventional materials to design a public space. There is no specific site given.

Area : 300 sq.m

The intend is to bring people back in the community and educate them about their strong culture, food styles. To bring back the real time connection between the users and also to facilitate workshops and learning. This set up also enhances the awareness about the environment through building language and involves the user in making the same. This setup is collectively also bringing different age groups as this space could be a buffer for various activities carried along the way.

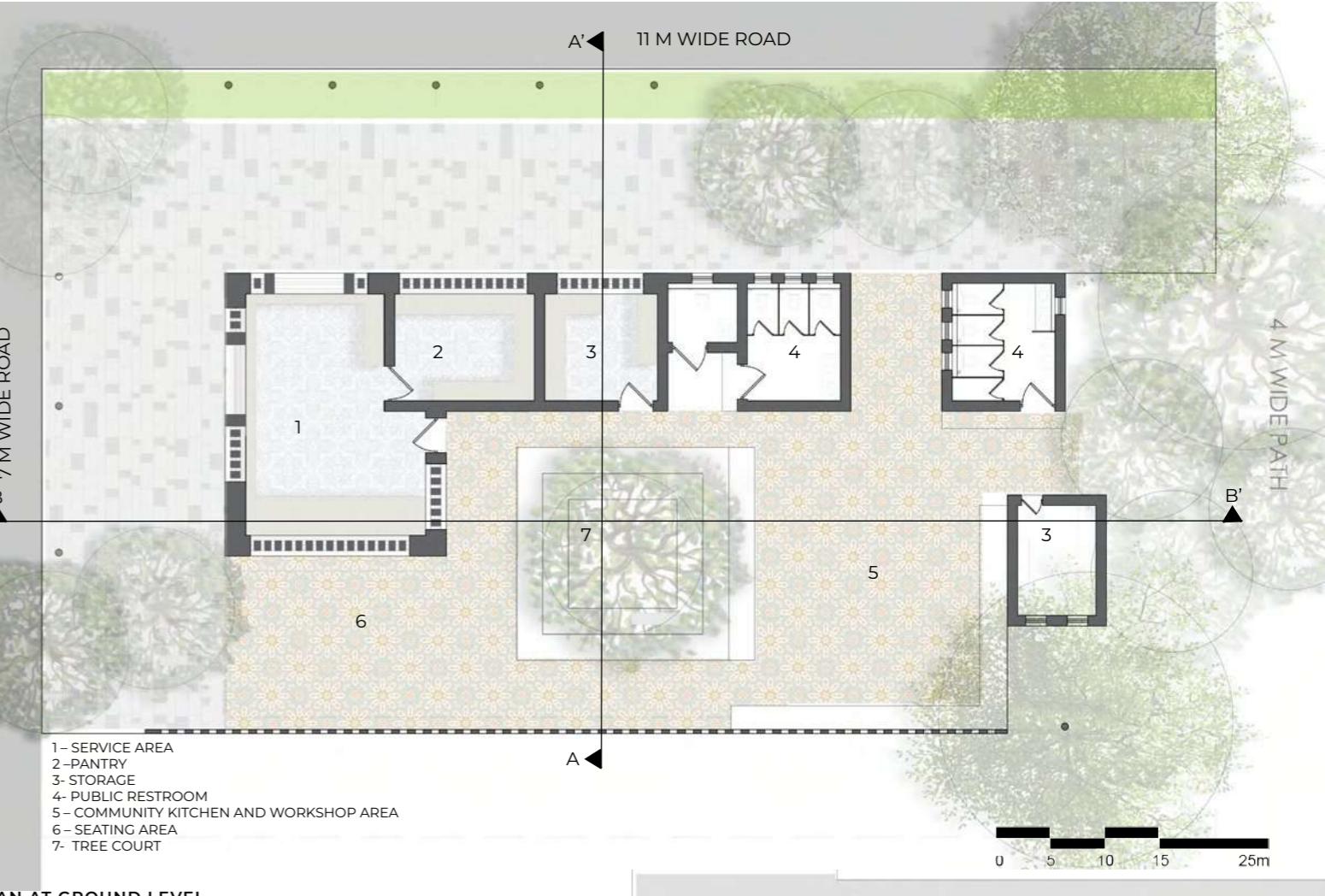
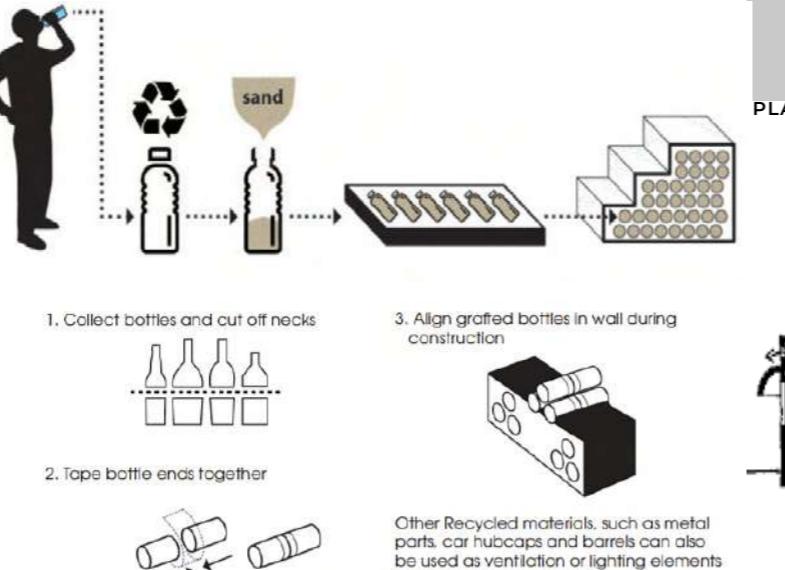
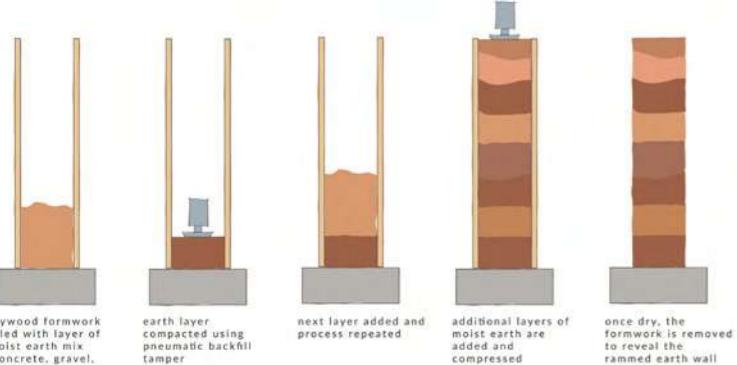
The intend is also to have a public restroom because the site links/ connects to various other activity zones.

The food made here—could serve as a learning community kitchen, a restaurant and also as service to mandir, hospital and school.



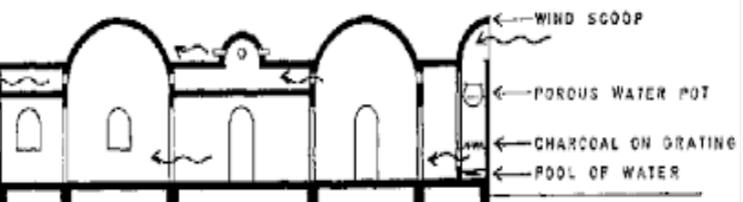
MATERIAL : Rammed Earth Bottle wall

Rammed earth is a technique for constructing foundations, floors and walls using natural raw materials such as earth, chalk, lime or gravel. It is an ancient method that has been revived recently as a sustainable building method.



ROOF

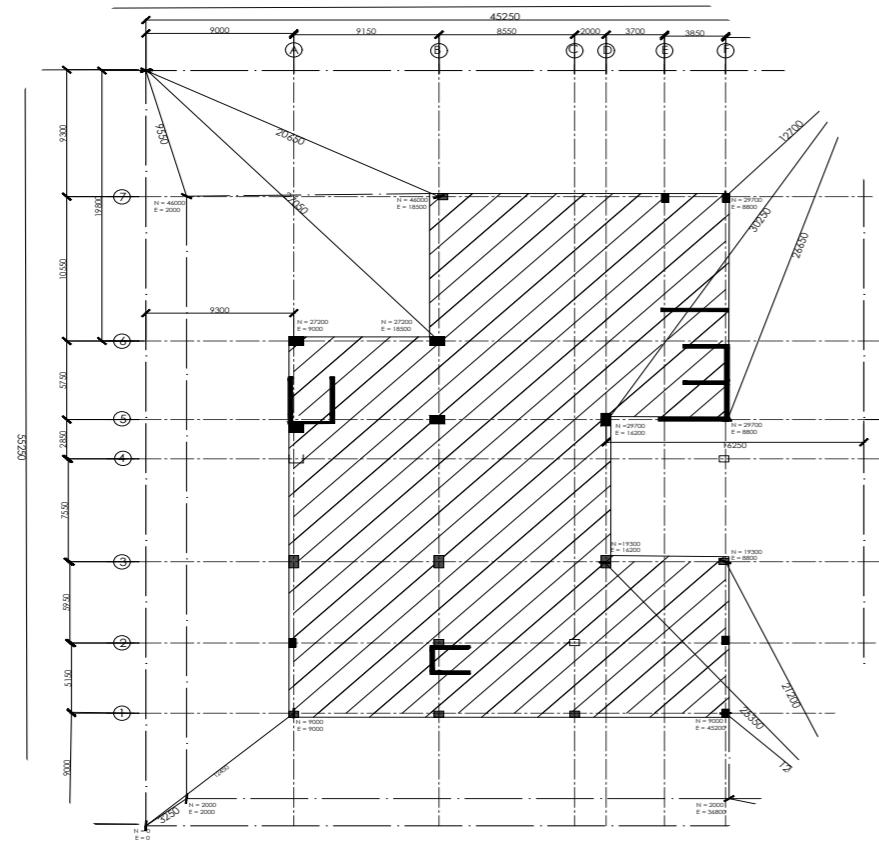
Vaulted Roof





06

WORKING DRAWING



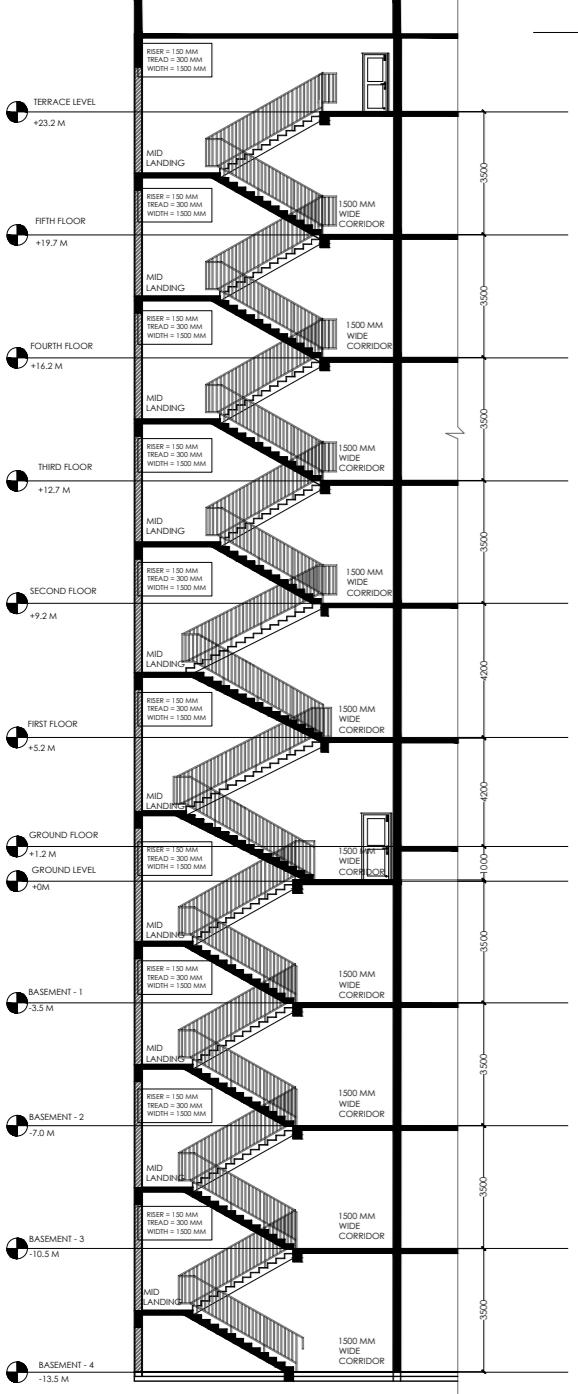
Bangalore, Karntaka

Semester 05 & 06

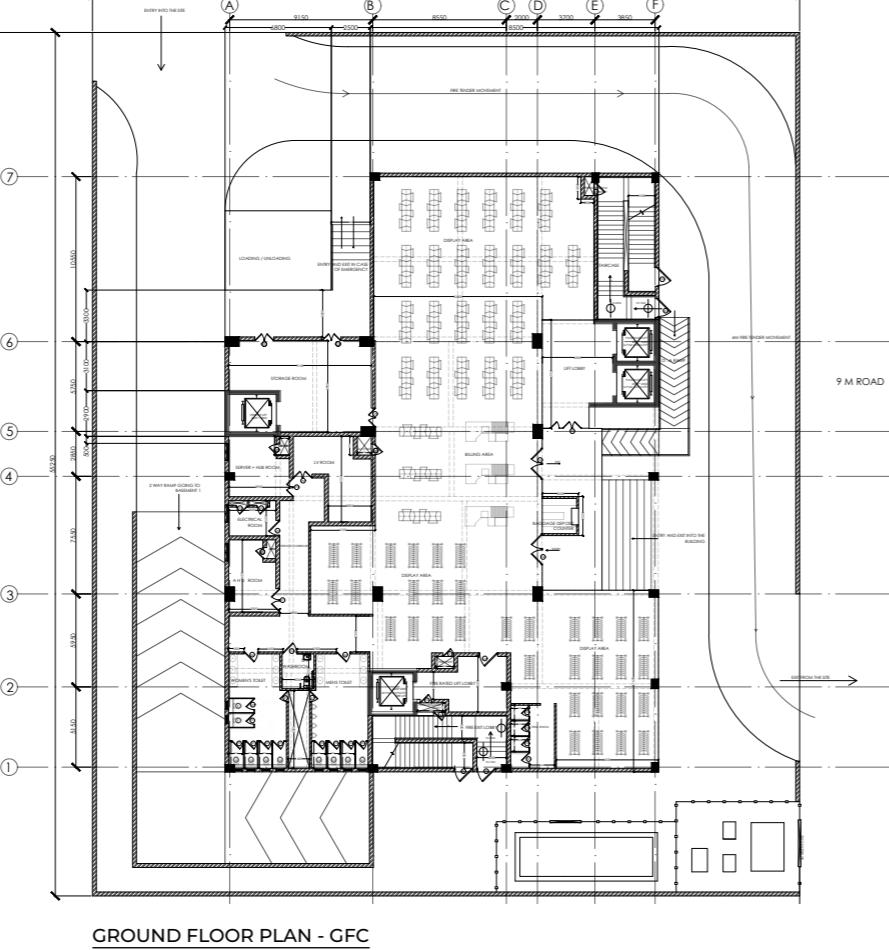
Studio Mentors : Anupriya Saxena | Ramya Krishna

The project is a commercial building where the bottom two floors are for retail and the upper floors for office. The buiding was carefully designed and calculated using NBC 2016 rules and regulations and Bangalore By-laws.

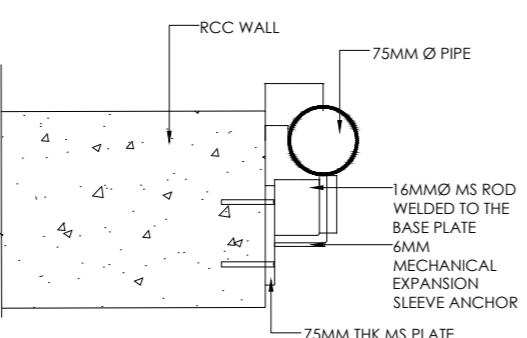
Complete set of civil drawings, architectural drawings and MEP drawings such as HVAC, lighting, plumbing and FPS drawings were produced by the end of the studio.



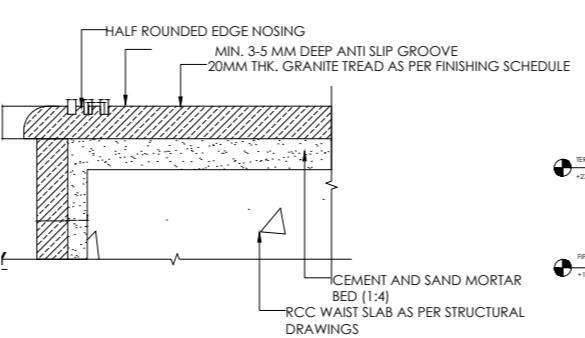
WORKING DRAWING OF A STAIRCASE PROPOSED FOR A
G + 5 MIXED USE BUILDING



GROUND FLOOR PLAN - GFC



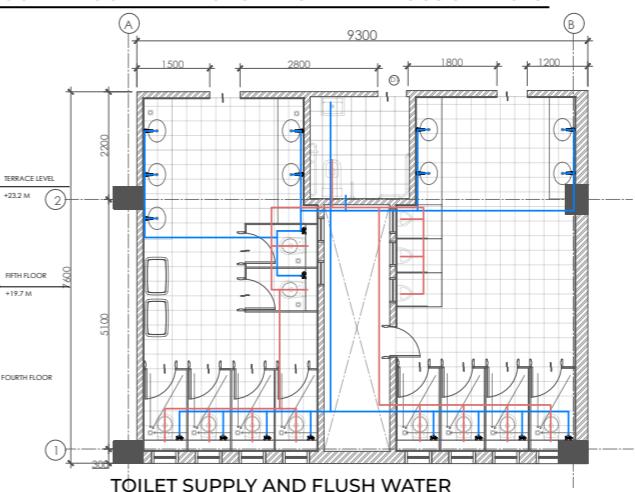
SECTION OF WALL MOUNTED HAND RAIL



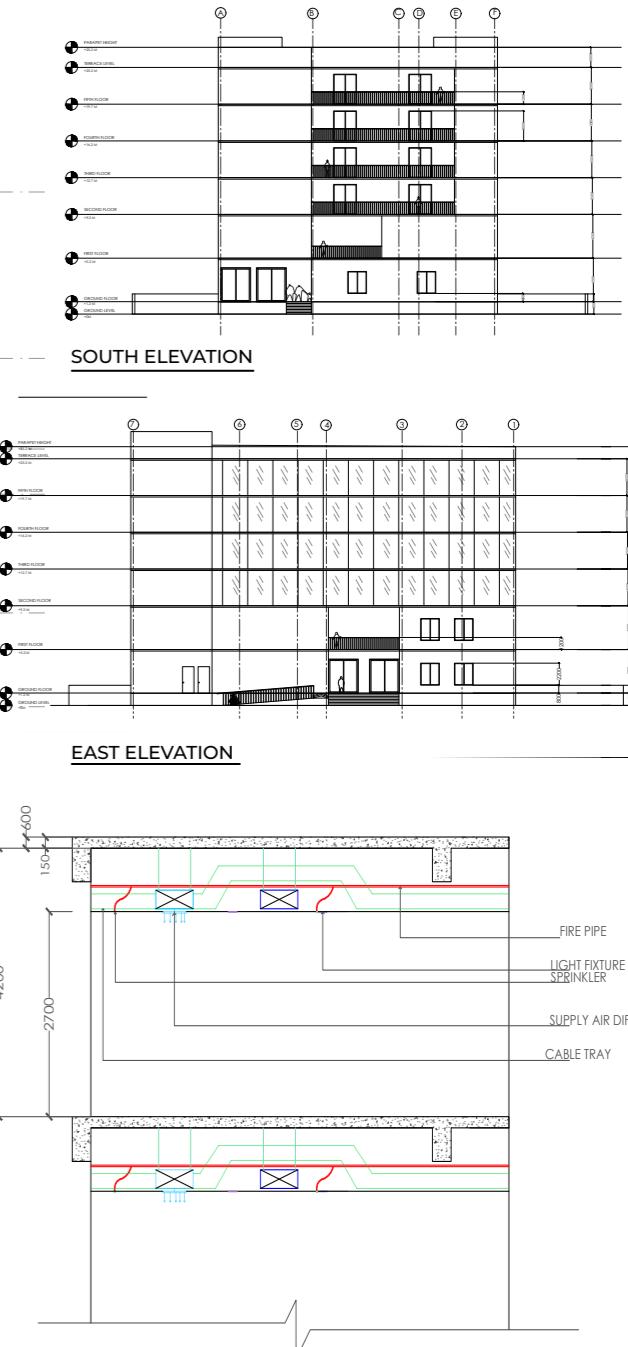
NOSING DETAIL



GROUND FLOOR PLAN - SHOWING THE VARIOUS SERVICES

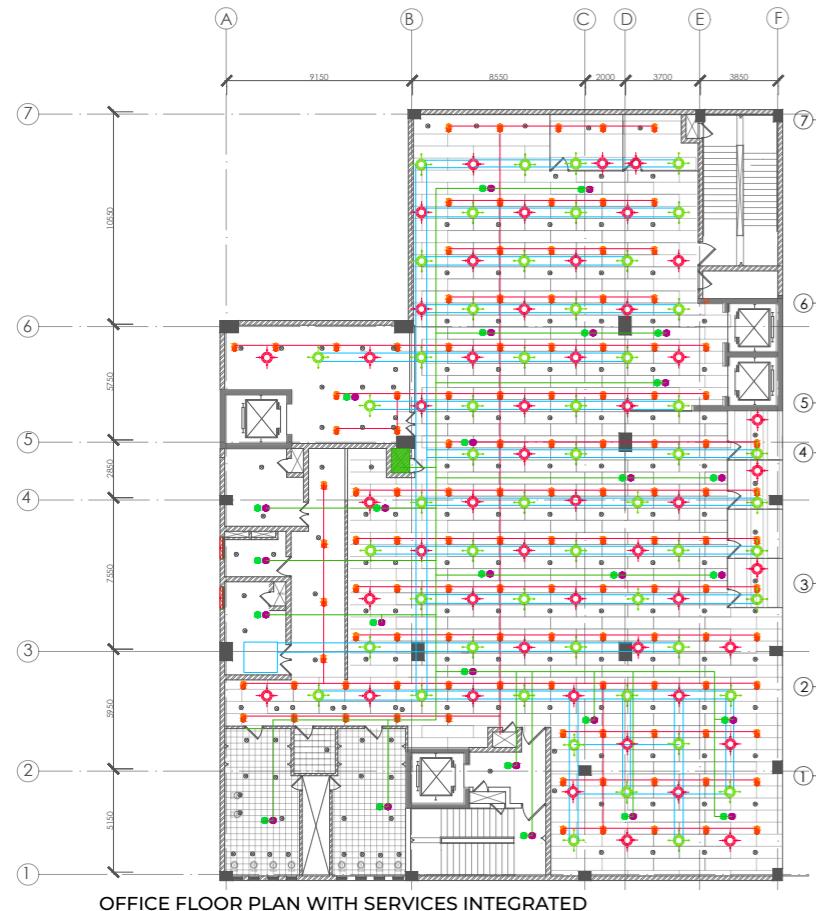


TOILET SUPPLY AND FLUSH WATER

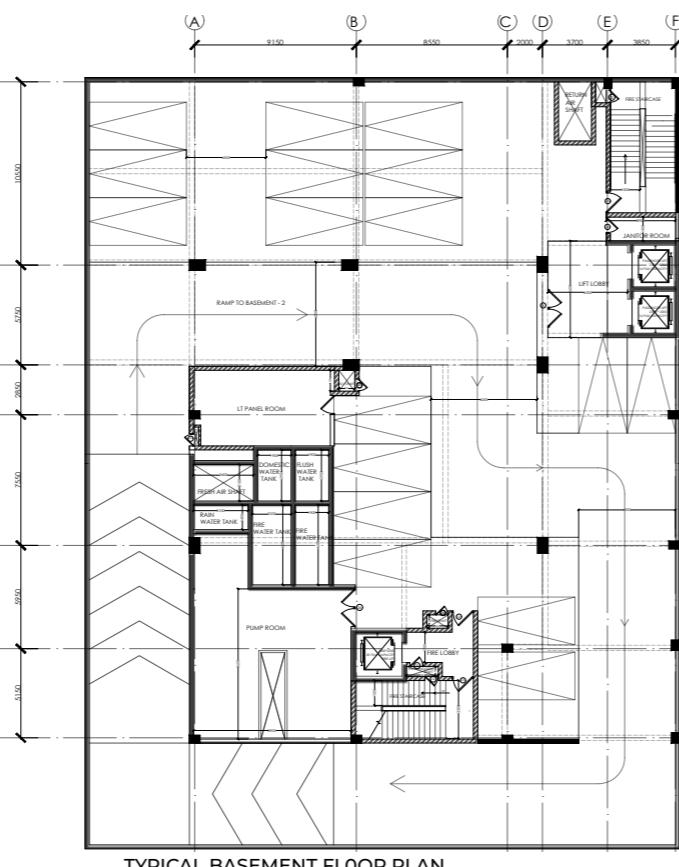


PART SECTION WITH SERVICES INTEGRATED

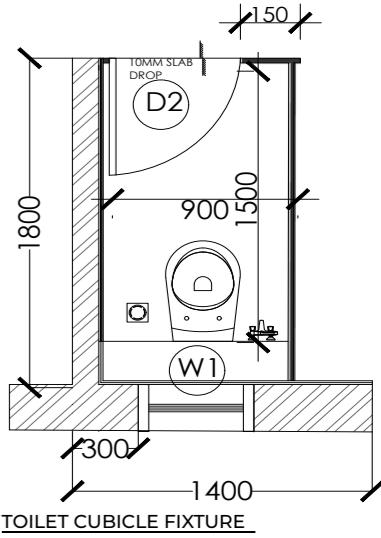
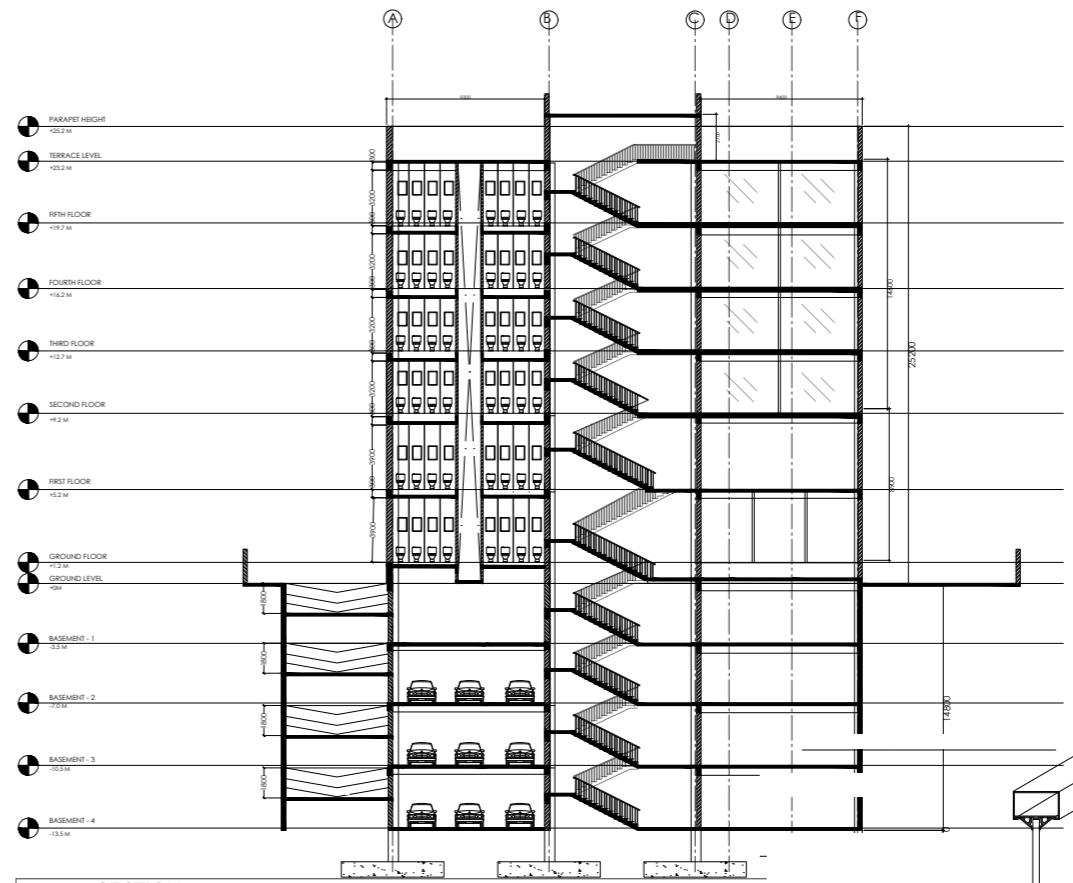
DRAWINGS NOT TO SCALE



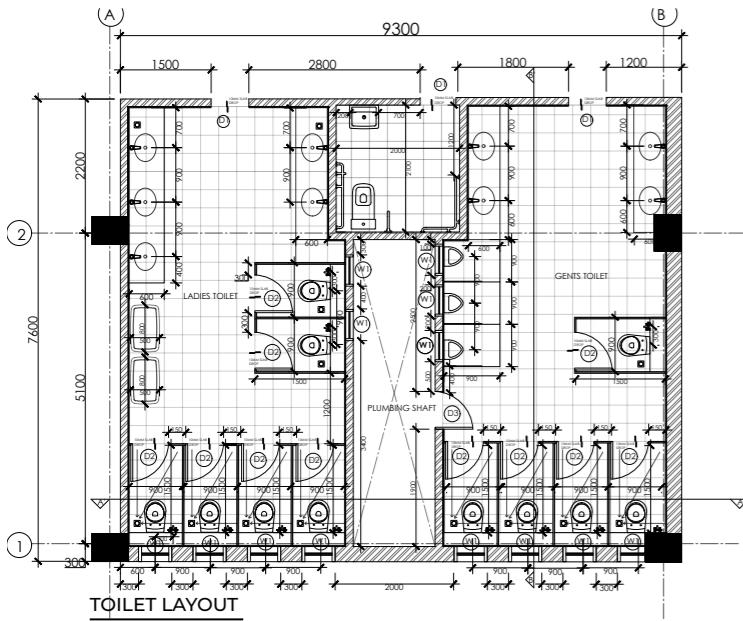
OFFICE FLOOR PLAN WITH SERVICES INTEGRATED



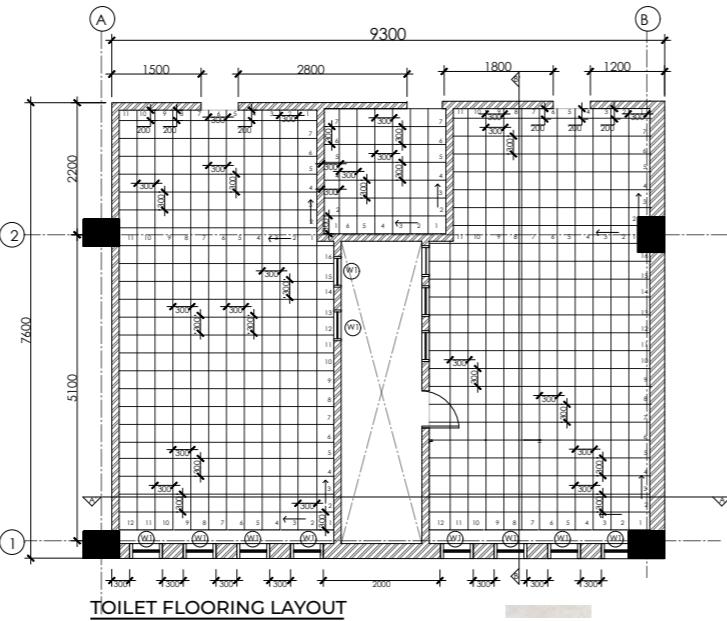
TYPICAL BASEMENT FLOOR PLAN



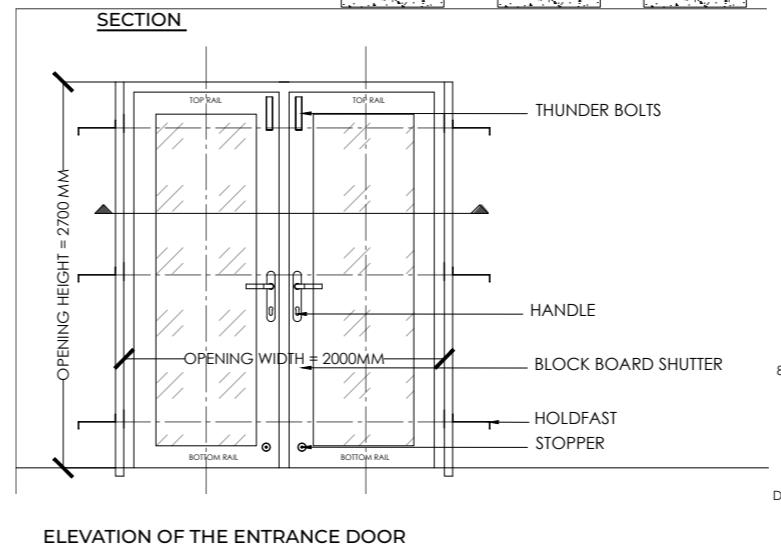
TOILET CUBICLE FIXTURE



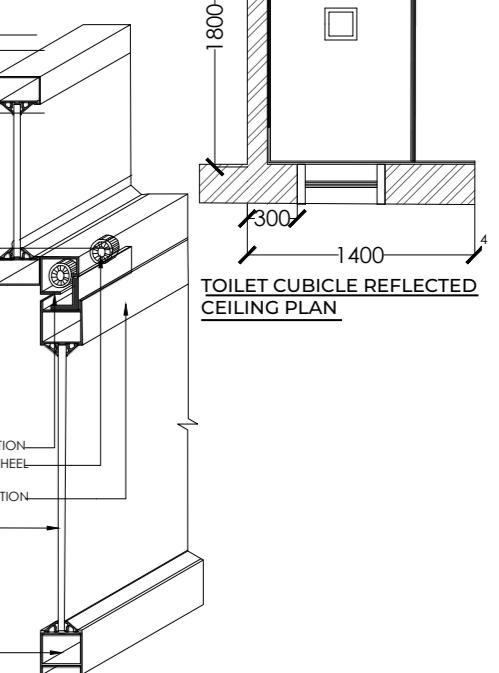
TOILET LAYOUT



TOILET FLOORING LAYOUT



ELEVATION OF THE ENTRANCE DOOR

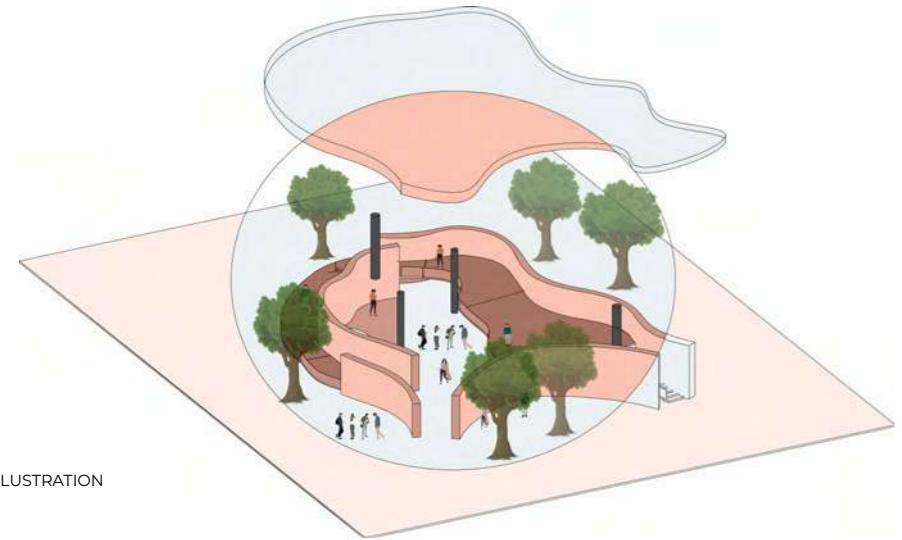


DRAWINGS NOT TO SCALE

07

M I S C E L L A N E O U S





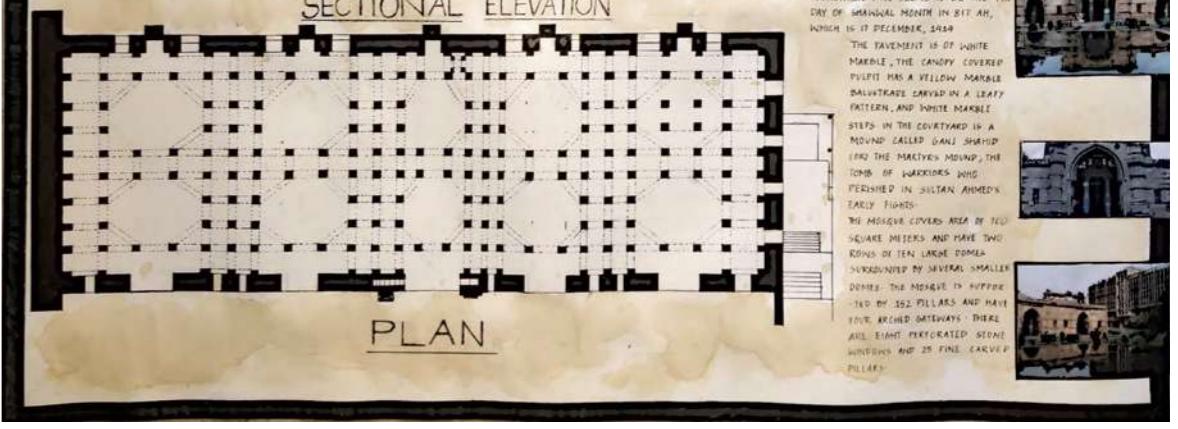
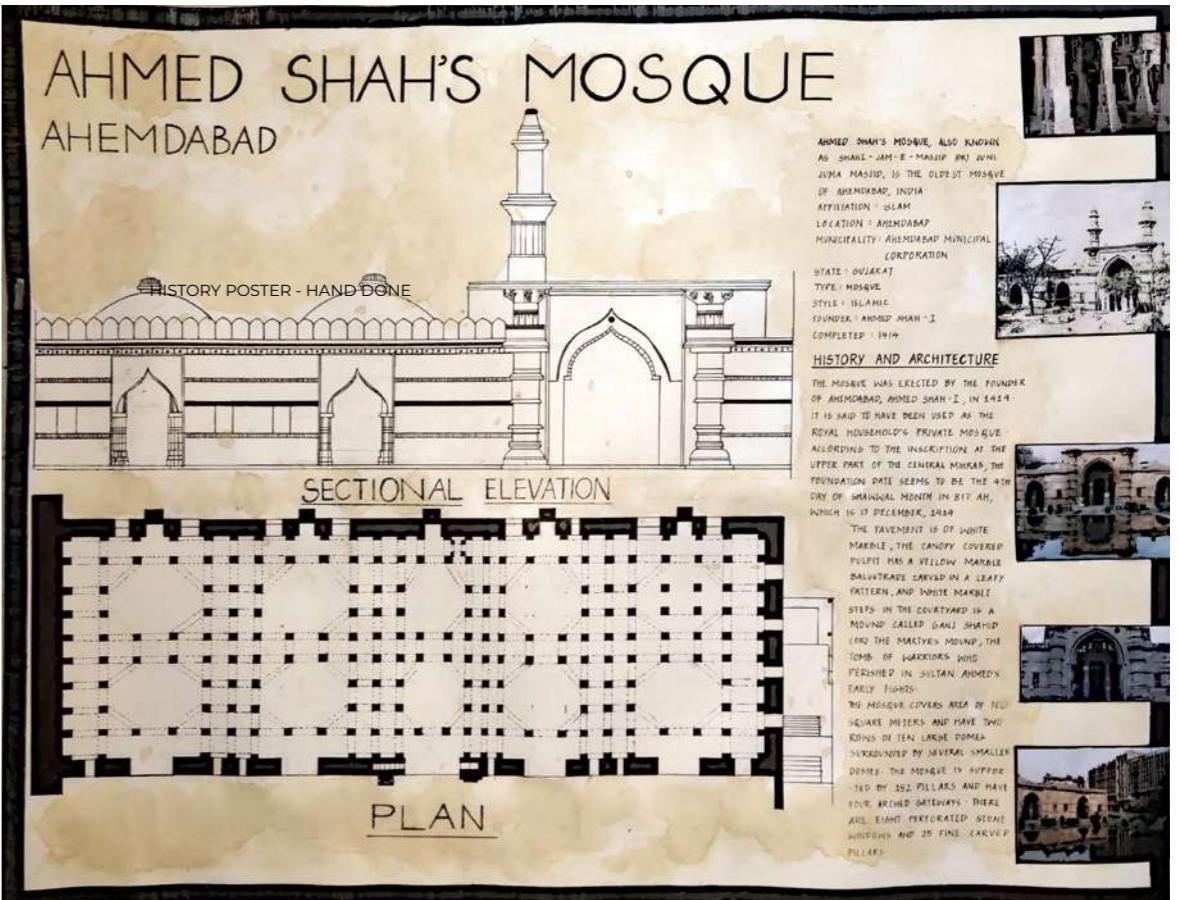
ILLUSTRATION



OBJECT MODELLING AND RENDERING ON BLENDER



ACRYLIC PAINTING



**LOCAL ROOTS**

HI-TECH CITY, HYDERABAD

The main idea of the public place is to create a space for reading, story telling and archiving. The public place tends to show the relation between the past and the present and how it holds everything together.

The whole process resulted in the creation of a space which acts like a beacon in the neighbourhood. The plan highlights the free flowing space which almost looks like as if it is emerging from the landscape. The main conceptual idea was the creation of a spine which plays with the surrounding by giving interior views at certain points whereas giving exterior views at some other places.



PHOTOSHOP POSTER DESIGN

TANA GAZAANA

The client is a couple who are chefs and love travelling and gardening. They have an interest in the cuisine of the western coast and would like to revive their cooking methods. The house to them is a place where they can experiment with the cooking and also sell it at the same time, explore various places, and also do gardening at the same time. The tiny house has been designed in such a way that it can appear anywhere and still function as a vending place as well as a dwelling for the two people.

Location- Kochi, Kerala, India
Travel route- Western Coast of India



CALCULATIONS

Table No. I (Data sheet) Estimation of water use in Institutional building

No. of uses* (In case of Water closets and urinals) - number of usage per person / per day
No. of uses* (In case of faucets) - duration of use * number of usage per person / per day

Please specify Total Building occupancy, female occupants, male occupants.

Present design case	Building occupancy (x)	40		20		Working days		200	
		Fixtures	No. of fixtures	Flow rates (lpm)	No. of uses *			Water Consumption	
1	Water Closets (solids)	4	4	0.35	56				
2	Kitchen Faucets	2	4	1.25	200				
3	Water Closets (liquid)	4	2	31.240					
4	Urinal/Waterless urinals	2	2	31.20					
5	Showers	4	6	5.513.20					
6	Urinal/Waterless urinals (With basins)	3	1.89	0.35	56				
7	Lavatory faucets(Wash basins)	4	1.89	3.75	293.5				
8	Water Closets (liquid)	4	2	4	283.5				
9	Water Closets (solids)	4	4	31.60					
	Daily water consumption (l)			2806.64					
	Annual water consumption (l)			561328					

Base case	Building occupancy	40		20		Working days		365	
		Fixtures	No. of fixtures	Flow rates (lpm)	No. of uses *	Water Consumption			
1	Water Closets (solids)	8.6	1	240					
2	Kitchen Faucets	2.8	3	960					
3	Water Closets (liquid)	8.3	5	600					
4	Urinal/Waterless urinals	2.38	0	0					
5	Showers	4.10	12	1200					
6	Lavatory faucets(Wash basins)	7.8	3	960					
	Daily water consumption (l)			39560					
	Annual water consumption (l)			1445400					

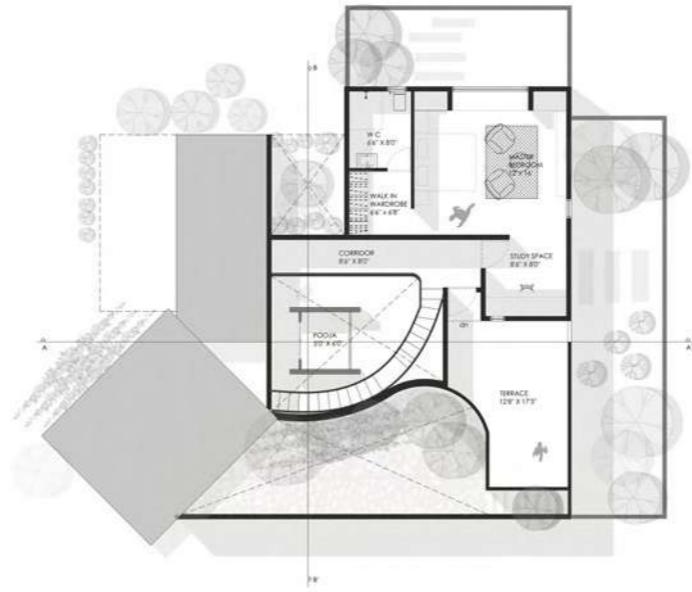
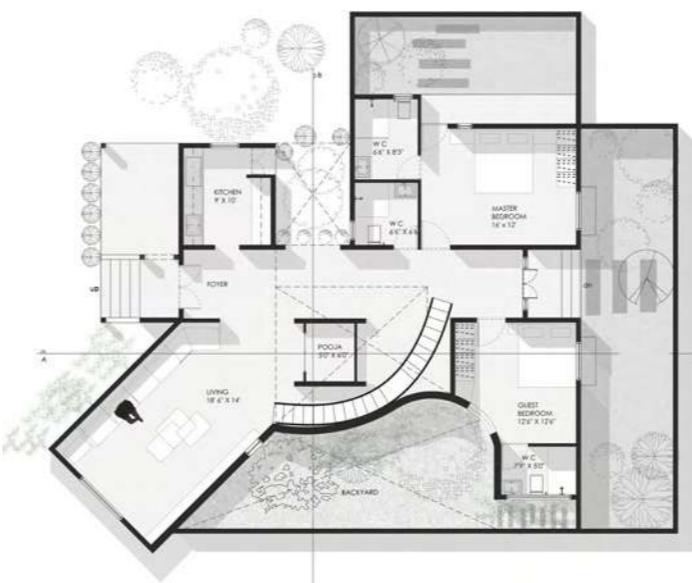
Water use reduction (%) = $\frac{[\text{Annual water demand (Base case)} - \text{Annual water demand (design case)}]}{\text{Annual water demand (Base case)}}$ / 100

Water use reduction: 29.1%



APP FRAMEWORK FOR SOLAR DECAHTLON COMPETITION

INTERNSHIP WORK



PLANS RENDERS FOR INSTAGRAM



MODEL VIEWS

DISHITA GOEL

dishitagoel1402@gmail.com
Phone No. : +91 8169871857

LIGHTING CALCULATIONS:

FOR DISPLAY AREA:

ACCORDING TO NBC , LUX LEVEL REQUIRED FOR RETAIL / MERCANTILE SPACE IS : 300 - 500 - 700 LUX
FOR OUR PROJECT , I AM CONSIDERING 300 LUX

FALSE CEILING HEIGHT = 2700 MM
WORK PLANE HEIGHT = 2700 MM
WORK PLANE AREA = 450 M²
MAINTENANCE FACTOR = 0.8
UTILIZATION FACTOR = 0.6
TOTAL LUMEN REQUIRED = TOTAL AREA TO BE ILLUMINATED*LUX LEVEL REQUIRED
 $=450*300$
 $=135000$ LUMENS

TOTAL LUMEN REQUIRED AT THE LUMINAIRE = TOTAL LUMEN REQUIRED /(MAINTENANCE FACTOR * UTILIZATION FACTOR)
 $=135000/(0.8*0.6)$
 $=281250$ LUX

CONSIDERING SPACE - HEIGHT RATIO TO BE : 0.8-1.2

MINIMUM LAMP SPACING = 0.8*2.7
 $=2.16M$

MAXIMUM LAMP SPACING = 1.2*2.7
 $=3.24 M$

TOTAL NO. OF LAMPS = 57

WATTAGE OF EACH LUMINAIRE = TOTAL LUMEN REQUIRED AT THE LUMINAIRE / TOTAL NUMBER OF LUMINAIRE
 $=\frac{281250}{57}$
 $=4934$ LUMENS
 $=49$ WATTS LED

FOR LIFT LOBBY:

ACCORDING TO NBC , LUX LEVEL REQUIRED FOR LOBBY SPACE IS : 200 - 300 LUX
FOR OUR PROJECT , I AM CONSIDERING 200 LUX

FALSE CEILING HEIGHT = 2700 MM
WORK PLANE HEIGHT = 2700 MM
WORK PLANE AREA = 31 M²
MAINTENANCE FACTOR = 0.8
UTILIZATION FACTOR = 0.6

TOTAL LUMEN REQUIRED = TOTAL AREA TO BE ILLUMINATED*LUX LEVEL REQUIRED
 $=31*200$
 $=6200$

TOTAL LUMEN REQUIRED AT THE LUMINAIRE = TOTAL LUMEN REQUIRED /(MAINTENANCE FACTOR * UTILIZATION FACTOR)
 $=6200/(0.8*0.6)$
 $=12916$ LUX

CONSIDERING SPACE - HEIGHT RATIO TO BE : 0.8-1.2

MINIMUM LAMP SPACING = 0.8*2.7
 $=2.16M$

MAXIMUM LAMP SPACING = 1.2*2.7
 $=3.24 M$

TOTAL NO. OF LAMPS = 5

WATTAGE OF EACH LUMINAIRE = TOTAL LUMEN REQUIRED AT THE LUMINAIRE / TOTAL NUMBER OF LUMINAIRE
 $=\frac{12916}{5}$
 $=2583$ LUMENS
 $=25$ WATTS LED

FOR OFFICE FLOOR :

ACCORDING TO NBC , LUX LEVEL REQUIRED FOR OPEN OFFICE SPACE IS : 300 - 500 LUX
FOR OUR PROJECT , I AM CONSIDERING 300 LUX

FALSE CEILING HEIGHT = 2700 MM
WORK PLANE HEIGHT = 2000 MM
WORK PLANE AREA = 650 M²
MAINTENANCE FACTOR = 0.8
UTILIZATION FACTOR = 0.6
TOTAL LUMEN REQUIRED = TOTAL AREA TO BE ILLUMINATED*LUX LEVEL REQUIRED
 $=650*300$
 $=195000$

TOTAL LUMEN REQUIRED AT THE LUMINAIRE = TOTAL LUMEN REQUIRED /(MAINTENANCE FACTOR * UTILIZATION FACTOR)
 $=195000/(0.8*0.6)$
 $=406250$ LUX

CONSIDERING SPACE - HEIGHT RATIO TO BE : 0.8-1.2

MINIMUM LAMP SPACING = 0.8*2.0
 $=1.6M$

MAXIMUM LAMP SPACING = 1.2*2.0
 $=2.40 M$

TOTAL NO. OF LAMPS = 150

WATTAGE OF EACH LUMINAIRE = TOTAL LUMEN REQUIRED AT THE LUMINAIRE / TOTAL NUMBER OF LUMINAIRE
 $=\frac{406250}{150}$
 $=2708$ LUMENS
 $=27$ WATTS LED

ACCORDING TO NBC , LUX LEVEL REQUIRED FOR
MEETING ROOM = 200 - 300 LUX
CONFERENCE ROOM = 300 - 500 LUX
RECEPTION = 300 - 500 LUX
LOBBY = 200 - 300 LUX

FOR OUR PROJECT WE ARE CONSIDERING THE LUX LEVEL IN ALL THE ABOVE SPACES TO BE 300 LUX

FOR STAIRCASE :

ACCORDING TO NBC , LUX LEVEL REQUIRED FOR STAIRCASE IS : 50 - 150 LUX
FOR OUR PROJECT , I AM CONSIDERING 50 LUX

FALSE CEILING HEIGHT = 2700 MM
WORK PLANE HEIGHT = 2700 MM
WORK PLANE AREA = 33 M²
MAINTENANCE FACTOR = 0.8
UTILIZATION FACTOR = 0.6
TOTAL LUMEN REQUIRED = TOTAL AREA TO BE ILLUMINATED*LUX LEVEL REQUIRED
 $=33*50$
 $=1650$ LUMENS

TOTAL LUMEN REQUIRED AT THE LUMINAIRE = TOTAL LUMEN REQUIRED /(MAINTENANCE FACTOR * UTILIZATION FACTOR)
 $=1650/(0.8*0.6)$
 $=3437$ LUX

CONSIDERING SPACE - HEIGHT RATIO TO BE : 0.8-1.2

MINIMUM LAMP SPACING = 0.8*2.7
 $=2.16M$

MAXIMUM LAMP SPACING = 1.2*2.7
 $=3.24 M$

TOTAL NO. OF LAMPS = 2 (1 AT EACH LANDING)

WATTAGE OF EACH LUMINAIRE = TOTAL LUMEN REQUIRED AT THE LUMINAIRE / TOTAL NUMBER OF LUMINAIRE
 $=\frac{3437}{2}$
 $=1718$ LUMENS
 $=17$ WATTS LED

FOR TOILET:

ACCORDING TO NBC , LUX LEVEL REQUIRED FOR TOILET IS : 100 - 300 LUX
FOR OUR PROJECT , I AM CONSIDERING 100 LUX

FALSE CEILING HEIGHT = 2700 MM
WORK PLANE HEIGHT = 2700 MM
WORK PLANE AREA = 54 M²
MAINTENANCE FACTOR = 0.8
UTILIZATION FACTOR = 0.6
TOTAL LUMEN REQUIRED = TOTAL AREA TO BE ILLUMINATED*LUX LEVEL REQUIRED
 $=54*100$
 $=5400$

TOTAL LUMEN REQUIRED AT THE LUMINAIRE = TOTAL LUMEN REQUIRED /(MAINTENANCE FACTOR * UTILIZATION FACTOR)
 $=5400/(0.8*0.6)$
 $=11250$ LUX

CONSIDERING SPACE - HEIGHT RATIO TO BE : 0.8-1.2

MINIMUM LAMP SPACING = 0.8*2.7
 $=2.16M$

MAXIMUM LAMP SPACING = 1.2*2.7
 $=3.24 M$

TOTAL NO. OF LAMPS = 16

WATTAGE OF EACH LUMINAIRE = TOTAL LUMEN REQUIRED AT THE LUMINAIRE / TOTAL NUMBER OF LUMINAIRE
 $=\frac{11250}{16}$
 $=703$ LUMENS
 $=7$ WATTS LED

FOR STORAGE AREA :

ACCORDING TO NBC , LUX LEVEL REQUIRED FOR STORAGE AREA IS : 50 - 200 LUX
FOR OUR PROJECT , I AM CONSIDERING 50 LUX

FALSE CEILING HEIGHT = 2700 MM
WORK PLANE HEIGHT = 2000 MM
WORK PLANE AREA = 45 M²
MAINTENANCE FACTOR = 0.8
UTILIZATION FACTOR = 0.6
TOTAL LUMEN REQUIRED = TOTAL AREA TO BE ILLUMINATED*LUX LEVEL REQUIRED
 $=45*50$
 $=2250$

TOTAL LUMEN REQUIRED AT THE LUMINAIRE = TOTAL LUMEN REQUIRED /(MAINTENANCE FACTOR * UTILIZATION FACTOR)
 $=2250/(0.8*0.6)$
 $=4687$ LUX

CONSIDERING SPACE - HEIGHT RATIO TO BE : 0.8-1.2

MINIMUM LAMP SPACING = 0.8*2.0
 $=1.6M$

MAXIMUM LAMP SPACING = 1.2*2.0
 $=2.40 M$

TOTAL NO. OF LAMPS = 5

WATTAGE OF EACH LUMINAIRE = TOTAL LUMEN REQUIRED AT THE LUMINAIRE / TOTAL NUMBER OF LUMINAIRE
 $=\frac{4687}{5}$
 $=937$ LUMENS
 $=9$ WATTS LED

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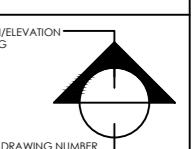
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ANUPRIYA SAXENA
RAMYA

PROJECT :

ARCHITECTURAL CONCEPT :

DRAWING TITLE :

SCALE :



SHEET SIZE :

A2

STUDENT NAME :

DISHITA GOEL

SECTION :

A

SEMESTER :

VI

USN :

1RW19AT035 SUBJECT NAME :

WORKING DRAWING - 2

DATE : 19 - 04 - 2022

R V COLLEGE OF ARCHITECTURE

CALCULATIONS:

SITE AREA:	2500
GROUND FLOOR AREA:	880
TOTAL BUILT-UP :	6250.2
NO. OF FLOORS :	6
FLOOR TO HEIGHT (RETAIL):	4.2
FLOOR TO HEIGHT (OFFICE):	4.2
BUILDING HEIGHT:	26.4
SETBACK :	9
TOTAL FLOOR AREA :	5641
FAR :	2.25

FLOORS:	
MERCANTILE:	2
BUSINESS(OFFICE):	4

OCCUPANCY:	
GROUND :	293
MERCANTILE :	146
BUSINESS :	384
TOTAL :	823

SITE DETAILS:

WIDTH OF THE ROAD (NORTH) = 24 M
SITE AREA = 2500 SQ.M
MAX. HEIGHT OF THE BUILDING =
1.5*(W+F) = 60 M

WATER REQUIREMENT:

OFFICE - CAPACITY OF UGT = 16560 L
MERCANTILE - CAPACITY OF OHT = 2310 L
STAFF - 720 L
FIRE - 1,00,000 FOR OFFICE
10,000 FOR MERCANTILLE

FIRE TENDER REQUIREMENT:

6M CLEARANCE ON ONE - THIRD OF THE SITE
FOR FIRE TENDER MOVEMENT

PARKING REQUIREMENTS:

REQUIREMENT = 124 PARKING SPACES
33% MERCANTILE = $\frac{33}{100} * 6250 = 41$ SLOTS
66% BUSINESS = $\frac{66}{100} * 6250 = 83$ SLOTS

TOILETS:	PUBLIC:	
OFFICE	MEN	WOMEN
WATER CLOSET	5	6
URINALS	4	0
SINKS	4	4
MERCANTILE	PUBLIC:	STAFF:
WATER CLOSET	3	3
URINALS	3	0
SINKS	3	3

WATER REQUIREMENTS	OFFICE	MERCANTILE VISITORS	STAFF
DOMESTIC	16560	2310	720
UGT		OHT	
WATER REQUIREMENTS	1,00,000	10,000	

LIFT CALCULATIONS:

GROSS AREA PER FLOORS = 967 SQ.M
NO. OF LANDINGS INCLUDING GROUND FLOOR = 6
PROBABLE POPULATION IN UPPER FLOOR = 823 (TOTAL OCCUPANCY)

GIVEN ,

16 PASSENGER LIFT = 90 - 120 SECONDS
20 PASSENGER LIFT = 90 - 120 SECONDS

Q = 80% OF NO. OF PASSENGER IN THE LIFT AT ONE POINT
LIFT CAPACITY = 16
LIFT CAPACITY = 20

Q = 80% * 16
= 12.8

Q = 80% * 20
= 16

ITERATION - 1 :

1A . ASSUMING NO . OF LIFTS = 3

1B . T (WAITING INTERVAL) = RTT / N
= $\frac{100}{3}$
= 33.33

1C . HC = $(300 * Q * 100) / (T * P)$
= $(300 * (12.8 + 16.8 + 16) / 3) * 100$ / $(33.33 * 823)$
= $(300 * 14 * 100) / (33.33 * 823)$
= $(420000) / (27430.59)$
= 15.31 %
= 15.3 %

SINCE , I AM CONSIDERING MULTIPLE TENANCY IT SATISFIES THE REQUIREMENTS OF HC (IT SHOULD BE BETWEEN 15 - 20 %)

HVAC CALCULATIONS:

CHILLER CAPACITY = AC AREA / FLOOR
= 44670 SQ.FT

AC AREA PER FLOOR
= GROUND FLOOR = 630 SQ.M = 6781 SQ.FT
= FIRST FLOOR = 600 SQ.M = 6458 SQ.FT
= SECOND TO FIFTH FLOOR = 730 SQ.M = 7857 SQ.FT

AS PER THUMB RULE 1.5 CFM / SQ.FT FOR NORMAL COMFORT APPLICATION =
36812 * 1.5

= 55218 CFM (GF - 4TH FLOOR)

= 7857 * 2.5 = 19642 CFM (5TH FLOOR)

TOTAL AIR QUANTITY = 74860 CFM

AS PER THUMB RULE 400CFM/TR
= 74860 / 400
= 187.15 TR
= 190 TR (100% LOAD)

ALWAYS SELECT CHILLER CAPACITY CALCULATE WITH DIVERSITY 85%
= TOTAL TR * 85% DIVERSITY
= 190TR * 85%
= 161.5
= 162 TR

AHU CAPACITY :

GROUND FLOOR = $6781 * 1.5 = 10171.50$
FIRST FLOOR = $6458 * 1.5 = 9687$ SQ.FT

OFFICE FLOOR (2,3,4 FLOOR) = $7857 * 1.5 * 3 = 35356.5$ SQ.FT
OFFICE FLOOR (5 FLOOR) = $7857 * 2.5 = 19642.50$ SQ.FT

CHILLER PLANT ROOM :

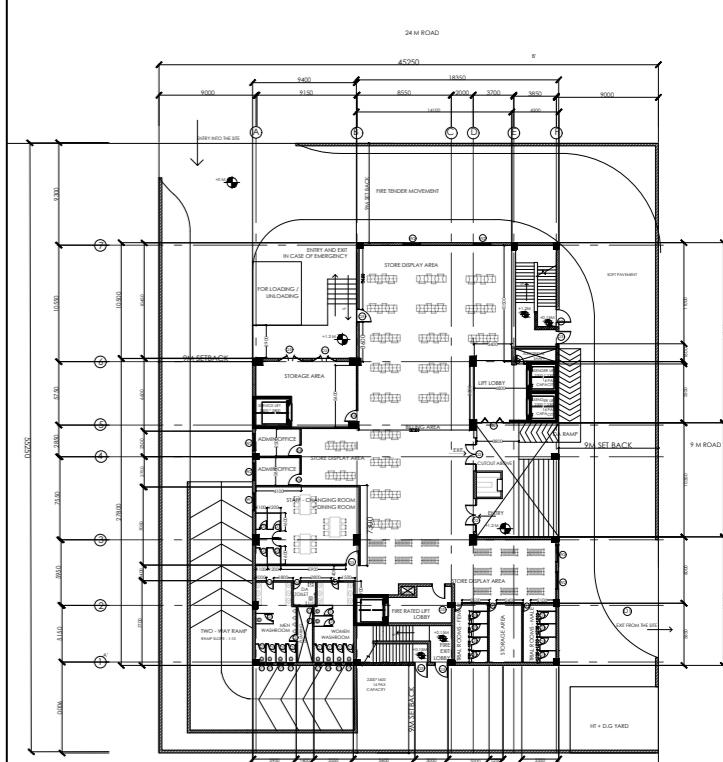
TOTAL AIR CONDITIONING AREA * 0.04
= 44670 SQ.FT * 0.04
= 1786.8 SQ.FT
= 165 SQ.M

AHU ROOM REQUIRED AREA PER FLOOR :

= AC AREA / FLOOR
= 7857 SQ.FT
= 7857 SQ.FT * 0.02 SQ.FT
= 157 SQ.FT
= 15 SQ.M

CONSULTANT :

KEY PLAN :



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CLIENT : CHECKED BY :

PROJECT : ARCHITECTURAL CONCEPT :

DRAWING TITLE : SCALE : SECTION/ELEVATION MARKINGS
CALCULATION DRAWING NUMBER :

SHEET SIZE : RELEASED FOR : A2

STUDENT NAME : DISHITA GOEL

SECTION : SEMESTER : A VI

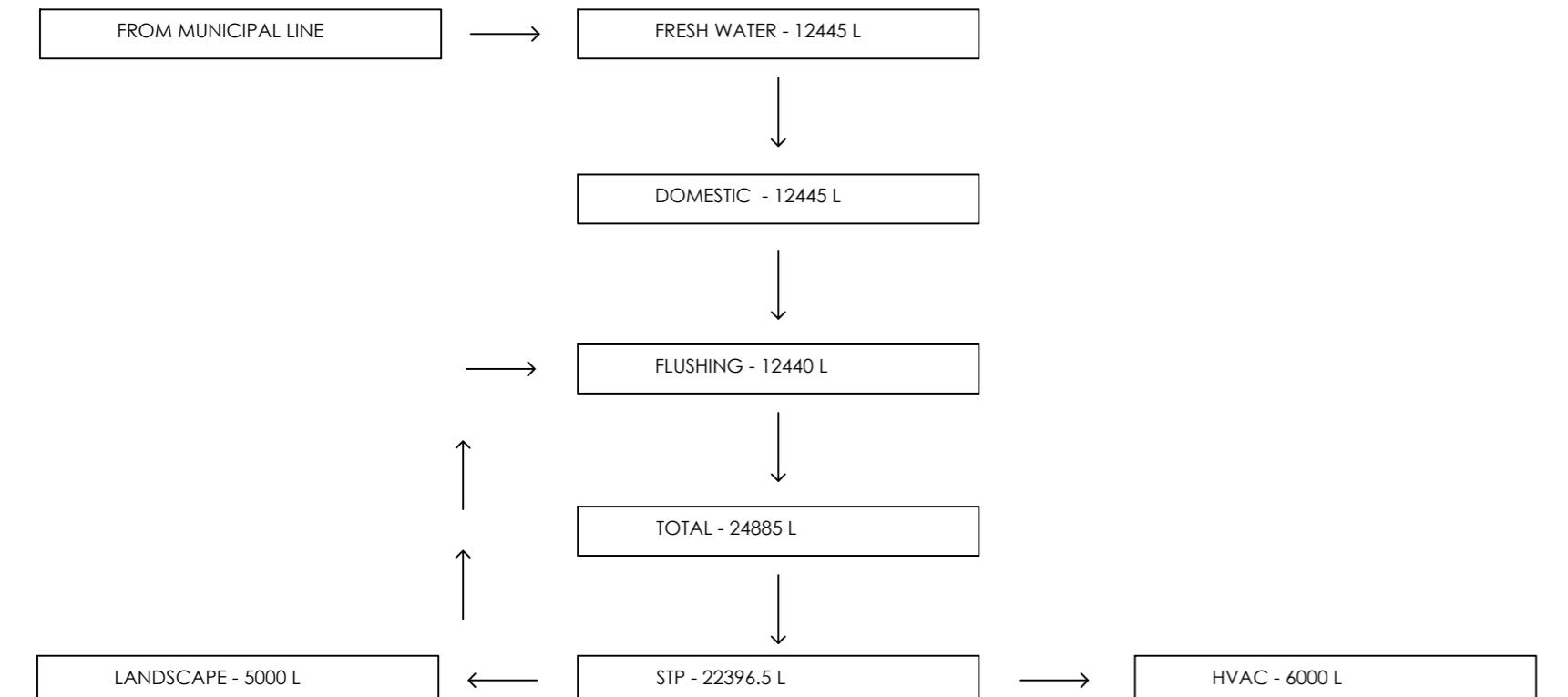
USN : SUBJECT NAME : 1RW19AT035 WORKING DRAWING - 2

DATE : 15 - 05 - 2022

R V COLLEGE OF ARCHITECTURE

PHE CALCULATIONS:

S. NO.	AREA	OCCUPANT	OCCUPANT LOAD	DEMAND		DOMESTIC	FLUSH	TOTAL
				DOMESTIC	FLUSH			
1.	RETAIL	VISITORS	414	5	10	2070	4140	6210
		STAFF	47	25	20	1175	940	2115
2.	OFFICE	STAFF	368	25	20	9200	7360	16560
3.	UNDERGROUND WATER TANK					18667.5	18660	37327.5
4.	OVERHEAD WATER TANK					6222.5	6222	12442.5

WATER BALANCING DRAWING :**TERRACE RAIN WATER CALCULATION :****RAIN WATER CALCULATION**

AVERAGE DAILY RAIN FALL INTENSITY OF RAIN	=	70 MM / HR
RUN OFF COEFFICIENT	=	
ROOF TOP	=	0.90
ROOF TOP AREAS	=	658 M2
RUN OFF FROM ROOF TOP AREA (Q) CUM/DAY	=	
INTENSITY OF RAINFALL * HARVESTABLE AREA * IMPERMEABILITY FACTOR	=	
70 * 658 * 0.9	=	41454 LTS/HR
CONSIDERING 20MIN OF RAINFALL VOLUME OF RAINWATER AVAILABLE FOR STORAGE / HARVESTING (AS PER CGWB NORMS)	=	12436
PROPOSED CAPACITY OF RAINWATER SUMP	=	12 CU.M

MODEL NO	CAPACITY	DIAMETER	HEIGHT	MAN HOLE
300 DL	300 LITERS	660 MM	940 MM	400 MM
500 DL	500 LITERS	880 MM	950 MM	400 MM
750 DL	750 LITERS	1020 MM	1030 MM	400 MM
1000 DL	1000 LITERS	1100 MM	1180 MM	400 MM
1500 DL	1500 LITERS	1250 MM	1426 MM	400 MM
2000 DL	2000 LITERS	1370 MM	1465 MM	400 MM
3000 DL	3000 LITERS	1465 MM	1830 MM	400 MM
5000 DL	5000 LITERS	1805 MM	1905 MM	400 MM

OVERHEAD TANK IS CYLINDRICAL
DOMESTIC WATER STORAGE = 6222.5 L

MODEL NO. 3000DL
CAPACITY - 3000L
DIAMETER - 1465 MM
HEIGHT - 1830 MM
MANHOLE - 400 MM

MODEL NO . 300DL
CAPACITY - 300 L
DIAMETER - 660 MM
HEIGHT - 940MM
MANHOLE - 400 MM

FLUSH WATER STORAGE = 6222 L

MODEL NO. 3000DL
CAPACITY - 3000L
DIAMETER - 1465 MM
HEIGHT - 1830 MM
MANHOLE - 400 MM

MODEL NO . 300DL
CAPACITY - 300 L
DIAMETER - 660 MM
HEIGHT - 940MM
MANHOLE - 400 MM

TERRACE TANK

TERRACE TANK = 20000L

MODEL NO. 5000 DL
CAPACITY - 5000 L
DIAMETER - 1805 MM
HEIGHT - 1905 MM
MAN HOLE - 400 MM

MODEL NO . 300DL
CAPACITY - 300 L
DIAMETER - 660 MM
HEIGHT - 940MM
MANHOLE - 400 MM

UGT TANK DIMENSIONS**DOMESTIC TANK**

VOLUME = 18.6 M3
VOLUME = L*B*H
L = 3.1

18.6 = B * 3.1 * 3.6
B = 1.6 M

THEREFORE ,

B = 1.6 M
L=3.1 M

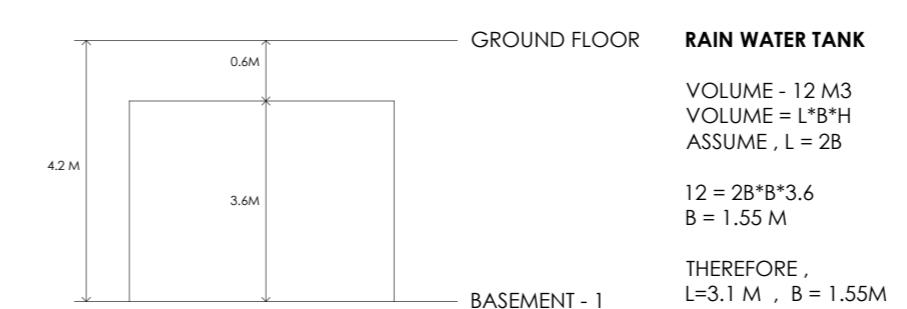
FLUSH WATER TANK

VOLUME = 18 M3
VOLUME = L*B*H
L = 3.1

18 = B * 3.1 * 3.6
B = 1.6 M

THEREFORE ,

B = 1.6 M
L=3.1 M

**FIRE WATER TANK**

ACCORDING TO NBC 2.65 , TABLE 7
FOR BUILDINGS ABOVE 24M AND UPTO 30 M

UNDERGROUND STATIC WATER STORAGE TANK = 150000L

VOLUME = 150 M3
VOLUME = L * B * H
150 = 2B * B * 3.6
B = 4.6 M

THEREFORE ,

L = 9.2 M
B = 4.6 M

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CLIENT :

CHECKED BY :
ANUPRIYA SAXENA
RAMYA

PROJECT :

ARCHITECTURAL CONCEPT :

DRAWING TITLE :

SCALE : DRAWING NUMBER

SHEET SIZE :

A2

RELEASED FOR :

STUDENT NAME :

DISHITA GOEL

SECTION :

SEMESTER :

A

VI

USN :

SUBJECT NAME :
1RW19AT035 WORKING DRAWING - 2

DATE : 19 - 04 - 2022

R V COLLEGE OF ARCHITECTURE

BASEMENT CALCULATIONS:

BASEMENT - 1

VENTILATION FAN ROOM REQUIRED AREA AS PER BASEMENT FLOOR - 840 M² = 9041 SQ.FT

BASEMENT EQUIPMENT CAPACITY CALCULATION :

FLOOR AREA = 9041 SQ.FT
FLOOR HEIGHT = 13.77 FEET

FORMULA - CFM = VOLUME * ACPH/60
VOLUME = 9041 * 13.77 = 124494.57

THEREFORE ,
CFM = 124494.57 * 6 / 60 = 12449.457 CFM
CFM = 124494.57 * 12/60 = 24898.914 CFM

AS PER NBC 2016 ,

6 AIR CHANGES FOR NORMAL MODE
12 AIR CHANGES FOR FIRE MODE
EQUIPMENT SELECTION SHALL BE 12 ACPH



TUNNEL VENTILATION JET FANS

CAPACITY - 6000 CFM
POWER - 2.2 KW

BASEMENT - 2

VENTILATION FAN ROOM REQUIRED AREA AS PER BASEMENT FLOOR - 1126 M² = 12120 SQ.FT

BASEMENT EQUIPMENT CAPACITY CALCULATION :

FLOOR AREA = 12120 SQ.FT
FLOOR HEIGHT = 13.77 FEET

FORMULA - CFM = VOLUME * ACPH/60
VOLUME = 12120 * 13.77 = 166892.4
THEREFORE ,
CFM = 166892.4 * 6 / 60 = 16689.24 CFM
CFM = 166892.6 * 12/60 = 33378.52 CFM

AS PER NBC 2016 ,

6 AIR CHANGES FOR NORMAL MODE
12 AIR CHANGES FOR FIRE MODE
EQUIPMENT SELECTION SHALL BE 12 ACPH



TUNNEL VENTILATION JET FANS

CAPACITY - 6000 CFM
POWER - 2.2 KW

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R V COLLEGE OF ARCHITECTURE

19 - 04 - 2022

1RW19AT035 WORKING DRAWING - 2

DATE : 19 - 04 - 2022

USN : 1RW19AT035 SUBJECT NAME : WORKING DRAWING - 2

SECTION : A SEMESTER : VI

STUDENT NAME : DISHITA GOEL

DRAWING TITLE :

SCALE : SECTION/ELEVATION MARKING
DRAWING NUMBER : A

PROJECT : ARCHITECTURAL CONCEPT :

DRAWING SIZE : A2

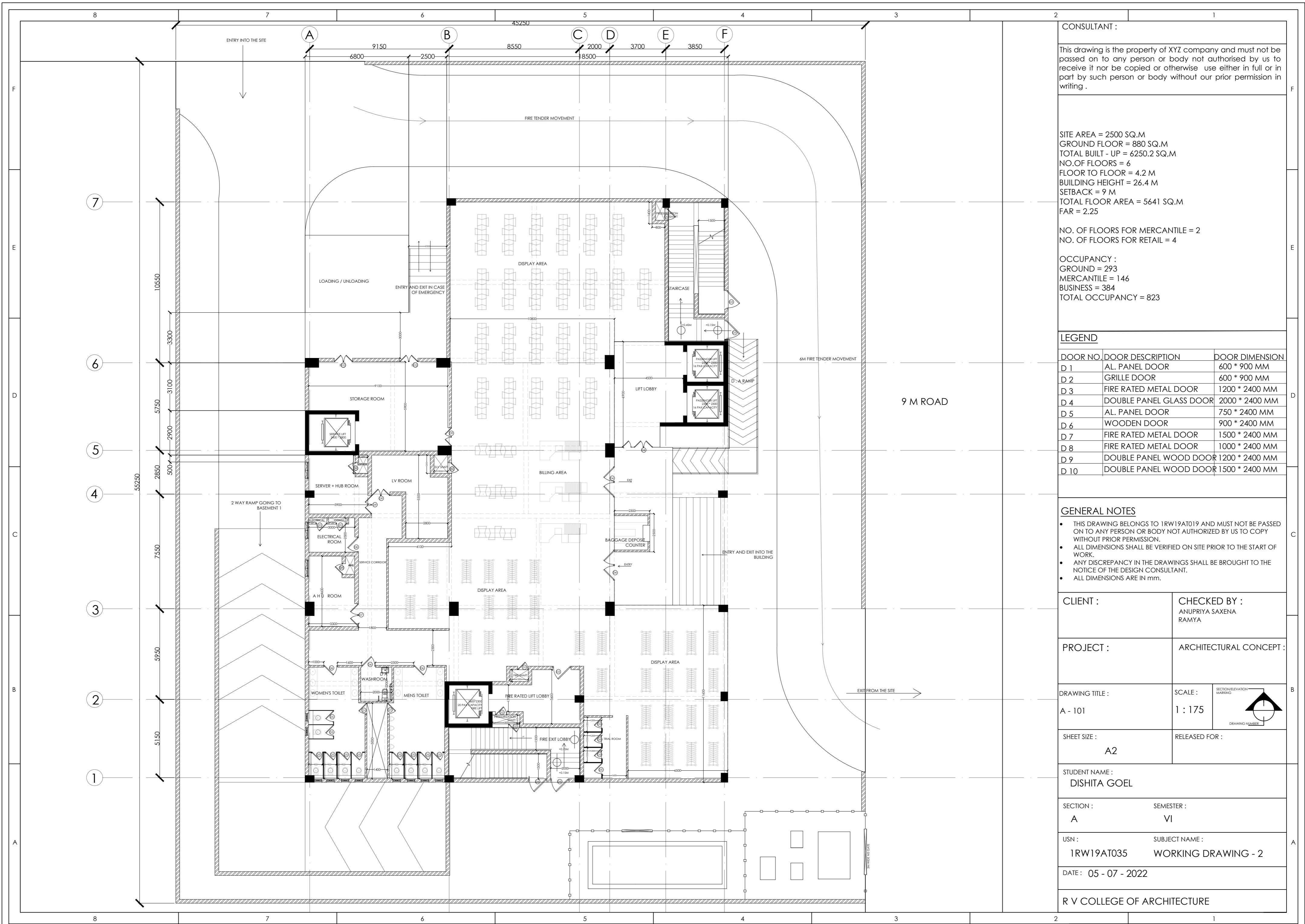
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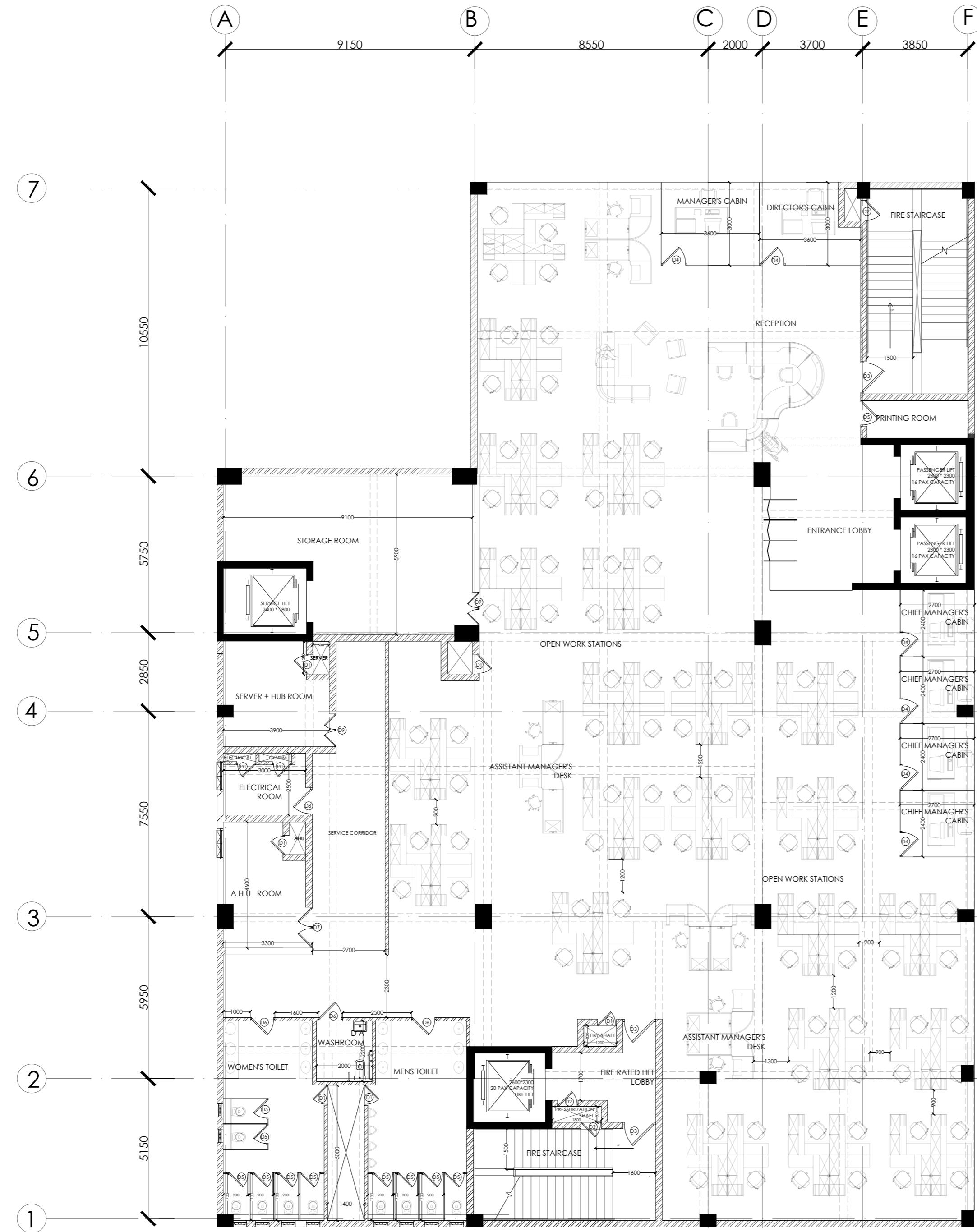
ANUPRIYA SAXENA
RAMYA

SHEET SIZE : RELEASED FOR :

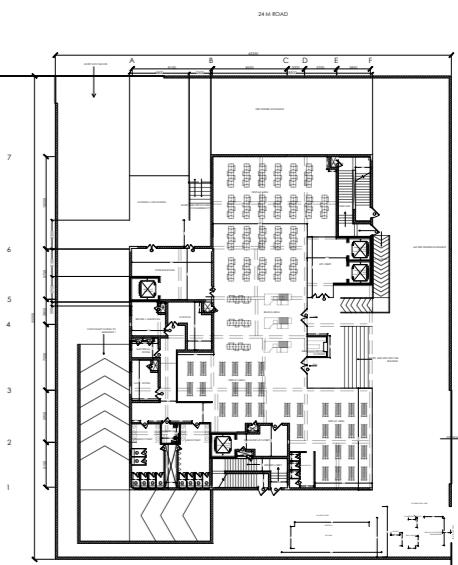
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KEY PLAN**LEGEND**

DOOR NO.	DOOR DESCRIPTION	DOOR DIMENSION
D1	AL. PANEL DOOR	600 * 900 MM
D2	GRILLE DOOR	600 * 900 MM
D3	FIRE RATED METAL DOOR	1200 * 2400 MM
D4	GLASS DOOR	1000 * 2400 MM
D5	WOOD DOOR	900 * 2400 MM

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CLIENT :

CHECKED BY :
ANUPRIYA SAXENA
RAMYA

PROJECT :

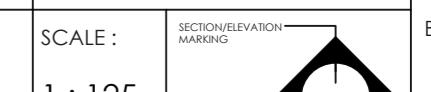
ARCHITECTURAL CONCEPT :

DRAWING TITLE :

A - 104

SCALE :

1 : 125

**SHEET SIZE :**

A2

RELEASED FOR :

STUDENT NAME :
DISHITA GOEL

SECTION :**SEMESTER :**

A

VI

USN :

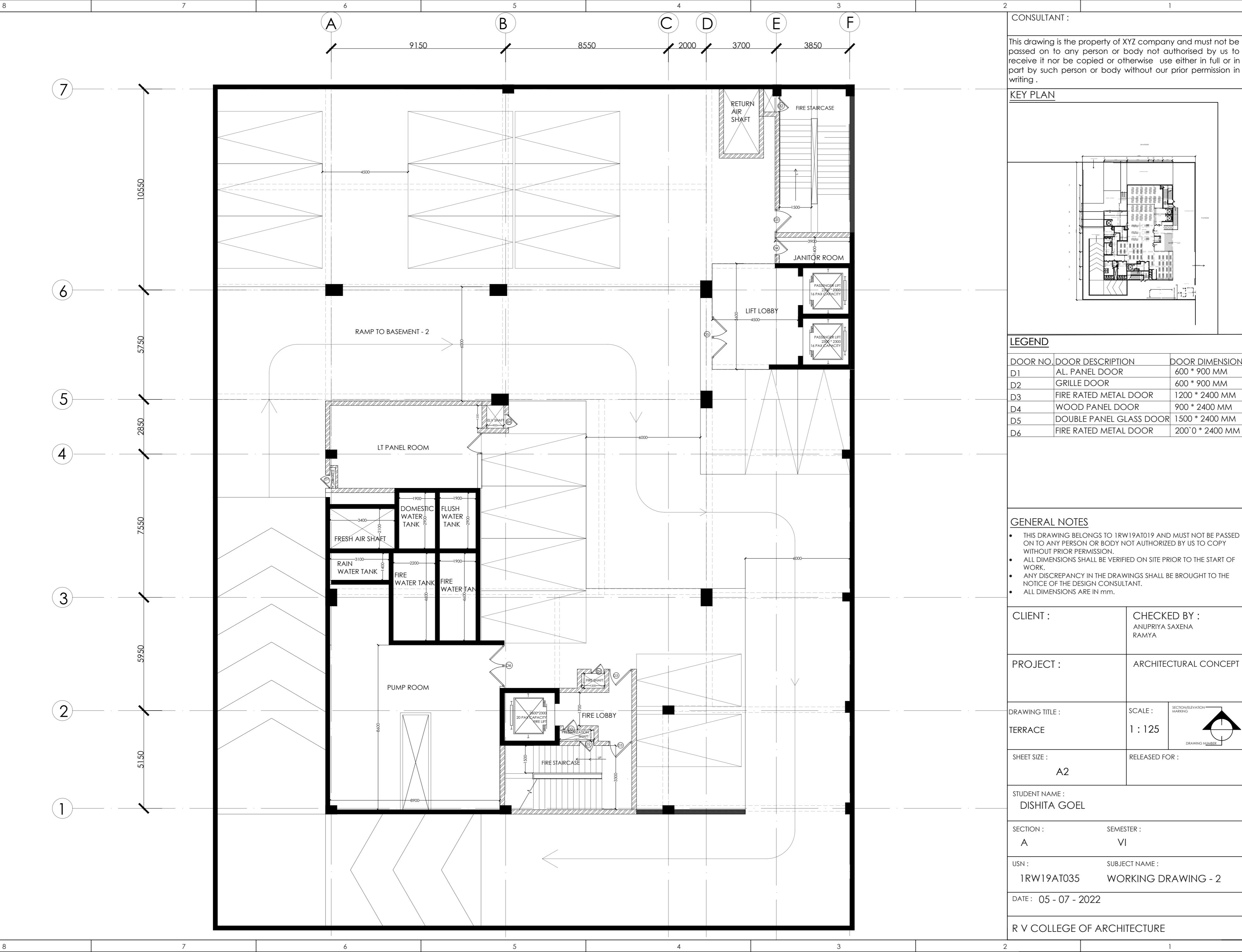
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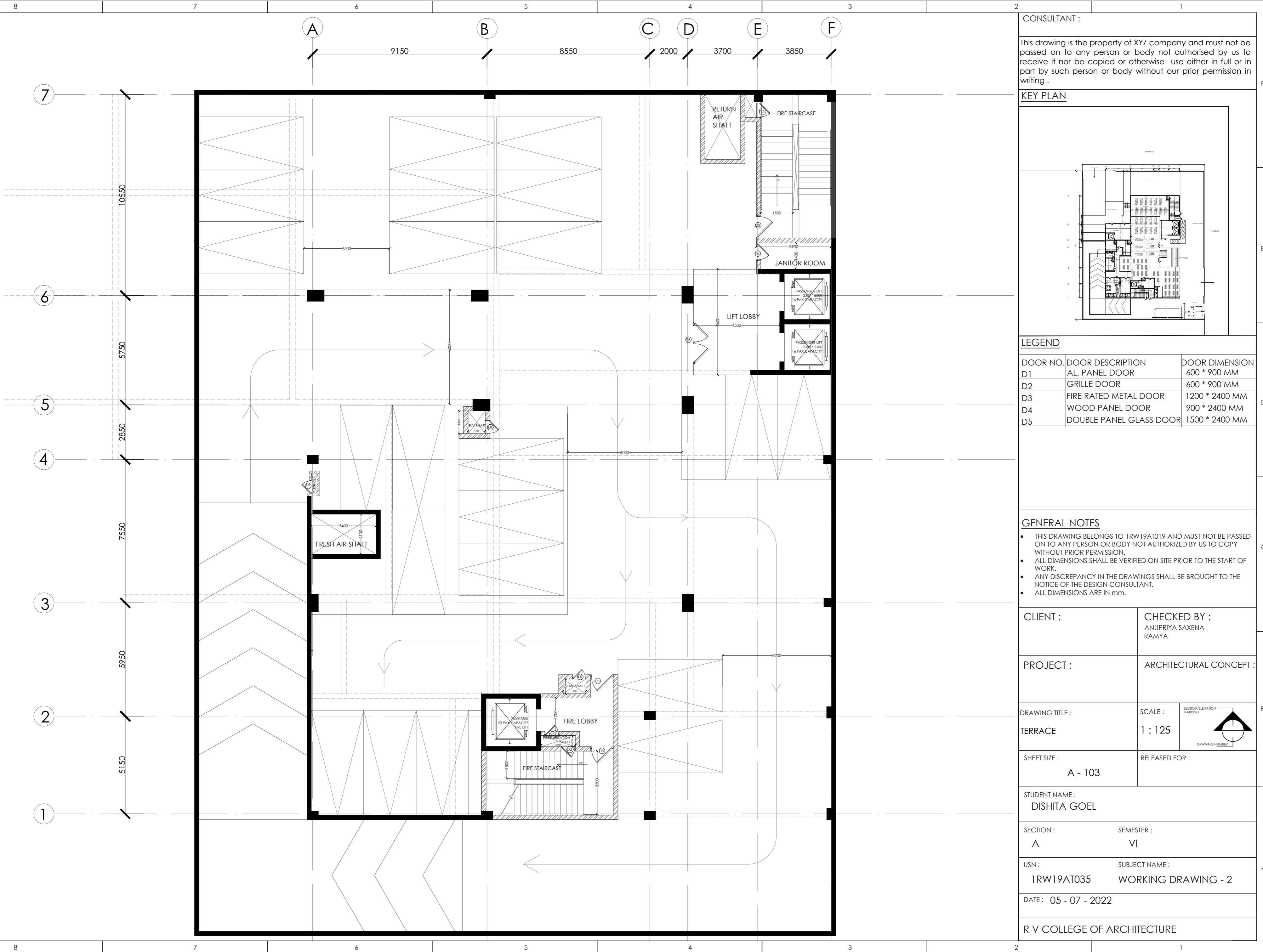
SUBJECT NAME :

WORKING DRAWING - 2

DATE : 05 - 07 - 2022

R V COLLEGE OF ARCHITECTURE



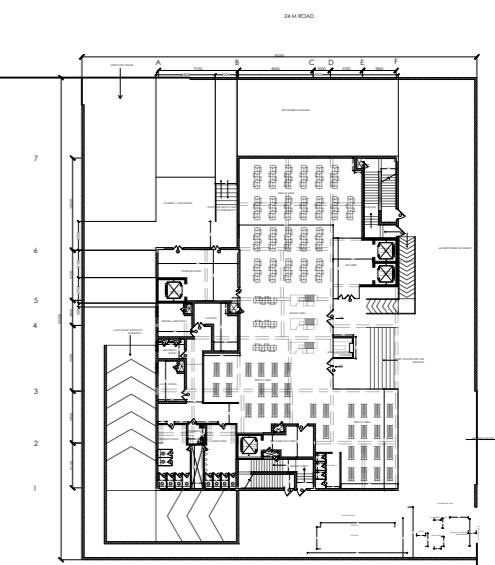




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KEY PLAN



LEGEND

DOOR NO.	DOOR DESCRIPTION	DOOR DIMENSION
D1	AL. PANEL DOOR	600 * 900 MM
D2	GRILLE DOOR	600 * 900 MM
D3	FIRE RATED METAL DOOR	1200 * 2400 MM

GENERAL NOTES

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CLIENT :

CHECKED BY :
ANUPRIYA SAXENA
RAMYA

PROJECT :

ARCHITECTURAL CONCEPT :

DRAWING TITLE :

SCALE :
1 : 175
SECTION/ELEVATION MARKING
DRAWING NUMBER

SHEET SIZE :

RELEASED FOR :

A2

STUDENT NAME :

DISHITA GOEL

SECTION :

SEMESTER :

A

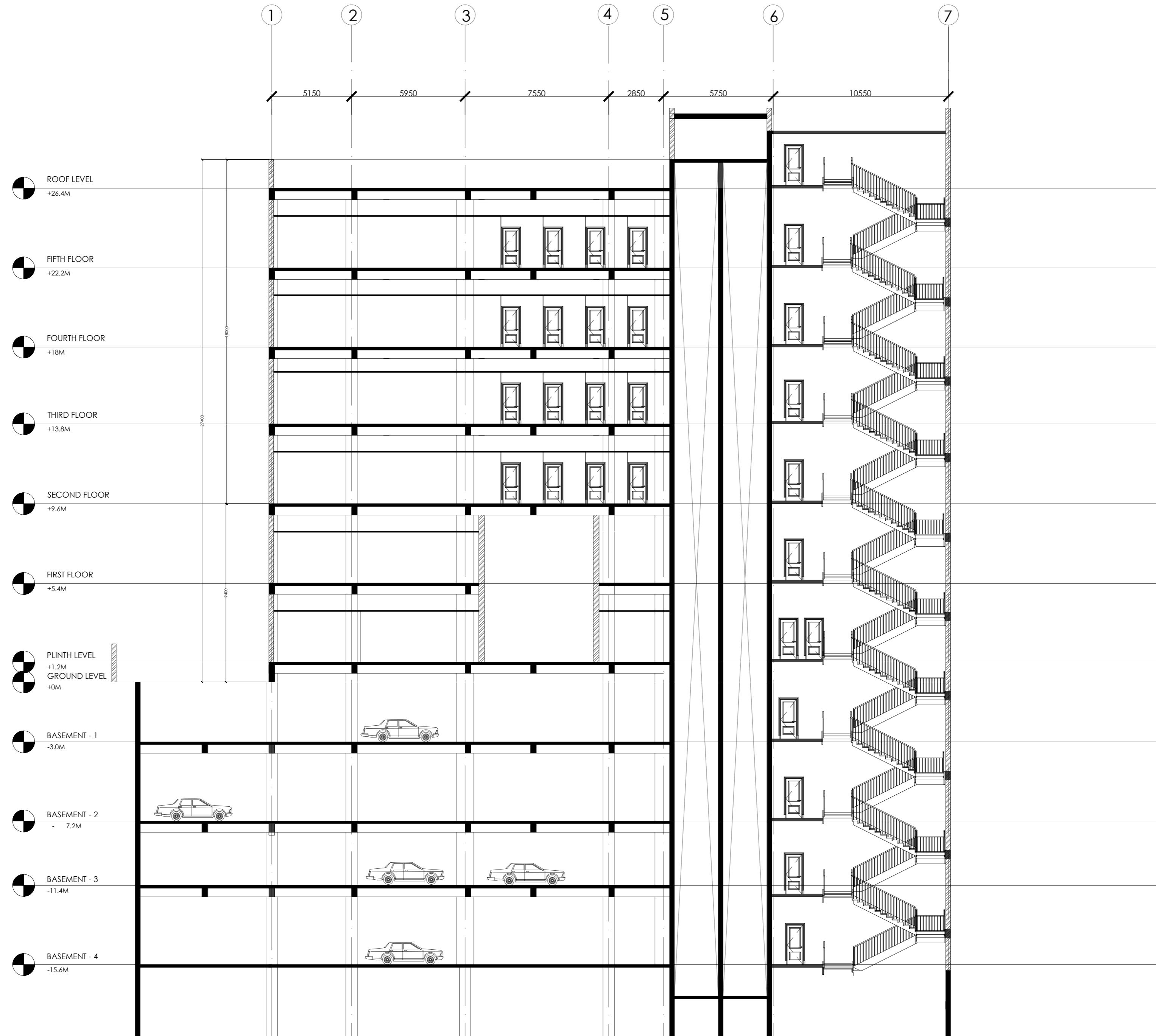
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USN :

SUBJECT NAME :
1RW19AT035 WORKING DRAWING - 2

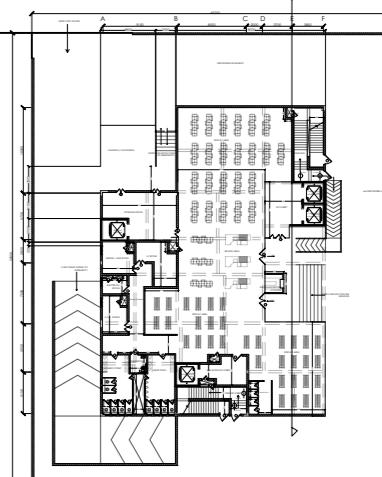
DATE : 22 - 05 - 2022

R V COLLEGE OF ARCHITECTURE



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CLIENT :	CHECKED BY :
	ANUPRIYA SAXENA RAMYA

PROJECT :	ARCHITECTURAL CONCEPT :
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DRAWING TITLE :	SCALE :
A - 301	1 : 125

SHEET SIZE :	SECTION/ELEVATION MARKING :
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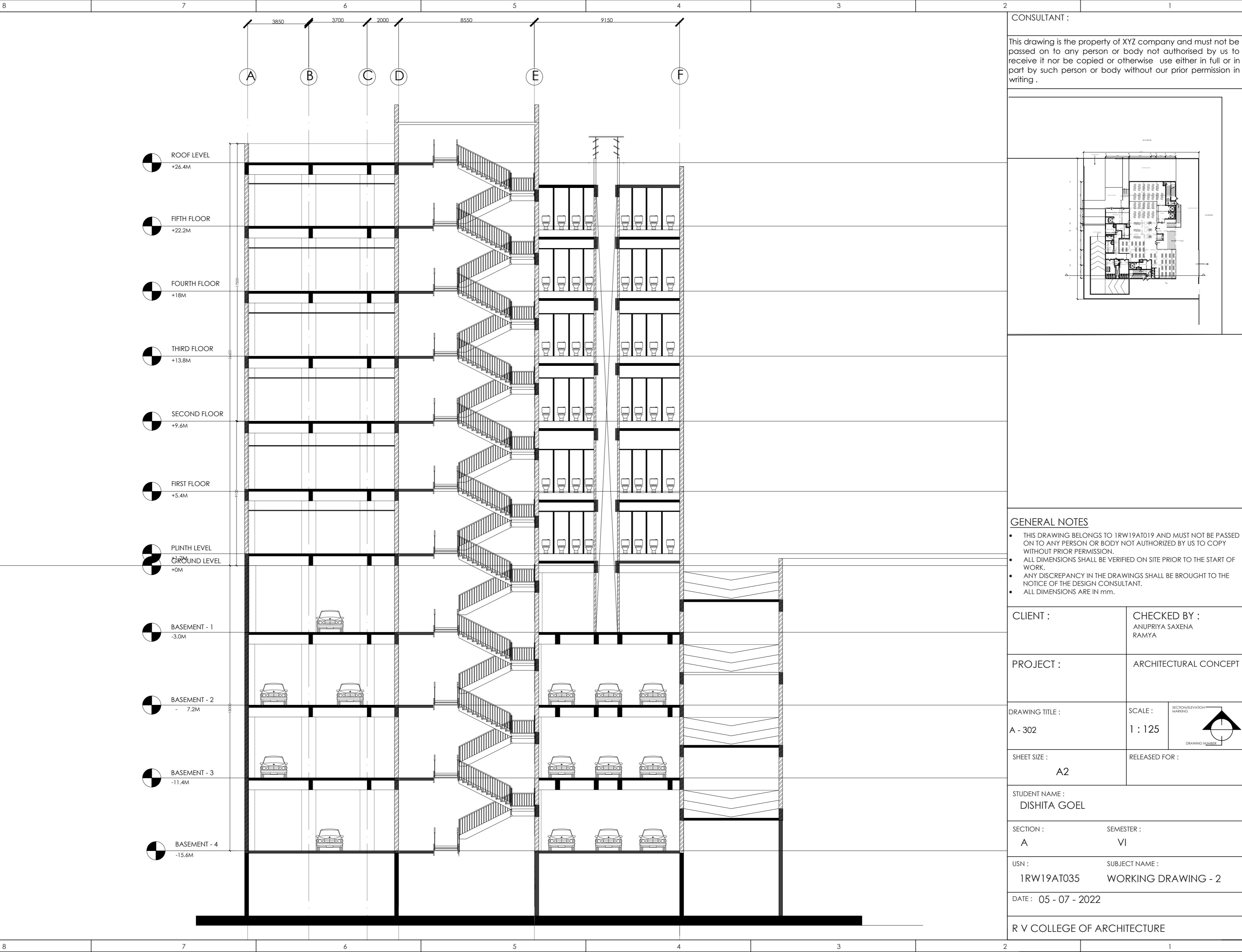
STUDENT NAME :	RELEASED FOR :
DISHITA GOEL	

SECTION :	SEMESTER :
A	VI

USN :	SUBJECT NAME :
1RW19AT035	WORKING DRAWING - 2

DATE :	05 - 07 - 2022
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R V COLLEGE OF ARCHITECTURE

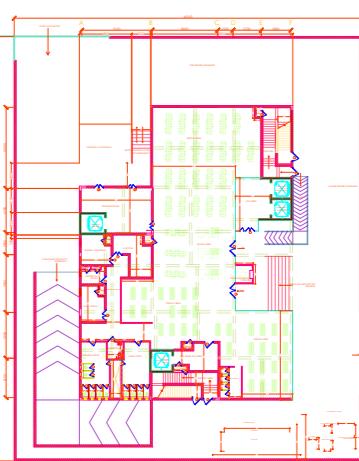


8 7 6 5 4 3 2 1



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LEGEND

- LIGHT FIXTURE
- SMOKE DETECTOR
- SPEAKER

GENERAL NOTES

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CLIENT :

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ANUPRIYA SAXENA
RAMYA

PROJECT :

ARCHITECTURAL CONCEPT :

DRAWING TITLE :

SCALE :

CRCP - 104 .4

1 : 175



SECTION ELEVATION MARKING

DRAWING NUMBER

SECTION ELEVATION MARKING

SHEET SIZE :

RELEASED FOR :

A2

DRAWING NUMBER

STUDENT NAME :

DISHITA GOEL

SECTION :

A

SEMESTER :

VI

USN :

SUBJECT NAME :

1RW19AT035

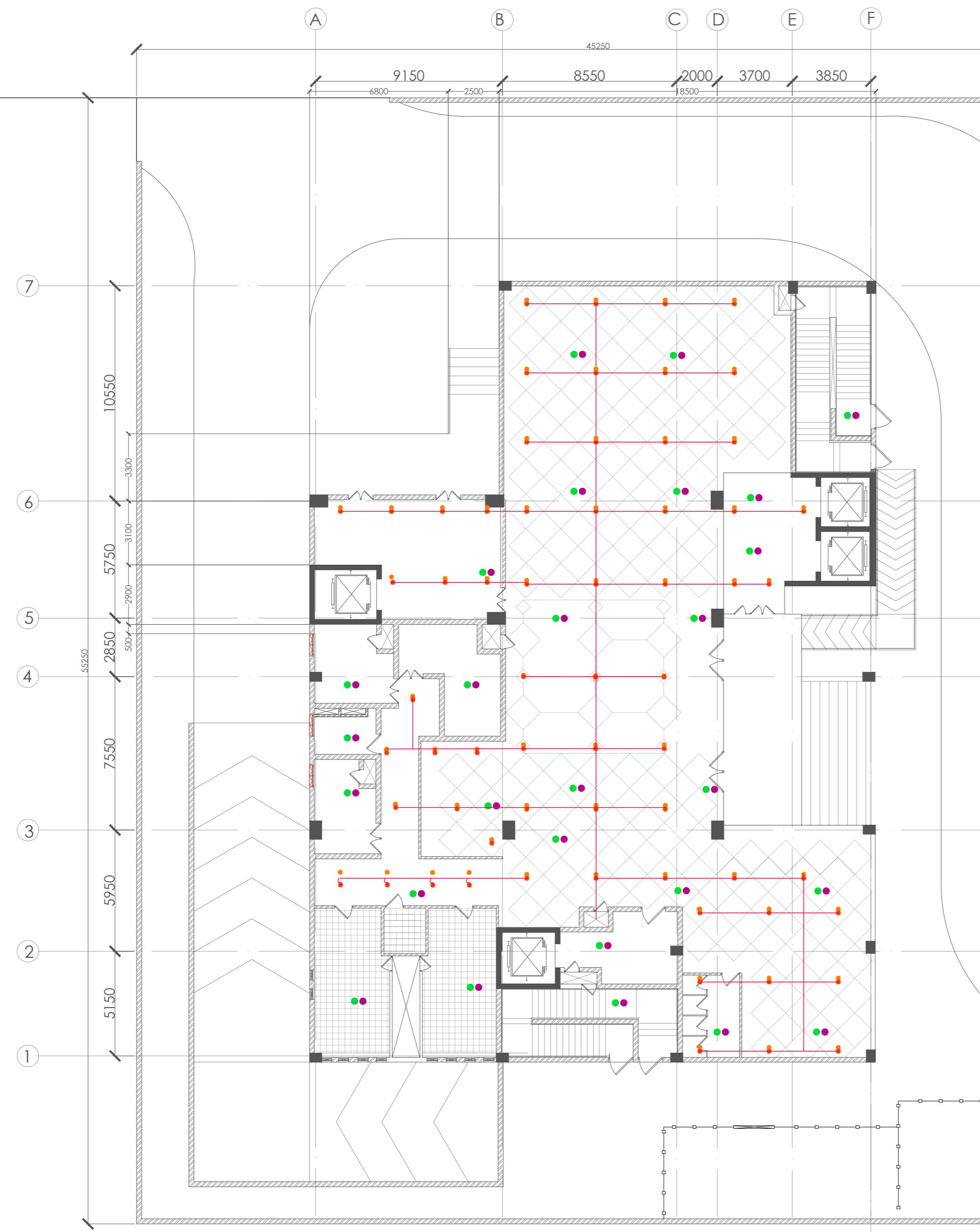
WORKING DRAWING - 2

DATE : 05 - 07 - 2022

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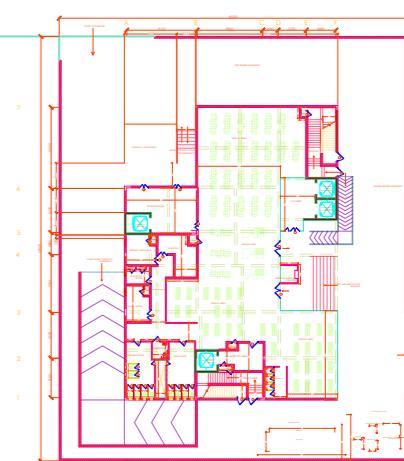
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LEGEND

- PENDENTIVE WATER SPRINKLER
- UPRIGHT WATER SPRINKLER
- LIGHT FIXTURE
- SMOKE DETECTOR
- SPEAKER

GENERAL NOTES

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CLIENT :

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ANUPRIYA SAXENA
RAMYA

PROJECT :

ARCHITECTURAL CONCEPT :

DRAWING TITLE :

SCALE :

CRCP - 104.2

1 : 175



SECTION/ELEVATION MARKING

DRAWING NUMBER

SHEET SIZE :

RELEASED FOR :

A2

A

STUDENT NAME :

B

DISHITA GOEL

SECTION : SEMESTER :

SECTION : A

VI

USN :

SUBJECT NAME :

1RW19AT035

WORKING DRAWING - 2

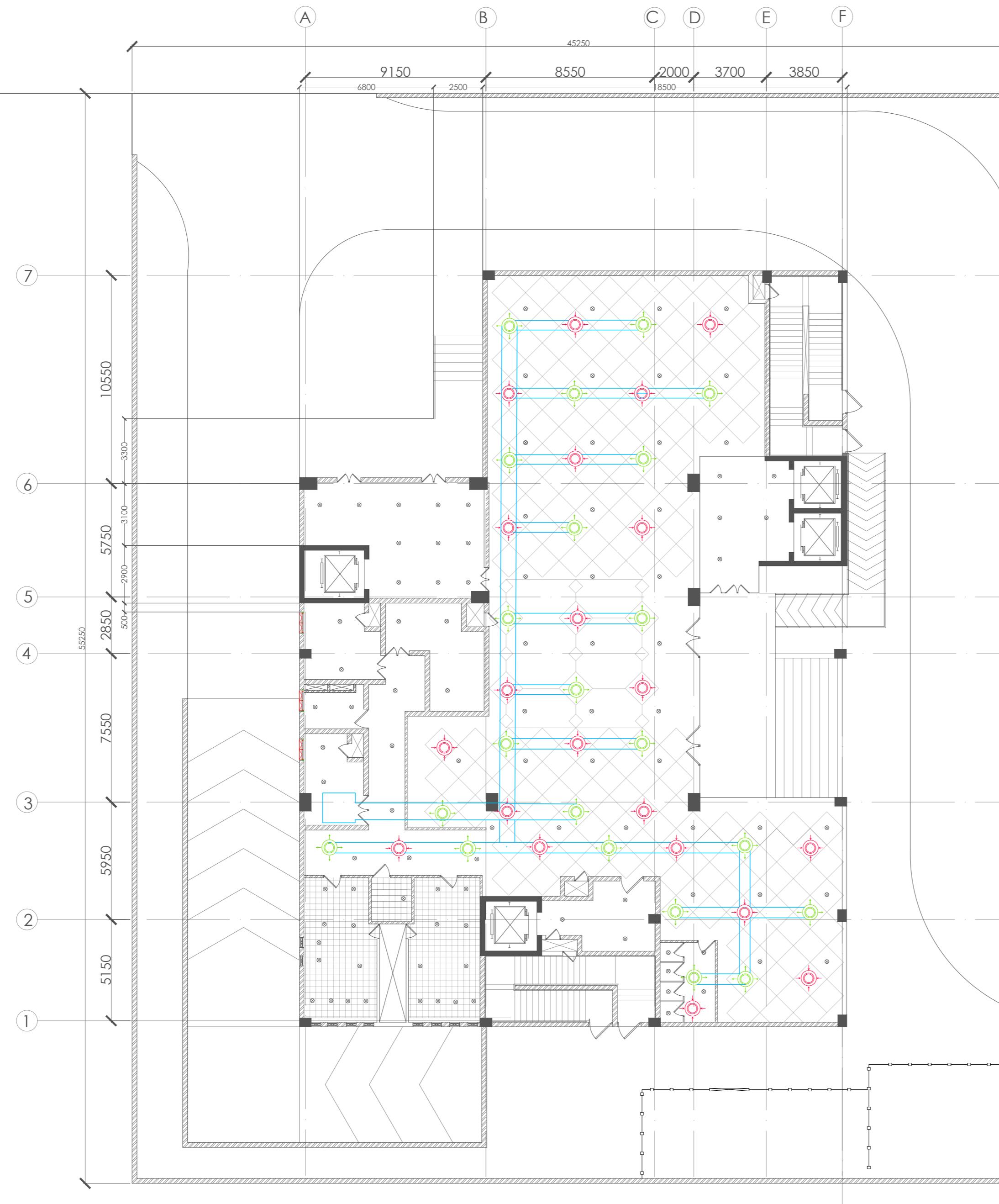
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05 - 07 - 2022

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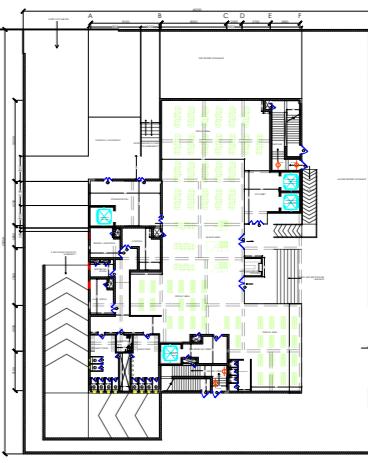
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8 7 6 5 4 3 2 1



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LEGEND

-  SUPPLY AIR DIFFUSER
-  RETURN AIR DIFFUSER

GENERAL NOTES

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CLIENT :	CHECKED BY :
	ANUPRIYA SAXENA RAMYA

PROJECT :	ARCHITECTURAL CONCEPT :
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DRAWING TITLE :	SCALE :
CRCP - 104 .4	1 : 175

SHEET SIZE :	RELEASED FOR :
A2	

STUDENT NAME :	
DISHITA GOEL	

SECTION :	SEMESTER :
A	VI

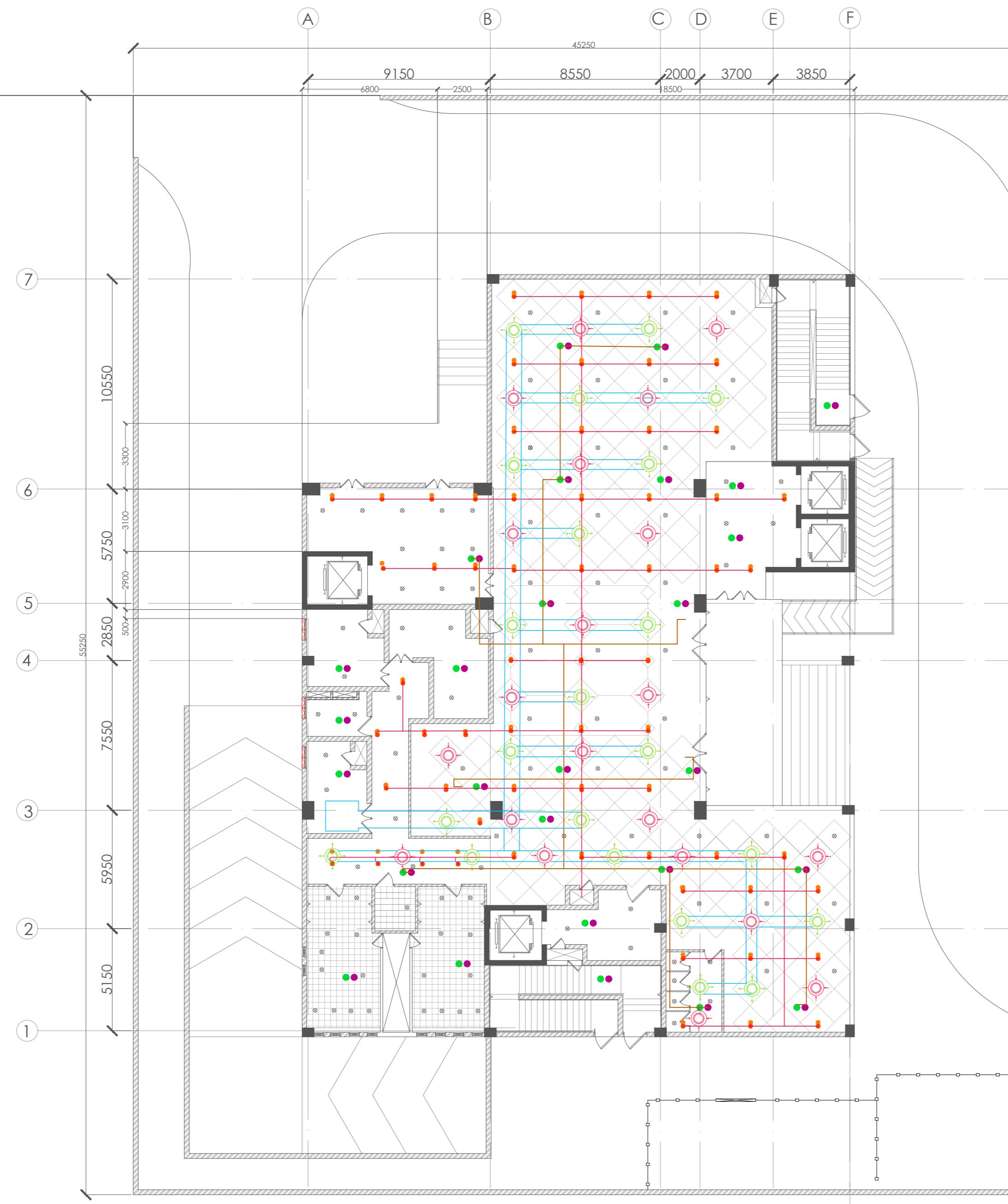
USN :	SUBJECT NAME :
1RW19AT035	WORKING DRAWING - 2

DATE : 05 - 07 - 2022	
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R V COLLEGE OF ARCHITECTURE	
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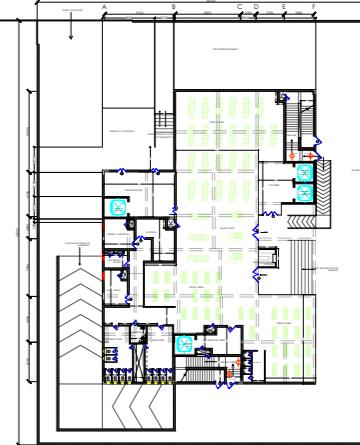
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LEGEND

- LIGHT FIXTURE
- SUPPLY AIR DIFFUSER
- RETURN AIR DIFFUSER
- SMOKE DETECTOR
- SPEAKER
- UPRIGHT WATER SPRINKLER
- PENDENTIVE WATER SPRINKLER

GENERAL NOTES

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CLIENT :

CHECKED BY :
ANUPRIYA SAXENA
RAMYA

PROJECT :

ARCHITECTURAL CONCEPT :

DRAWING TITLE :

SCALE :

CRCP - 104 .4

SECTION/ELEVATION MARKING

1 : 175

DRAWING NUMBER

SHEET SIZE :

RELEASED FOR :

A2

A

STUDENT NAME :

B

DISHITA GOEL

SECTION :

A

SEMESTER :

VI

USN :

SUBJECT NAME :

1RW19AT035

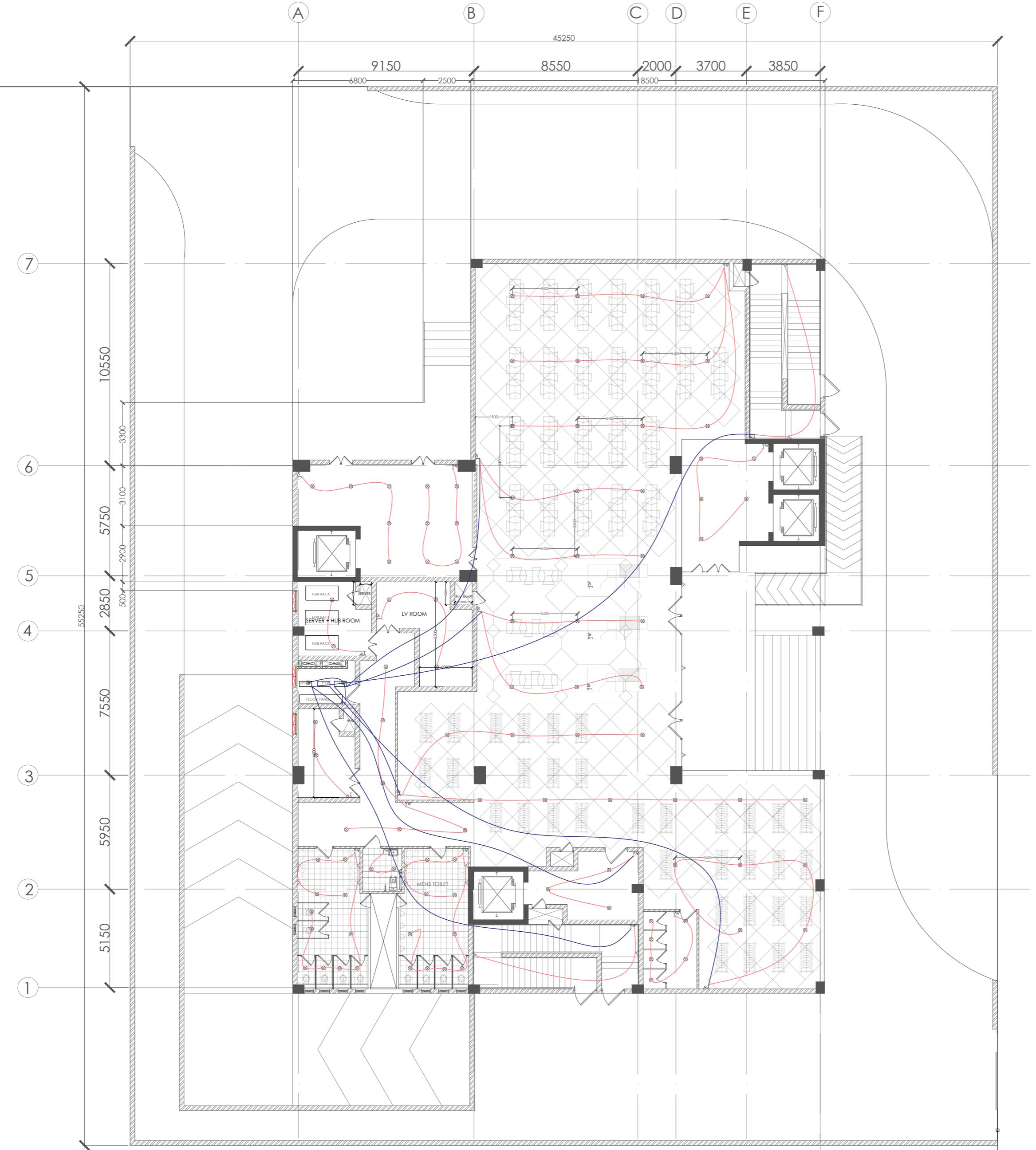
WORKING DRAWING - 2

DATE : 05 - 07 - 2022

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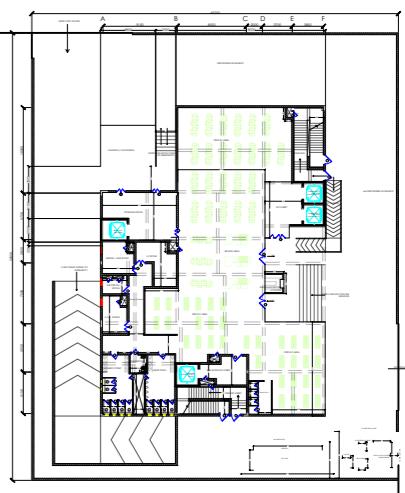
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LEGEND

- LIGHT FIXTURE
- SWITCH
- WALL MOUNTED CEILING
- ELECTRICAL WIRING FROM SWITCH BOARD TO APPLIANCE / FIXTURE
- ELECTRICAL WIRING FROM SWITCH BOARD TO DISTRIBUTION BOARD

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CLIENT : CHECKED BY :
ANUPRIYA SAXENA
RAMYA

PROJECT : ARCHITECTURAL CONCEPT :

DRAWING TITLE : SCALE :
CFP - 104 . 1 1 : 125

SECTION/ELEVATION MARKING :
DRAWING NUMBER :

SHEET SIZE : RELEASED FOR :
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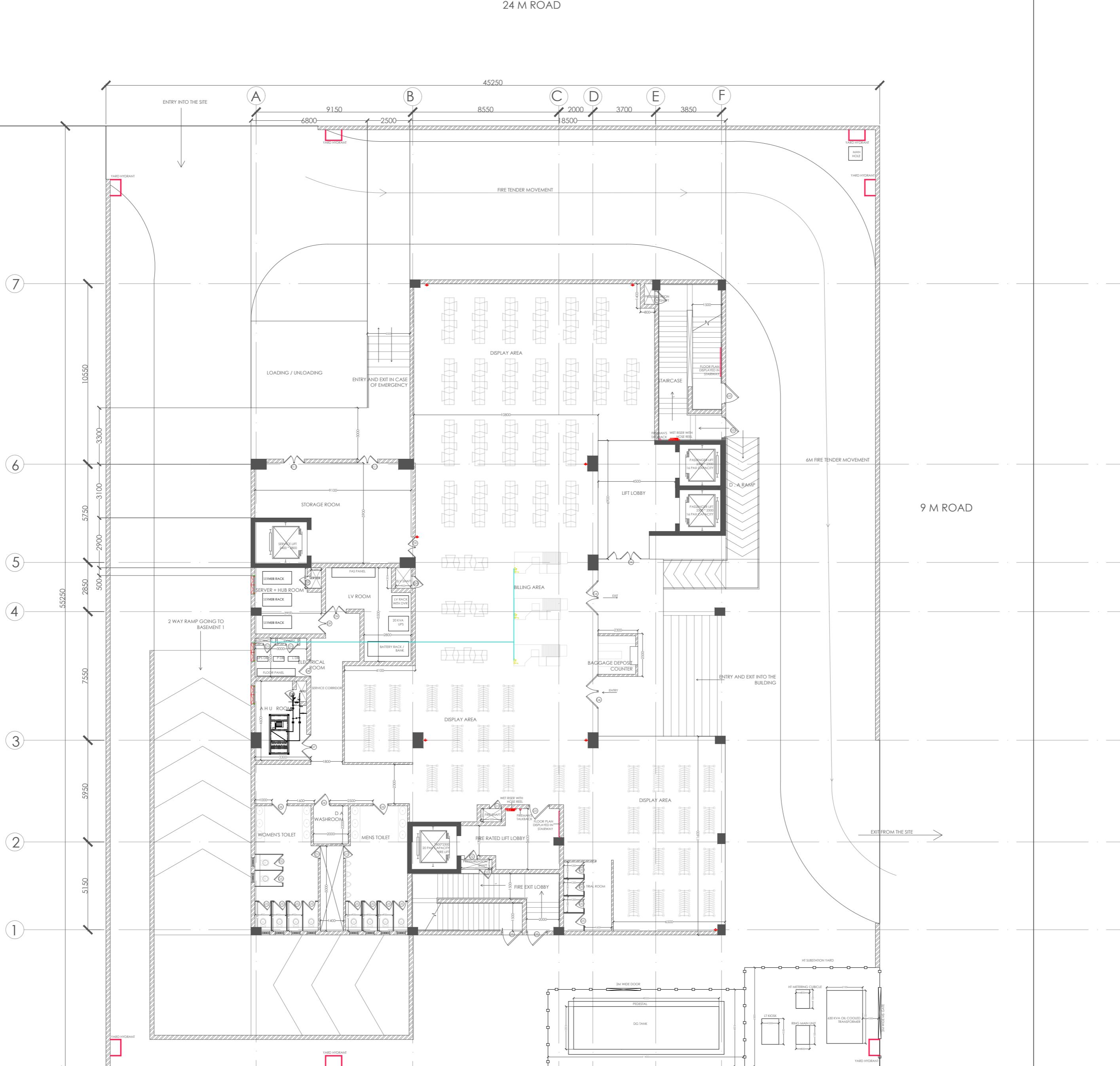
SECTION : SEMESTER :
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STUDENT NAME : SUBJECT NAME :
DISHITA GOEL 1RW19AT035 WORKING DRAWING - 2

DATE : 05 - 07 - 2022

R V COLLEGE OF ARCHITECTURE

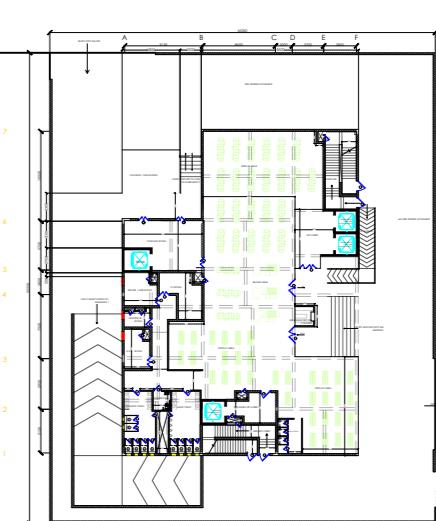
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KEY PLAN



LEGEND

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CLIENT :	CHECKED BY :
	ANUPRIYA SAXENA RAMYA

PROJECT :	ARCHITECTURAL CONCEPT :
-----------	-------------------------

DRAWING TITLE :	SCALE :
CFP 104.2	1 : 125

SHEET SIZE :	SECTION/ELEVATION MARKING :
A2	DRAWING NUMBER

STUDENT NAME :	RELEASED FOR :
DISHITA GOEL	

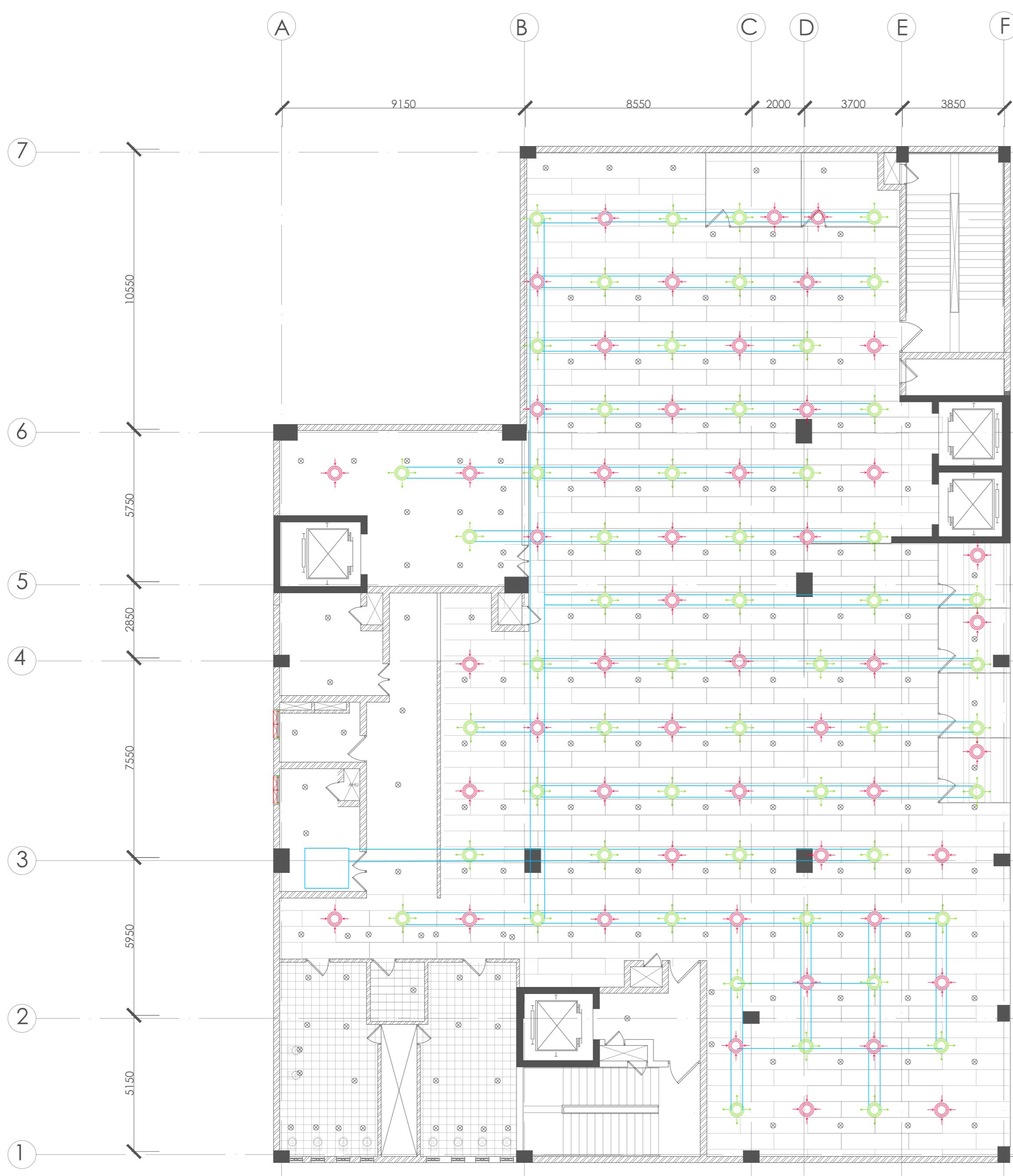
SECTION :	SEMESTER :
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USN :	SUBJECT NAME :
1RW19AT035	WORKING DRAWING - 2

DATE :	22 - 05 - 2022
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R V COLLEGE OF ARCHITECTURE

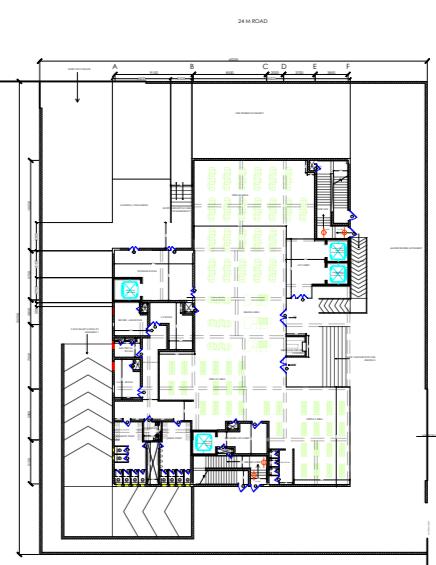
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KEY PLAN



LEGEND

- SUPPLY AIR DIFFUSER
- RETURN AIR DIFFUSER

GENERAL NOTES

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CLIENT :

CHECKED BY :
ANUPRIYA SAXENA
RAMYA

PROJECT :

ARCHITECTURAL CONCEPT :

DRAWING TITLE :

SCALE :

CRCP 105 .3

1 : 125

SECTION/ELEVATION MARKING

DRAWING NUMBER

SHEET SIZE :

RELEASED FOR :

A2

STUDENT NAME :

DISHITA GOEL

SECTION :

SEMESTER :

A

VI

USN :

SUBJECT NAME :

1RW19AT035

WORKING DRAWING - 2

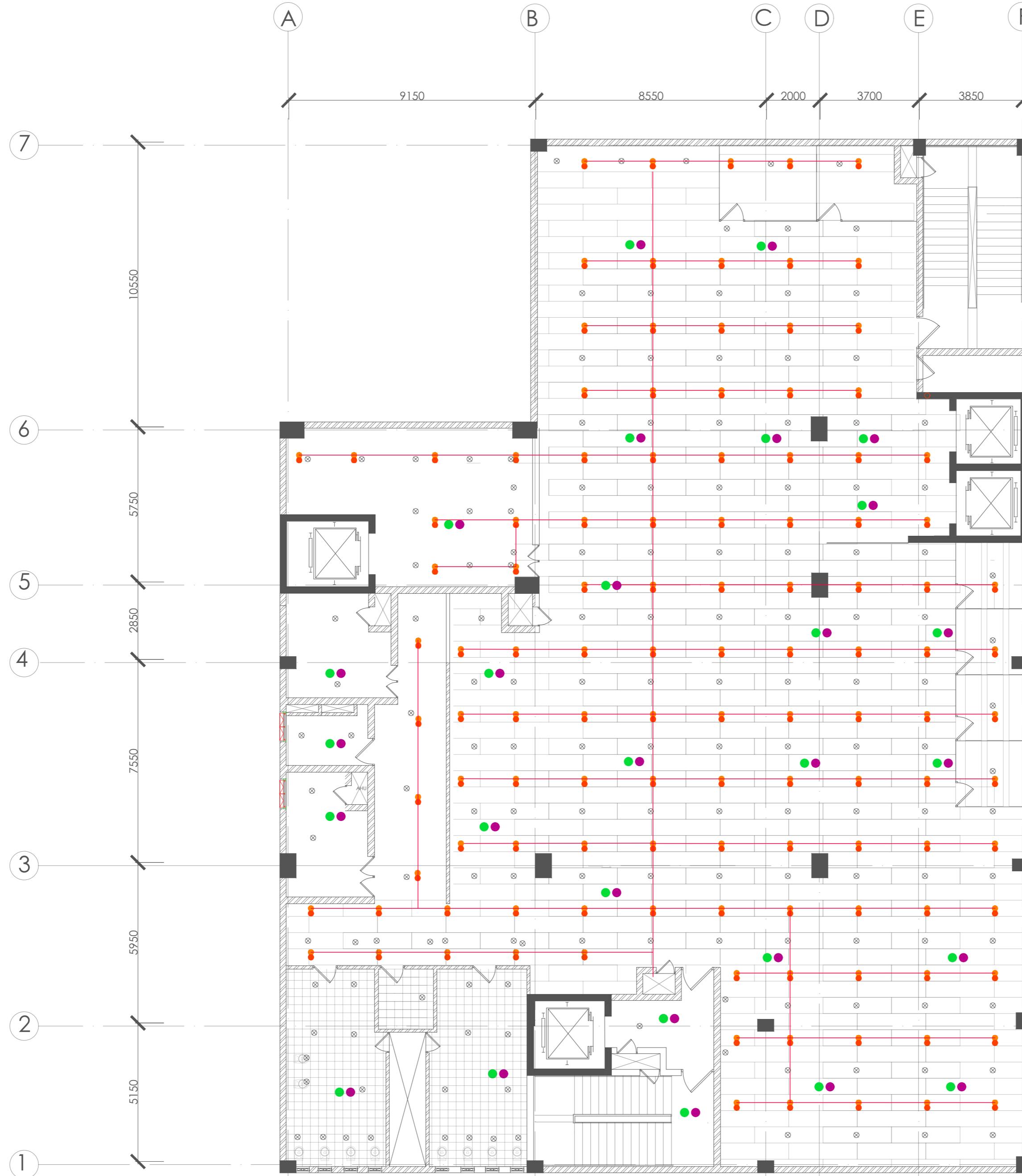
DATE :

05 - 07 - 2022

R V COLLEGE OF ARCHITECTURE

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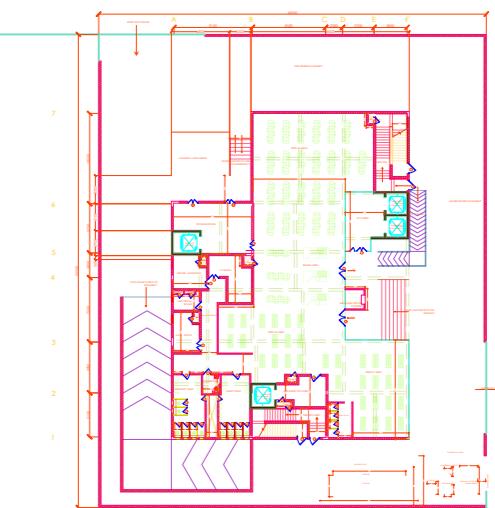
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KEY PLAN



LEGEND

- SMOKE DETECTOR
- SPEAKER
- PENDENTIVE WATER SPRINKLER
- UPRIGHT WATER SPRINKLER

GENERAL NOTES

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CLIENT :

CHECKED BY :
ANUPRIYA SAXENA
RAMYA

PROJECT :

ARCHITECTURAL CONCEPT :

DRAWING TITLE :

SCALE :

CRCP 105 . 2

1 : 125



SHEET SIZE :

RELEASED FOR :

A2

STUDENT NAME :

B

DISHITA GOEL

SECTION :

A

SEMESTER :

VI

USN :

SUBJECT NAME :

1RW19AT035

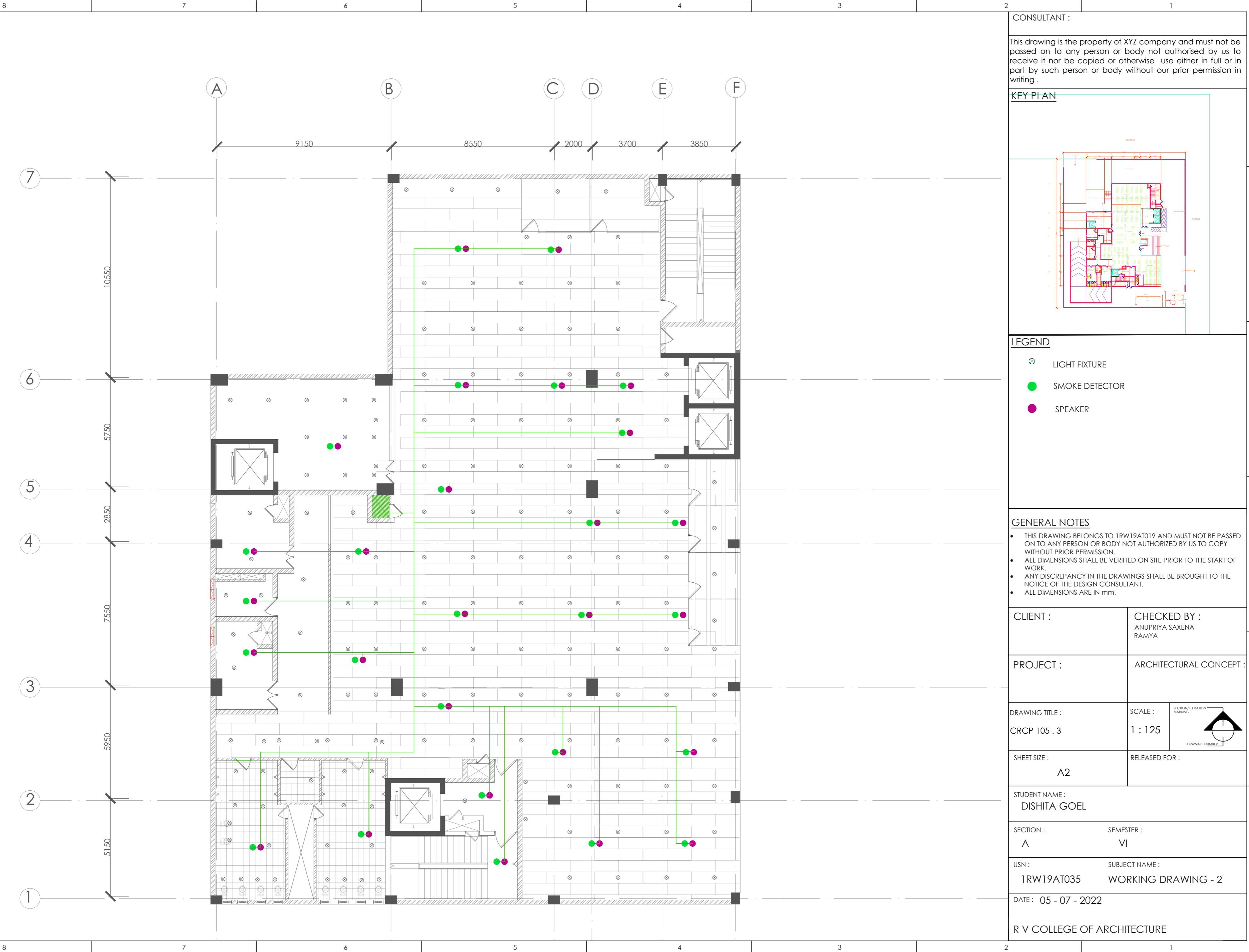
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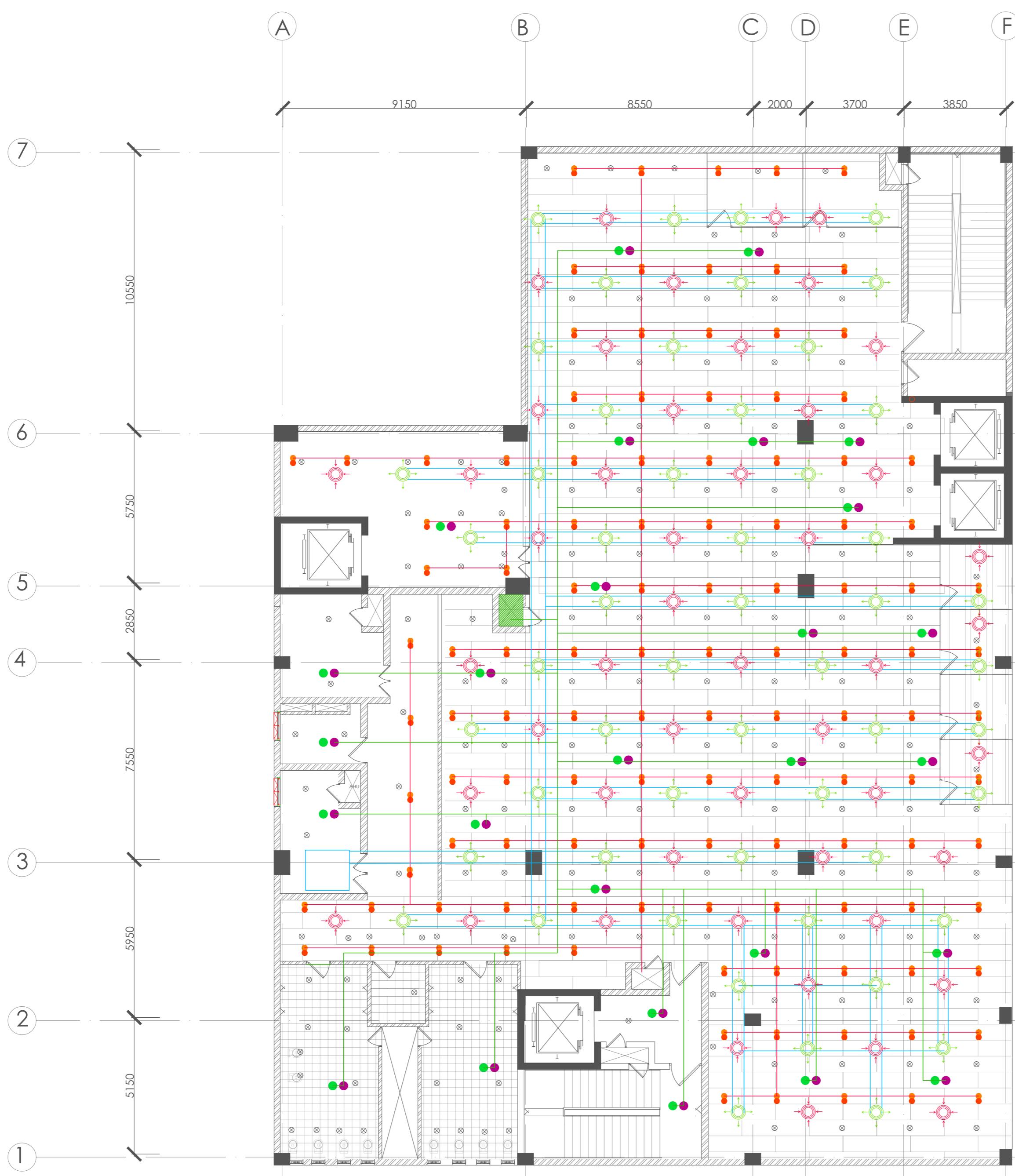
05 - 07 - 2022

R V COLLEGE OF ARCHITECTURE

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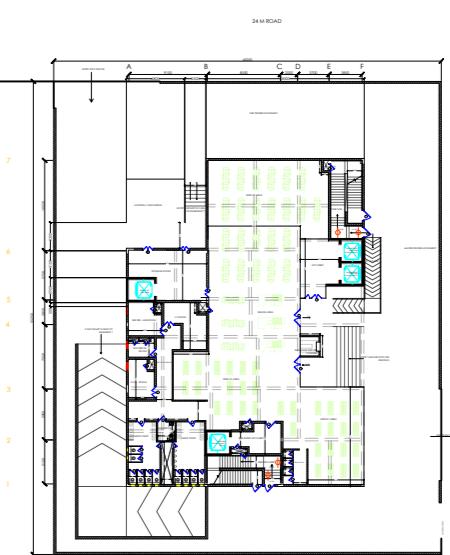
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KEY PLAN



LEGEND

- LIGHT FIXTURE
- SMOKE DETECTOR
- SPEAKER
- UPRIGHT WATER SPRINKLER
- PENDENTIVE WATER SPRINKLER
- SUPPLY AIR DIFFUSER
- RETURN AIR DIFFUSER

GENERAL NOTES

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- ALL DIMENSIONS ARE IN mm.

CLIENT :

CHECKED BY :
ANUPRIYA SAXENA
RAMYA

PROJECT :

ARCHITECTURAL CONCEPT :

DRAWING TITLE :

SCALE :

CRCR 105 .3

1 : 125



SECTION/ELEVATION MARKING

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DISHITA GOEL

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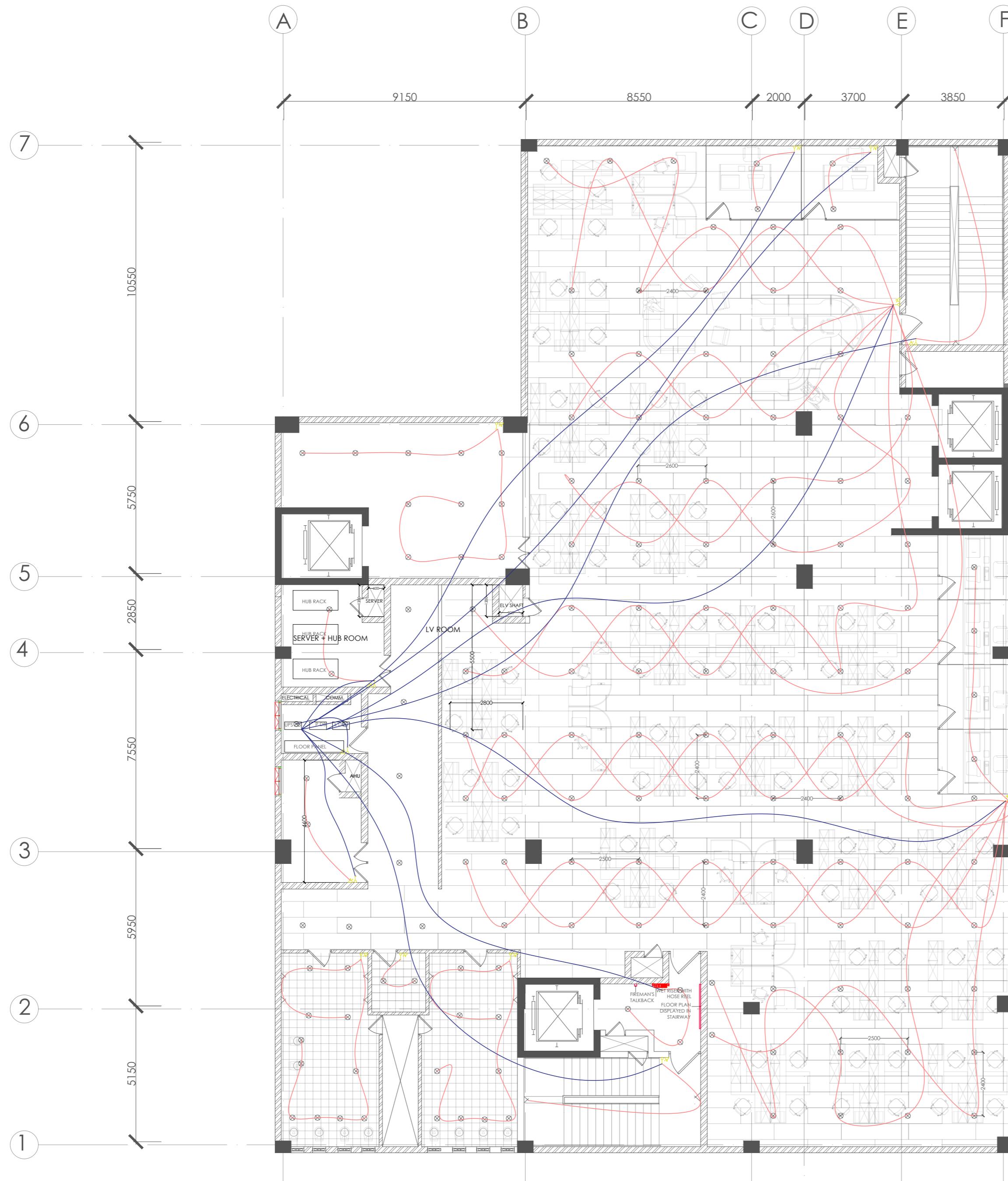
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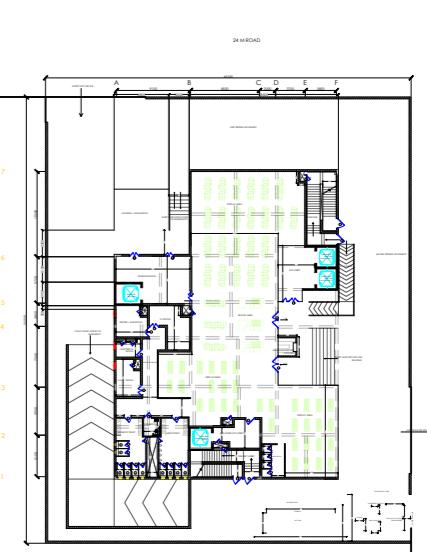
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KEY PLAN



LEGEND

- LIGHT FIXTURE
- SWITCH
- WALL MOUNTED CEILING
- ELECTRICAL WIRING FROM SWITCH BOARD TO APPLIANCE / FIXTURE
- ELECTRICAL WIRING FROM SWITCH BOARD TO DISTRIBUTION BOARD

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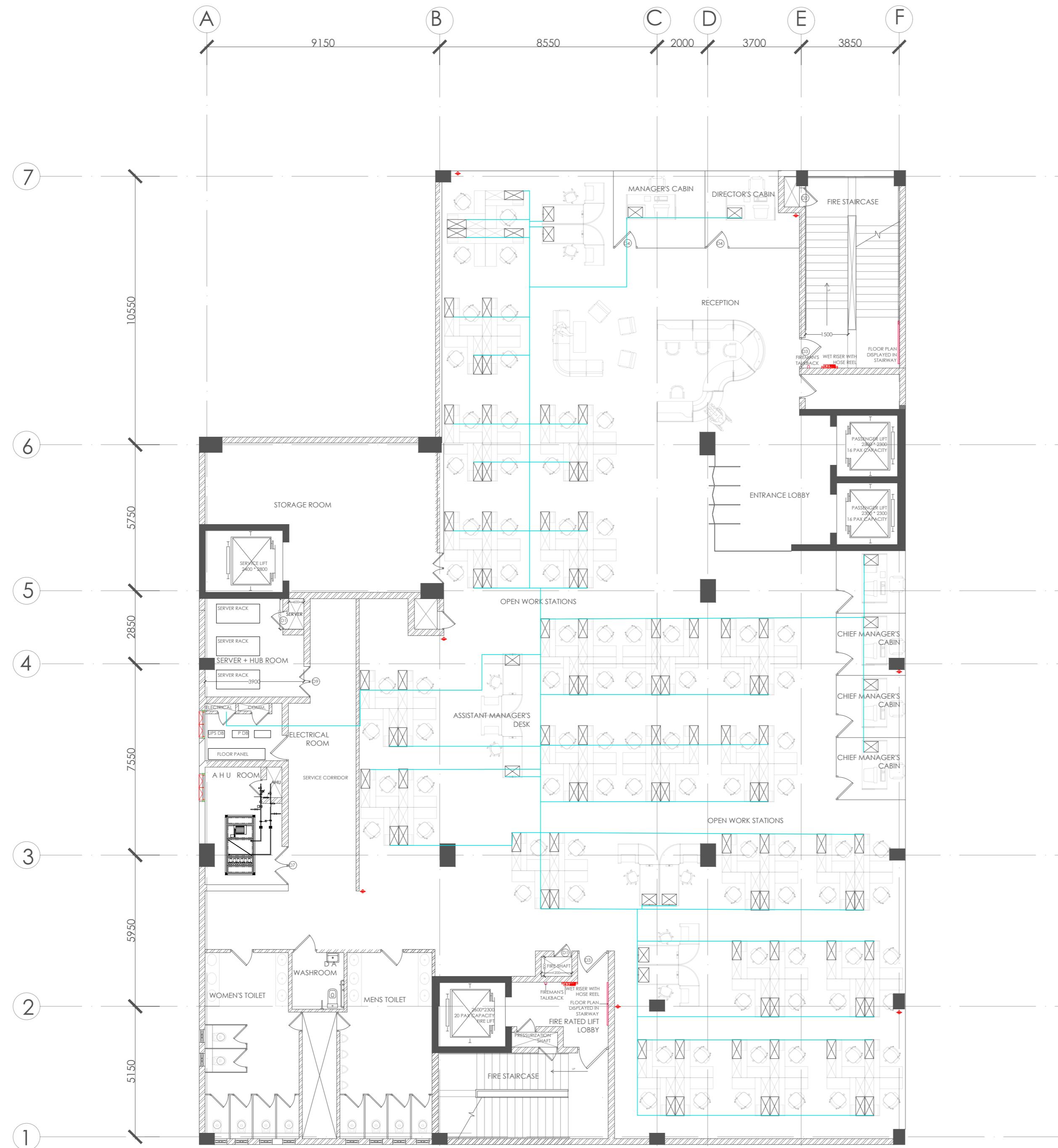
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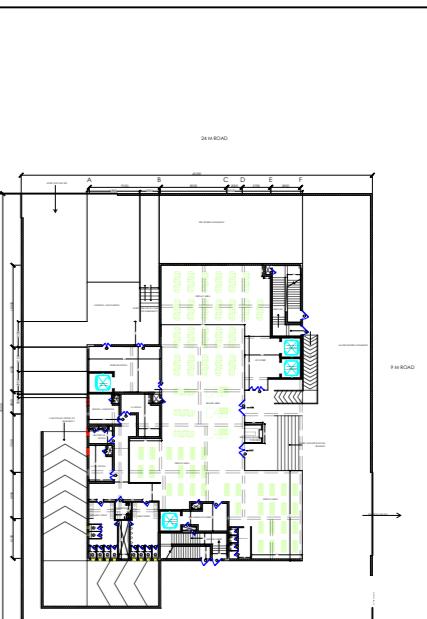
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KEY PLAN



LEGEND

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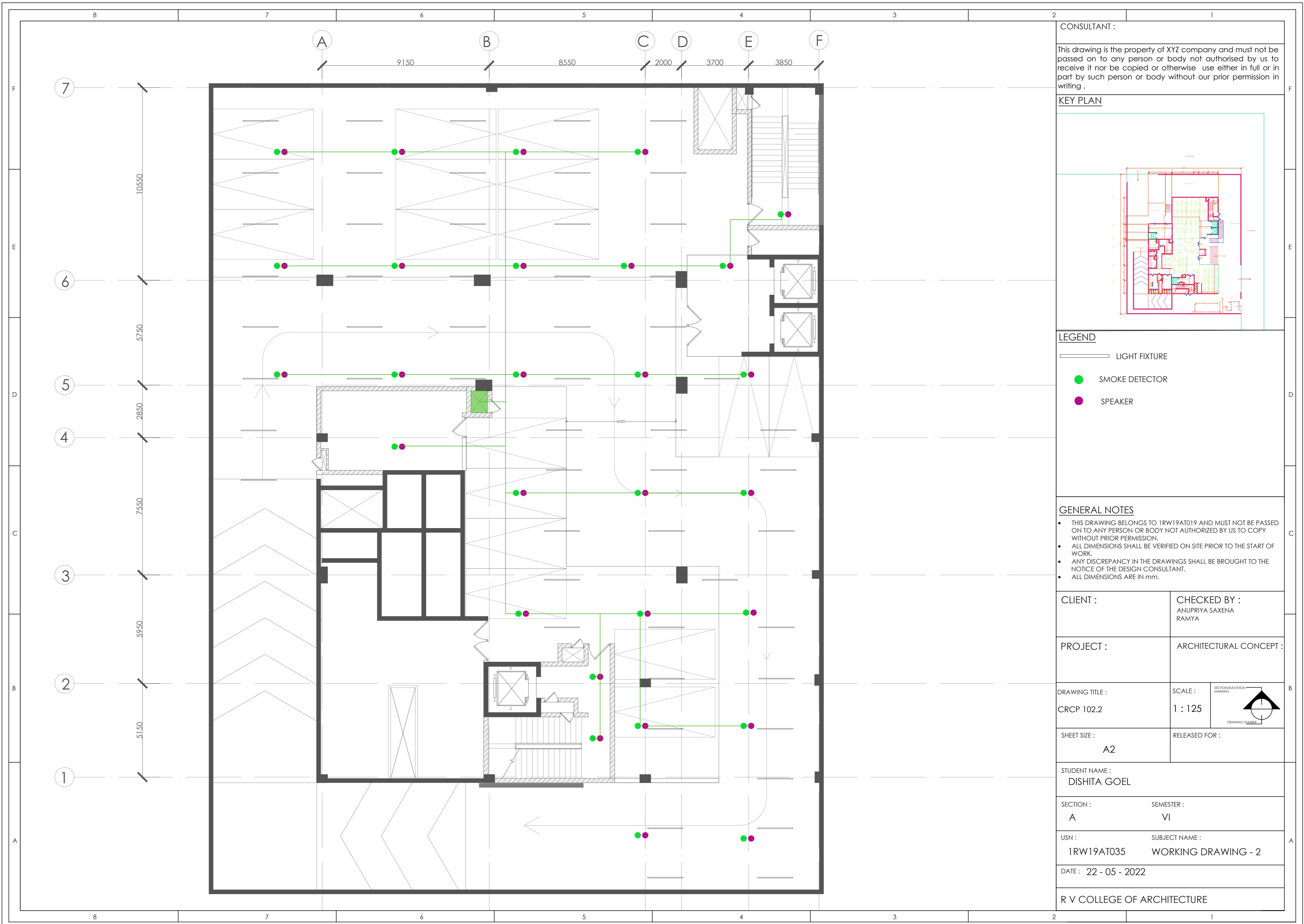
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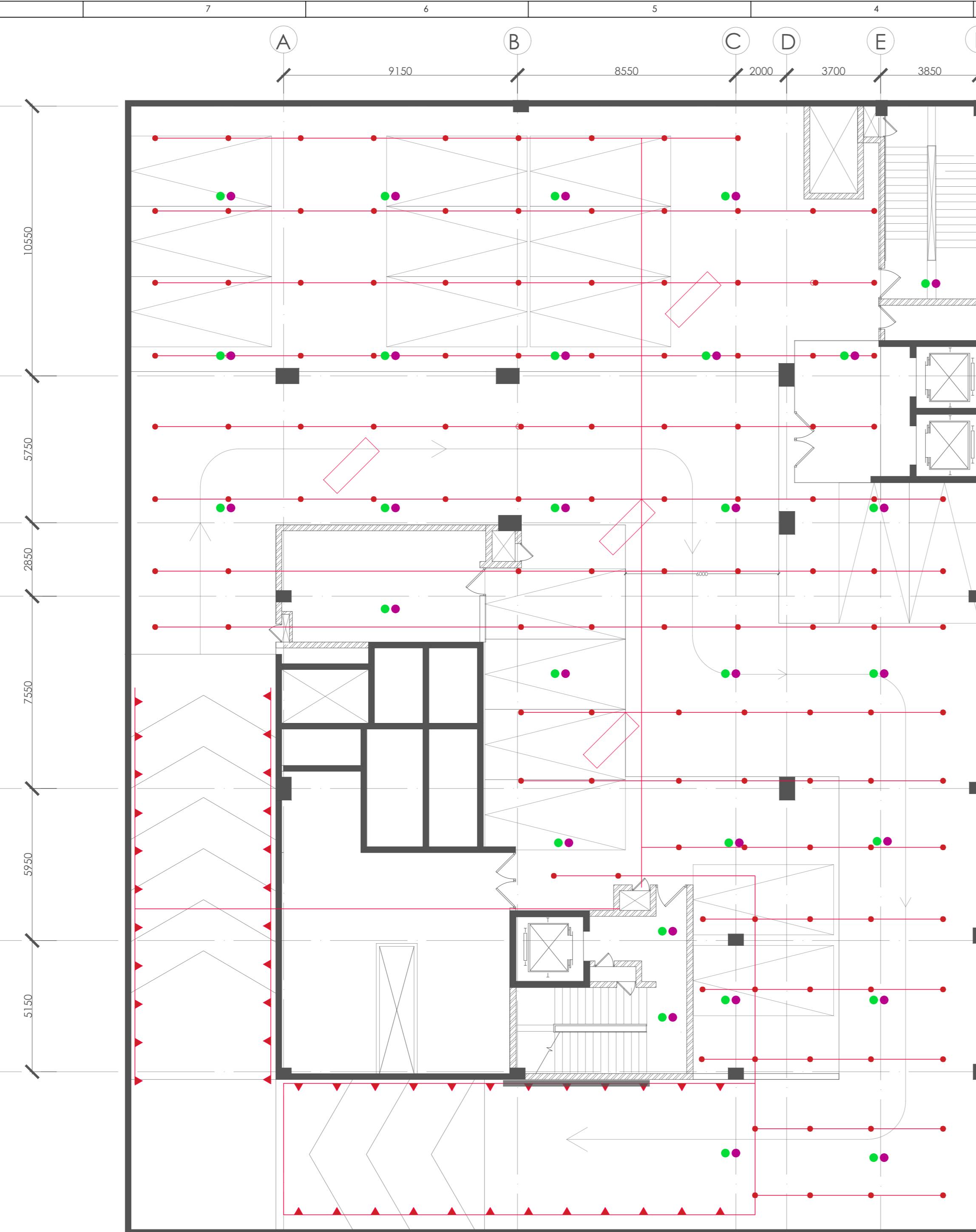
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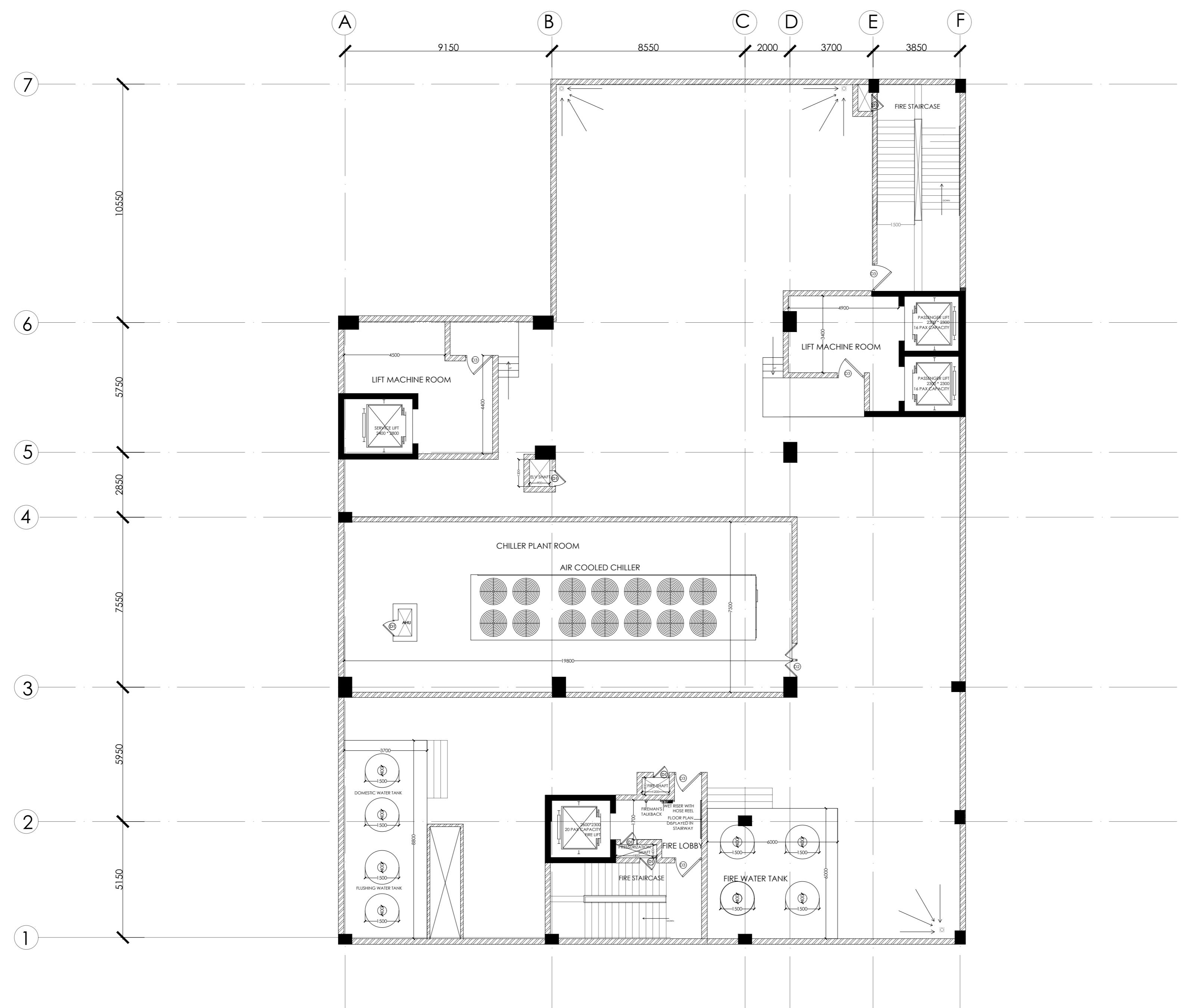




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KEY PLAN	
LEGEND	
LIGHT FIXTURE	
SMOKE DETECTOR	
SPEAKER	
WATER SPRINKLER	
GENERAL NOTES	
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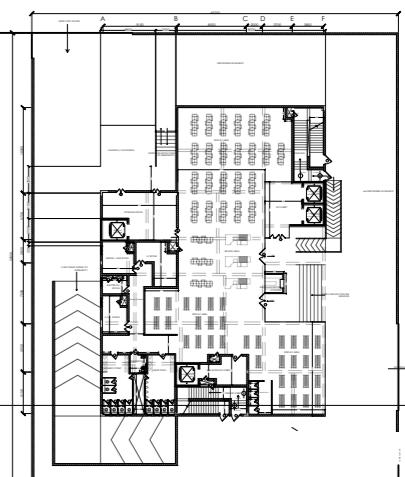


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KEY PLAN	
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PROJECT :	ARCHITECTURAL CONCEPT :
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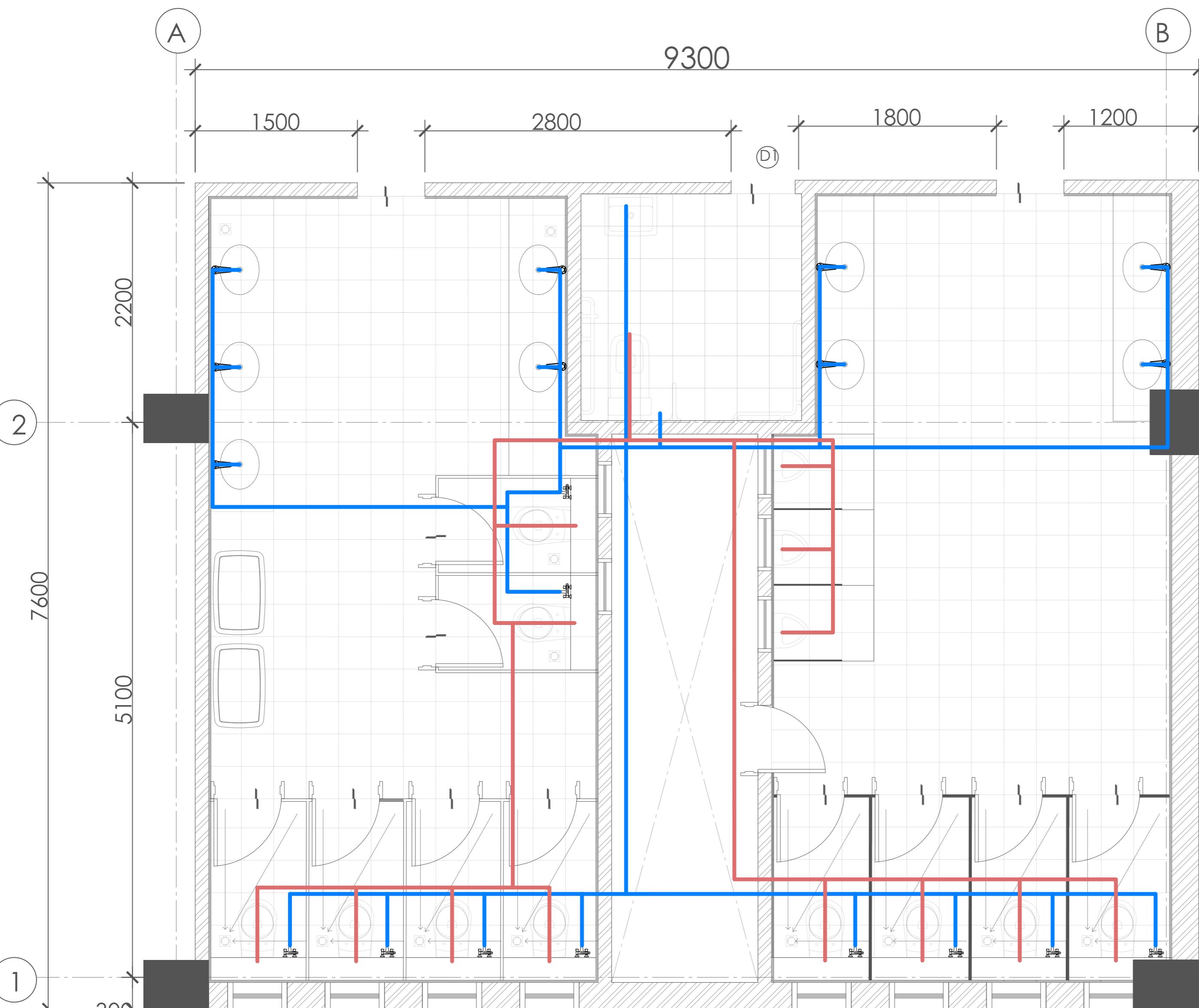
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█ SUPPLY WATER
█ FLUSH WATER

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PROJECT : ARCHITECTURAL CONCEPT :

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TOILET WATER 1 : 30
SUPPLY

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STUDENT NAME : DISHITA GOEL

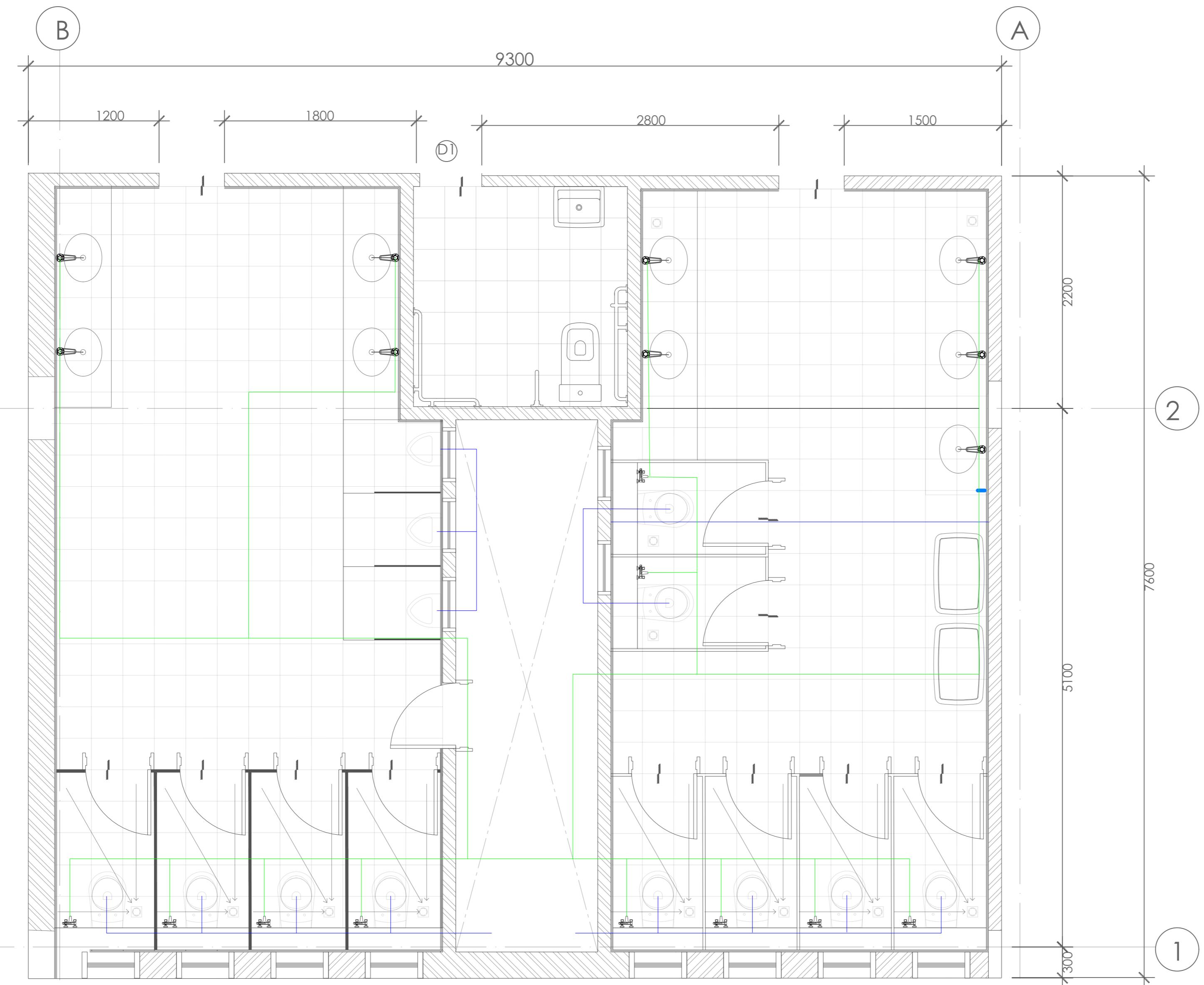
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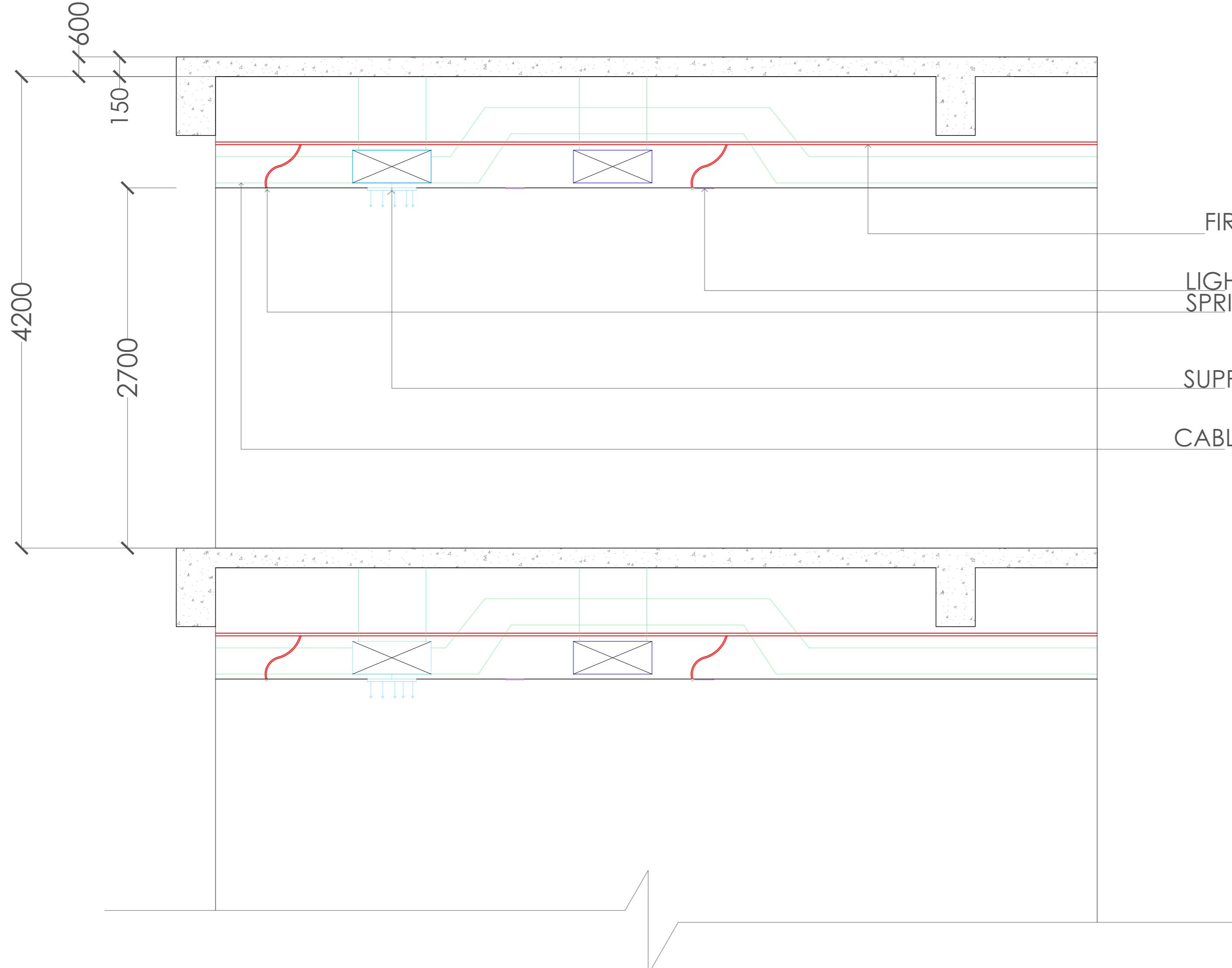
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KEY PLAN				
LEGEND				
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USN :	1RW19AT035	SUBJECT NAME :	WORKING DRAWING - 2				
DATE :	05 - 07 - 2022						
R V COLLEGE OF ARCHITECTURE							



Solar
Decathlon
India



COMMUNITY RESILIENCE SHELTER

FINAL DESIGN REPORT
April 2023



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2. REVIEWERS COMMENTS

REVIEWER 1

SECTION	REVIEWER'S COMMENTS	RESPONSE
Energy performance	Very good strategies with a good mix of passive design strategies and energy efficient fixtures for achieving low EPI. Detailed calculations and analysis provided in the annex. Good job!	Thank you
Water performance	Thorough and detailed presentation of strategies, calculations and analysis used for water management. Please recheck the calculations used for lpd water consumption especially for WC and Urinal. Not clear how you are able to achieve such less water consumption. Commendable job on achieving net positive annual water performance for the design.	Noted, has been incorporated in Section - 8.3, Water performance
Embodied carbon	Excellent analysis showing tradeoffs of the strategies chosen and good achievement in the reduction of embodied carbon. In the computation table in the appendix (section 9.4) need a description for what entails transport 1 and transport 2.	Noted, transportation details have been mentioned in appendix section - 9.9
Resilience	Good integration of resilience measures into the design of the building. Flash floods and soil erosion appear to be frequent hazards in Ittanagar and the design could consider building resilience in infrastructure for these hazards as well	Noted, has been incorporated in Section - 8.F, resilience
Engineering and operations	This section could touch upon the engineering system envisioned for the water system and waste management system. You could also touch upon energy generation from gym and prayer wheels and how the system around it works. Finally you could also touch upon a the labour situation, skills and any training needs for the construction and scalability of your ideas.	Noted, has been detailed in Section - 8.E, engineering and operations
Architectural design	Neat functional spaces and well thought out design and adjacencies. Would be nice to see some internal views as well in terms of material treatment. Finally do consider how an ambulance can access the field hospital.	Noted, Internal views are shown in appendix section-9.3 and the ambulance access is shown in architectural drawings
Affordability	Detailed and extension calculation to arrive at cot per SQM. Also consider labour cost involved especially in new methods of construction and training needs if required.	Noted, has been incorporated while doing the calculations
Innovation	Several innovations have been included that make this proposal very good.	Thank you
Health and well being	The design address both thermal comfort and ventilation requirements in an effective manner.	Noted
Value proposition	The value proposition is very good. It would be good to highlight the value for the project partners first in terms of the USP of the building design and then top it up with added value proposition such as apps and social media.	Noted, has been incorporated in section 8.J - value proposition



REVIEWER 2

SECTION	REVIEWER'S COMMENTS	RESPONSE
Energy performance	the epi looks good and is well presented	Thank you
Water performance	the performance report looks good, is detailed and well presented	Thank you
Embodied carbon	well collated data and good graphics	Thank you
Resilience	looks good. you can put earthquakes under resilience against disasters. Also, see if you can elaborate more on climate change and social resilience	Noted, has been incorporated in Section - 8.F, resilience
Engineering and operations	the drawings are very informative. please include hvac, electrical and waste and water management layouts	The project is naturally ventilated and hence does not use HVAC. Electrical, waste and water management layouts have been shown in the appendix section-9.4
Architectural design	well presented and integrated architectural design	Thank you
Affordability	the affordability report and comparative analysis looks good	Thank you
Innovation	the ideas explored are creative and promising	Thank you
Health and well being	the points covered are relevant and the graphics are well presented and informative	Thank you
Value proposition	The points covered look good. You can open with a note covering the points for the project partner benefits and then move on to the application description	Noted, has been incorporated in section 8.J - value proposition



3. EXECUTIVE SUMMARY



Fig. 1 Context



Fig. 2 Issues

Earthquakes
Seismic zone-v region
Richter scale magnitude - 2 to 6
Mercalli scale values - v to vii

Floods

Flash floods – due to heavy rainfall in downstream areas. Riverine floods occur majorly from the Dikrong River.

Border tension

Border disputes between India and China

Landslides

Debris flows - triggered by heavy rainfall.
Rockfalls - triggered by earthquakes
Soil slips - occurring on gentle slopes



Project partner
To address these issues, the Public Works Department, AP has proposed the construction of the State Disaster Management Agency office building in its capital, Itanagar, where SDMA experts can monitor the situation, and coordinate and facilitate relief efforts during crisis.

We, team EnCircle as part of the Solar Decathlon (India), have taken this opportunity to design a net-zero energy community resilience shelter for the PWD AP in Itanagar. We aim at improving the microclimate of the space (using GRIHA strategies) and provide shelter, aid, comfort, social resilience, water and food resilience to people during disaster. Our proposed project Aikyam, is a G+2 storeyed office building situated in the Civil Secretariat complex at Itanagar, with a site area of 3640 smt, adjacent to NH415.

Office

Uninterrupted workflow even during disaster

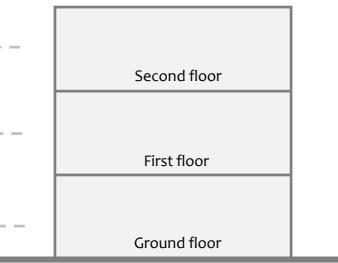
Refuge shelter

The design we finally arrived at, provides not only a comprehensive usage pattern during normalcy, but also can swiftly transform to a Community Resilience Shelter

The Second floor is reserved exclusively for the offices of the SDMA which has.

The First floor comprises of Workshops and a small conference room, along with day-care center for employee children, as also a dormitory for visiting officers from other locations. These, while meant primarily for the SDMA training purposes, can be pressed into service as a part of the disaster shelter, whenever necessary.

The Ground floor, mostly comprises of common-use areas such as the Canteen facility, the appurtenant Kitchen and Store, but also Public-use areas such as a Bank, a Gymnasium, and Workshop / Auditorium which may be leased out if needed.



Second floor

First floor

Ground floor

Fig. 3 Program

Design process and solutions – Being a structure that could function as community refuge, our main aim was to provide resilience during all circumstances. The potential disasters on site are landslides and earthquake. Floods are not an issue due to the slope of the site. Landslides are countered using gabion walls while earthquakes are countered using pile foundation, bamboo reinforced walls and other material usage like polycarbonate and linoleum.

HIGHLIGHTS



Water resilience

The building can store enough for 4 days during times of disaster



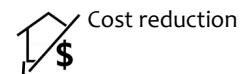
Food resilience

An underground food/medicine storage system has been proposed, for use during disasters - this works on the principle of cooling through wind energy.



Social resilience

Strategies to ensure well-being of people at all times have been proposed.



Cost reduction



Climate resilience

Improving the microclimate and strategies to combat climate change



100% natural ventilation

Passive strategies have been used to maximize daylight, in addition to ventilation.



Net zero energy (EPI: 21.5 kWh)

Solar PV panels and other innovative solutions have been used.



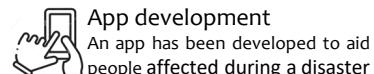
Net positive water

8,663 kl of rainwater are harvested per annum, of which only 30% is consumed, and the rest may be contributed to the Public Water Supply system.



Low embodied carbon materials

Use of local, rapidly renewable, recycled and recyclable materials and fly ash-based products



App development

An app has been developed to aid people affected during a disaster



Flexible interiors

Conversion of the building to refuge shelter during disaster scenario



Disaster resilience

Resilient to man-made disasters, conflicts, pandemics and natural disasters. 122 people may be sheltered during a pandemic, 209 in case of conflict, and 460 during other disasters.

INNOVATIONS

Innovative solutions have been proposed that effect a quick conversion of the public / common areas of the building into a refuge shelter, using ingenious systems of furniture that may be transformed to beds, as needed. Furthermore, extra beds have been designed, which may be stored in flattened form, and brought into play when needed. Extra toilets, to serve the community in case of a disaster, have again been proposed - these were inspired by the telescopic drawing rolls that all architectural students use - and can be stowed away, when not needed. In addition, keeping the religion of the area in mind, we have also proposed a system of power generation that we call the "Power of Prayer", which is detailed in a later section.



4. TEAM INTRODUCTION

4.A. Team Name : En-Circle

4.B. Name of Institutions : RV College Of Architecture, RV College Of Engineering, RV University.

4.C. Competition division : Community Resilience Centre

4.D. Team Members and team organization



Fig. 4 Team members

4.F. Background of the Institution:

R.V. College of Architecture (RVCA), established in 1992, as the Department of Architecture in R. V. College of Engineering (RVCE), Bengaluru. The courses offered include B.Arch and M.arch which deal with topics like architectural design, graphic design, interiors, structures and also the integration of modern digital means in the design process. Main RVCE campus offers many undergraduate and post graduate courses including almost all branches of engineering. RV University offers undergraduate courses including B.Sc, B.Com, B.Des, B.B.A, B.A and PG courses including M.Des, M.A and M.Tech.



Fig. 4 RV Group of institutions

4.H. Industry partner:



Fiducia | AI
Connecting consumers with brands in physical, digital world and metaverse

Fig. 5 Fiducia | AI logo

Fiducia | AI Inc. started in Sep'2021 with a vision to deliver traceability and transparency applications for multiple industries by using technologies that give capability to Brand Owners to connect to consumers with their Brands in Physical World, Digital World and Metaverse. Brands can convey their story to their consumers using augmented reality, video and content.

4.I. Design Management Process:

Team EnCircle followed an integrated design approach in order to establish a strong interrelationship between all the contests. An orderly schedule was formulated to organize the work efficiently. Weekly meetings with the team were held to update about individual research and debate on design. There were regular discussions with the faculty lead and advisor and their suggestions were evaluated and applied. The members have researched in various disciplines and reached out to people in respective fields of expertise. The team has been communicating with the project partner back and forth, thereby incorporating their feedback.

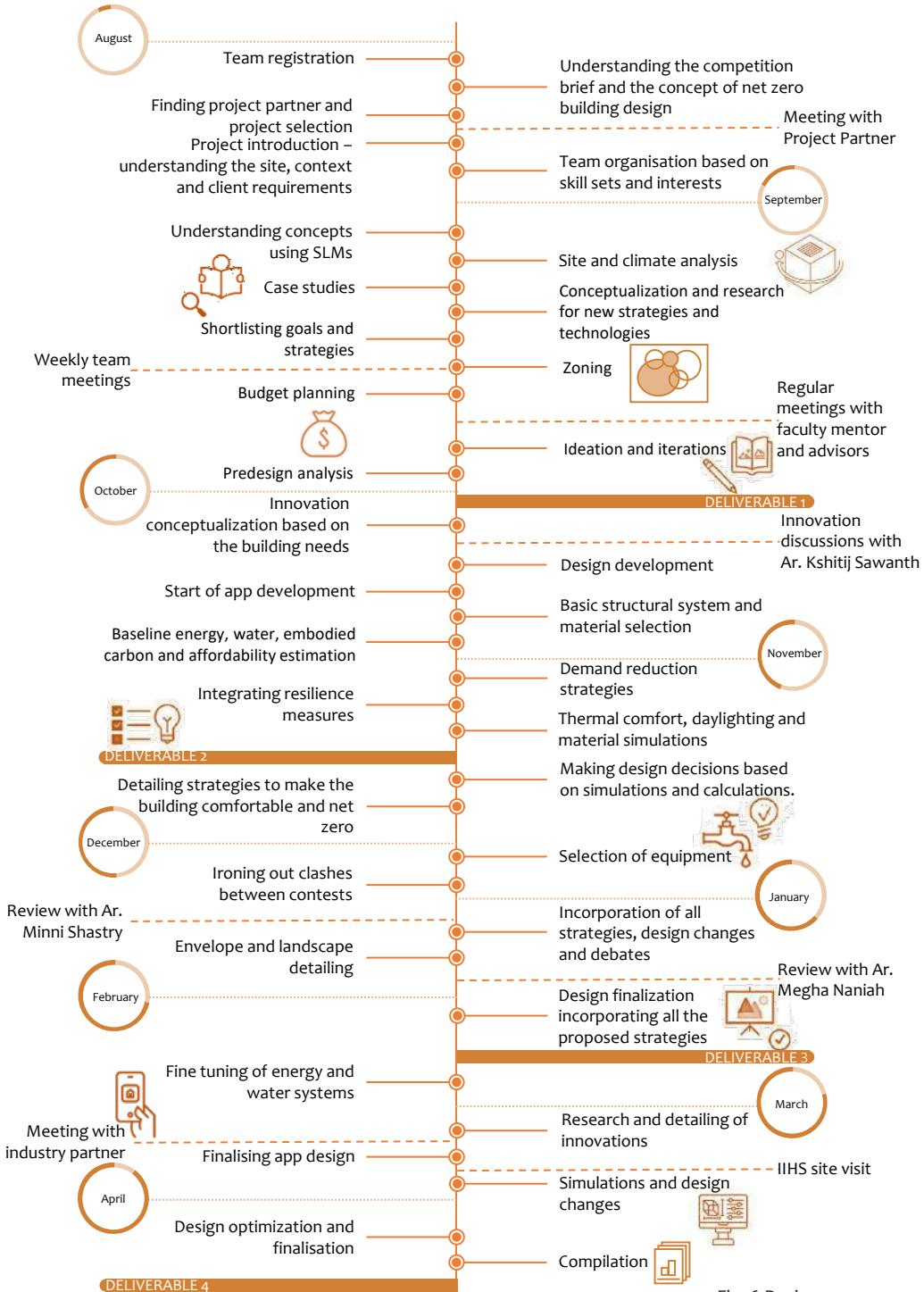


Fig. 6 Design management process

4.J. Tools Used:



Fig. 7 Tools used

5. PROJECT INTRODUCTION

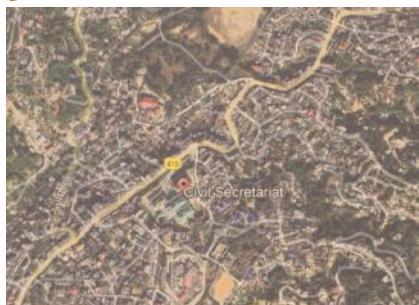


Fig.8 Satellite image of Itanagar
Source : Google Earth



Fig.9 Context plan

5.A.Project name : Aikyam

The Sanskrit word “Aikyam”, which implies oneness, harmony, and unity, is a good fit with the adage "unity in diversity." To provide a venue for the community, which is seen as the first line of response following a calamity while simultaneously promoting social interaction under regular circumstances.

5.B.Project partner: Public Works Department, Arunachal Pradesh. About the project partner: The Public Works Departments, Arunachal Pradesh being the Nodal Agency for premier construction department with presence in all parts of the state. The main activities of the PWD are mainly the construction of roads, bridges, RCC Slab Culverts, RCC Hume pipe, CC Drain, retaining walls, and breast wall, buildings both residential and non-residential under the different head of accounts such as RIDF, CRIF, SPA, etc. and maintenance work of all the above heads.

5.C.Project brief: The Public works department is responsible for the construction and maintenance of government infrastructure. The region is prone to natural calamities, and owing to the climatic conditions the occupants are at constant risk. To overcome these perils the PWD AP has proposed the construction of an office for the state disaster management officials to monitor and provide relief in the event of any forthcoming danger. It is set within the Civil Secretariat complex of Itanagar, within a site area of 3640 square meters adjacent to the national highway 415(NH415). The intent is to construct an office building that is resilient under all conceivable disaster events. Under normal conditions, the building functions as a government office with related training and public functions, whereas during a disaster apart from functioning as an office it also shelters the affected from nearby areas.

Other buildings situated in this complex include police headquarters, department of public relations, human rights commission and department of rural and urban development.

Status of the project : Unbuilt



Location: Itanagar,
Arunachal Pradesh



Latitude: 27.08° N,
Longitude: 93.61° E



Climate:
Humid subtropical

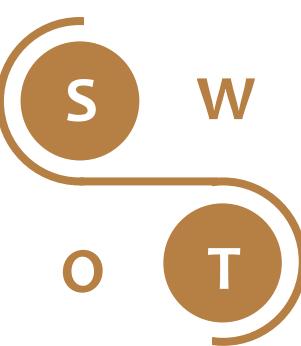


Profile of occupants: Hours of occupation:
Govt officials & NGO, 8 hours
Village & Voluntary
trainees



Strengths - The site is located in the Civil Secretariat region, making it easier for local people to locate in times of disaster since it is a landmark. Heavy rainfall helps in rainwater harvesting. Solar radiation allows for the generation of electricity.

Opportunities - Located near the NH415, facilitating with specialized if any during the time of disaster. The internal and external roads allow for easier accessibility for the locals as well as the office goers. The existing contours help in drainage without any great difficulty.



Weakness - There is no existing vegetation on the site and the site is not very green. The state's bylaws only allow a building to be built of a height of not more than 17m.

Threat - The site lies in an earthquake zone. There is high humidity. Flash floods are common in the location.



5.D.Building use:



Office

Whole second floor; First floor – records, server room, visitors room; Ground floor – food court, gym



Training

Only education and workshops



Disaster

Entire ground and first floor

Total site area	3640 sq.m
Max permissible FAR	2
Max permissible built-up area	7279 sq.m
Max permissible height	15 m, 17.5m with stilts
Proposed total built up area	4240 sq.m (1.16 FAR)
Proposed ground coverage	43.25%
Proposed height	3.75 x 3 =11.25 m
Setbacks	5 m
Occupancy - normal times	Office - 70 people, Training - 112 people
Occupancy - disaster times	Refugee seekers – 460, Officers - 70

Table i. Building use

5.E.Special Requirement by project partner:

- The project partner looks to expand the project by adding a health care facility as an extended program, as a result of frequent natural disasters, compared to the rest of India
- The design should be aimed at achieving as close to net zero as possible
- The project partner looks to achieve a lower cost per sqm in comparison with going market rates without compromising on the efficiency of the building
- The office department in the proposed building is required to continue to function being self sufficient even during disruptions due to natural calamities, therefore being multifunctional.

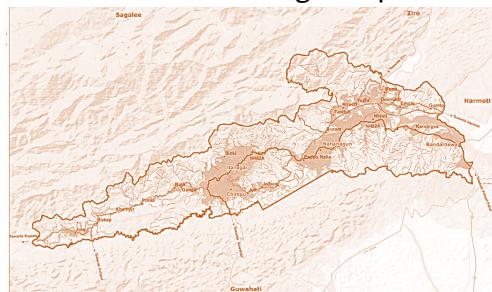


Fig.10 Context map
Source : Google Images

State area: 83,743 km²

Capital: Itanagar is the capital of Arunachal Pradesh, India. known for its scenic beauty, Buddhist culture and heritage.

GDP: 9,357 (Rupees in crores)

International Border: 1628 kms

Major Towns: Itanagar, Naharlagun, Tawang, Bomdila



Important Minerals

Dolomite, Graphite, Coal, Quartzite, Limestone, Crude Oil, Natural Gas, Yellow ochre marble

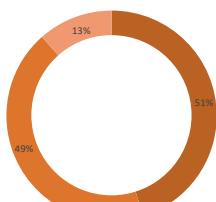


Fig.11 Population



Natural disaster

Under seismic zone V and experiences moderate to high risk of hazard with a magnitude 4 - 8.



Local materials

Bamboo, straw, stone, clay, cane, adobe.



Labor: Mostly works under the supervision of a labor contractor. Wages per person is about Rs. 350 to 400/day according to the PWD AP 2021 schedule of rates.



Fig.12 Division of Industries

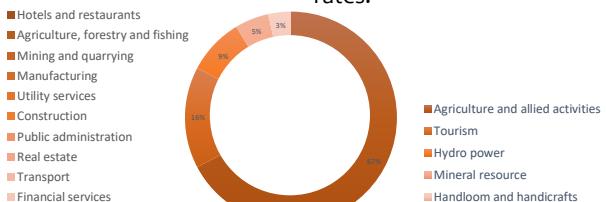


Fig.13 Economy division

Market potential : Our proposed building is a multi-functional building. It functions continually as an office department. The training and related public functions are created as per client special requirements as an aiding factor during disaster as well as for community engagement during normalcy. Workshops shall be conducted as per state/national DMA with respect to construction of temporary shelters, first aid and rescue; other helpful skills during disaster.

Rental opportunity: The Gym and Bank which had been asked for by the client could be used as a source of income during normalcy. This building pays for itself during normal times, functioning as an office and training center. During disasters however; the training and some public areas have been designed to convert quickly to refuge shelters. A similar program could be replicated across the country if needed. Number of innovations have been proposed - vide the furniture, the toilets and the app towards this end. These have been discussed in detail in section 8.



6. GOALS



ARCHITECTURAL DESIGN

To implement design strategies that help the community during disasters, while still functioning as an office at other times. (**achieved by the architectural design**)



EMBODIED CARBON

The total embodied carbon emissions of the project to be at least 50% less than the base case. (**68% achieved**)



INNOVATION

1. Customizable elements that can mold themselves based on user's needs. (**achieved using different kinds of furniture and collapsible toilets**)
2. Using peoples' activity to generate power. (**achieved using prayer wheel and gym equipment**)



AFFORDABILITY

1. Achieving optimal timing for construction. (**24 months**)
2. Minimizing construction cost by atleast 10% (**27.5% achieved**)



ENGINEERING AND OPERATIONS

1. To establish efficient coordination amongst the various systems (**achieved**)
2. To develop a context specific building structural system and envelope (**achieved**)



RESILIENCE

1. Improving water-resilience and self sustaining site. (**achieved**)
2. Providing earthquake resilience, pandemic resilience and climate resilience. (**achieved**)



VALUE PROPOSITION

1. To engage community to prepare them consciously in times of a disaster (**achieved**)
2. Understanding and working with the mindset - perspective of both occupants and investors. (**achieved**)



ENERGY PERFORMANCE

1. Achieve net zero energy and EPI value of 50 kWh/sq.m annually or less. (**21.5 kWh/sq.m achieved**)
2. To provide energy backup that can sustain the facility for 4 days of disaster. (**achieved**)



HEALTH AND WELL- BEING

1. Achieve acceptable IAQ as per ISHRAE. (**achieved**)
2. Achieve indoor comfort levels. (**achieved**)
3. Maintaining optimum lux levels. (**achieved**)
4. Promoting the well being of a person under all conditions (**achieved**)



WATER PERFORMANCE

1. Achieving net zero water and self sufficiency for 4 days during disaster. (**achieved**)
2. Curtailing water consumption for the operation of the building by minimum 50% (**achieved**)



7. DESIGN DOCUMENTATION

7.A. ARCHITECTURAL DESIGN

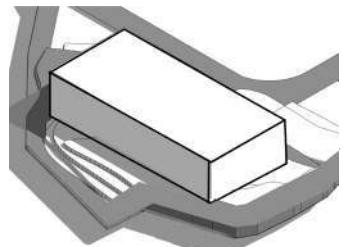


Fig 15a. Orientation

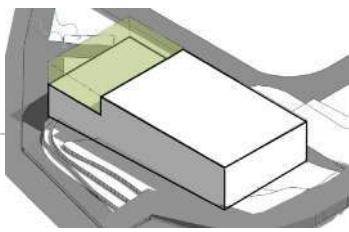


Fig 15b. Stepping, push and pull

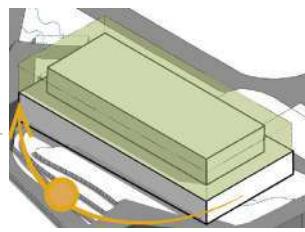


Fig 15c. Solar direction

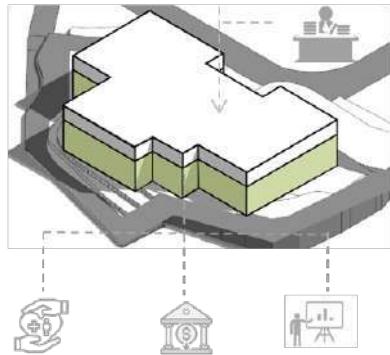


Fig 15d. Zoning

Due to the dual programmatic nature, the building is divided into two vertical zones, with the public functions happening on the lower floors, allowing the office to run without any disturbance and with privacy.

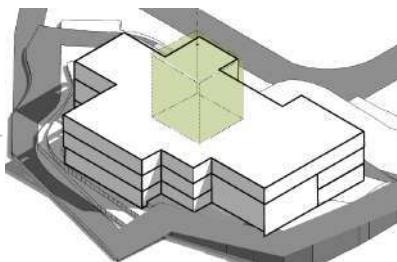


Fig 15e. Atrium

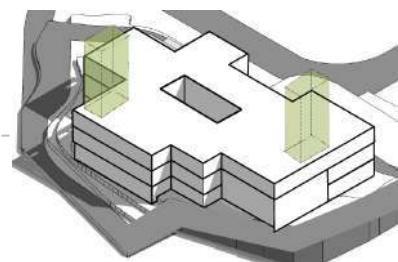
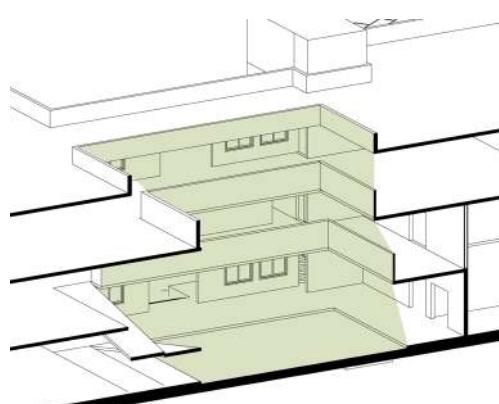


Fig 15f. Vertical circulation



For providing shade to the large interior spaces

STEPPING AND PUSH-PULL

- Creates an interesting form
- Allows for terraces to be formed on multiple levels
- Helps with terrace gardening
- Breaking the volume
- introduces visual connectivity among the levels.

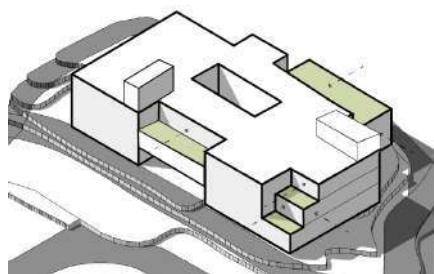


Fig 15g. Terraces

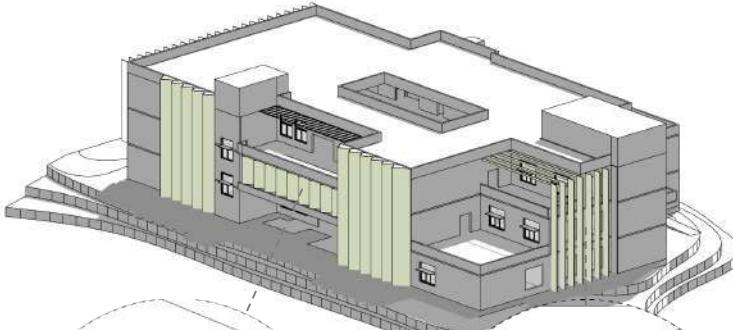


Fig 15i. Fins

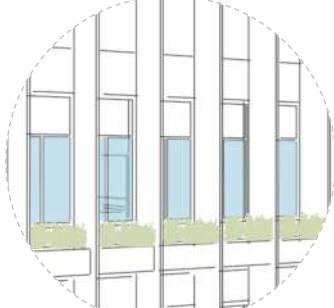
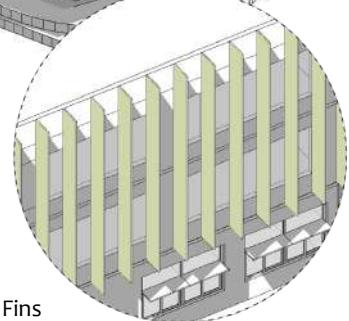


Fig 15h. Planter boxes



Fins and louvres at a calculated angle to properly shade the spaces inside and allow north light directly into the spaces.



Introduce greenery in the site



Fig 16a. Ground floor plan



SEMINAR HALL

During normalcy, the building acts as both, an educational community centre as well as an office.



VIEW FROM FIRST FLOOR
LOOKING INTO ATRIUM

The ground and first floor host leased out spaces for bank and gym and also as spaces where workshops and seminars are held, teaching people how to take precautions and survive if a disaster were to occur as well as how to rescue and aid others. These spaces could also be rented out for community programs.



OPEN OFFICE

The top most floor acts as an office for the state disaster management officials to monitor, coordinate and facilitate relief works in the event of any forthcoming danger.

Fig 16d. Views

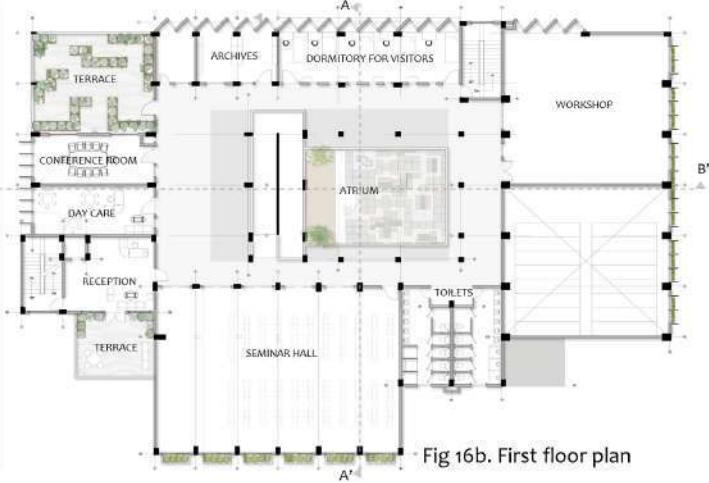


Fig 16b. First floor plan

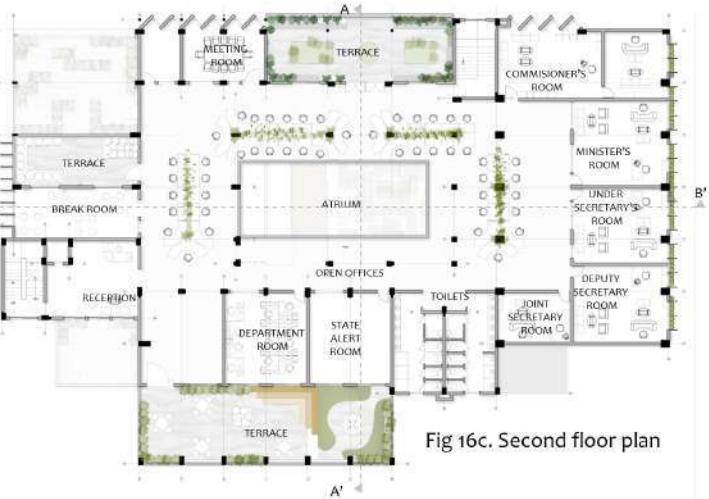
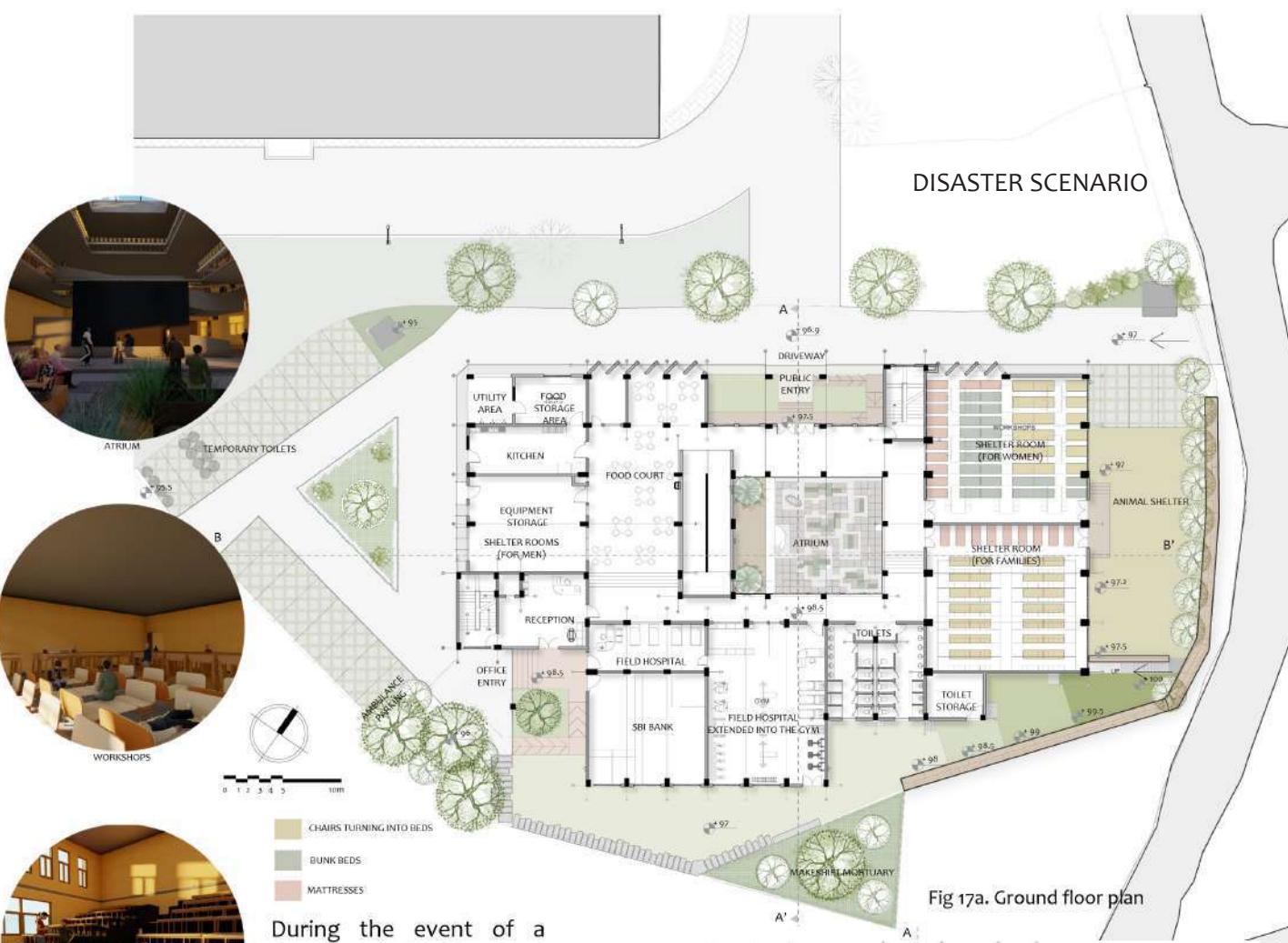


Fig 16c. Second floor plan





DISASTER SCENARIO

Fig 17a. Ground floor plan



SEMINAR HALL

During the event of a disaster, the building acts as a disaster shelter as well as a functioning office.



VIEW FROM FIRST FLOOR
LOOKING INTO ATRIUM

Now, the ground and first floor, can house refugees, with the original furniture turning into beds in some places. Some existing stalls in the washroom turn into baths and temporary washrooms, housed in the toilet storage are also brought out.



OPEN OFFICE

The top most floor continues to function as an office for state disaster management, helping monitor and coordinate relief works during the disaster.

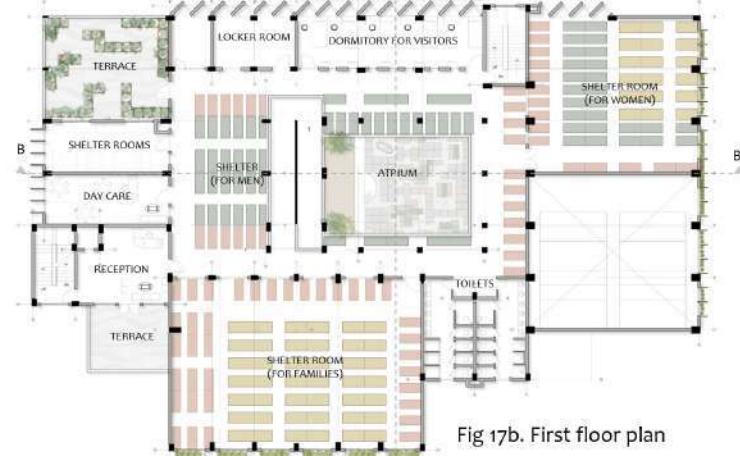


Fig 17b. First floor plan



Fig 17c. Second floor plan





Fins with planter boxes



Office balcony with pergola



Office entrance



Saw tooth wall for north light



Balcony with community garden to grow food



Fins

Fig 18. Interior views

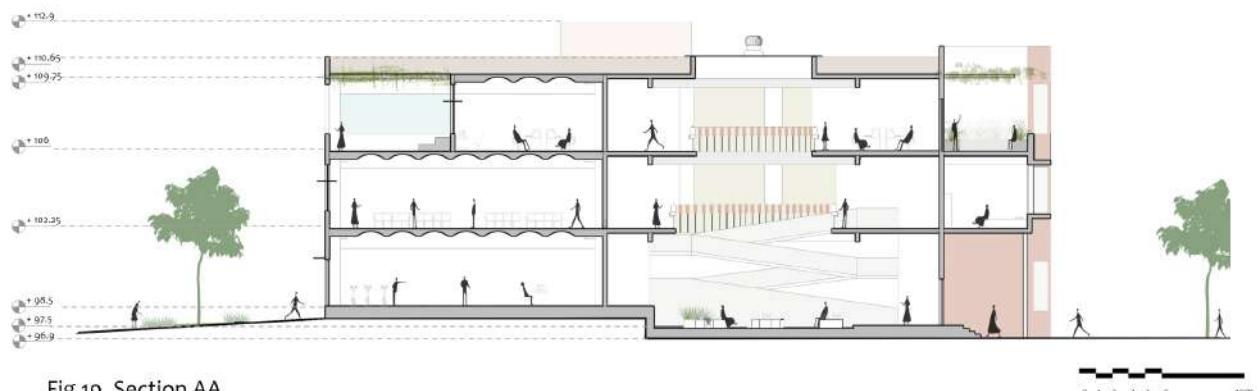


Fig 19. Section AA

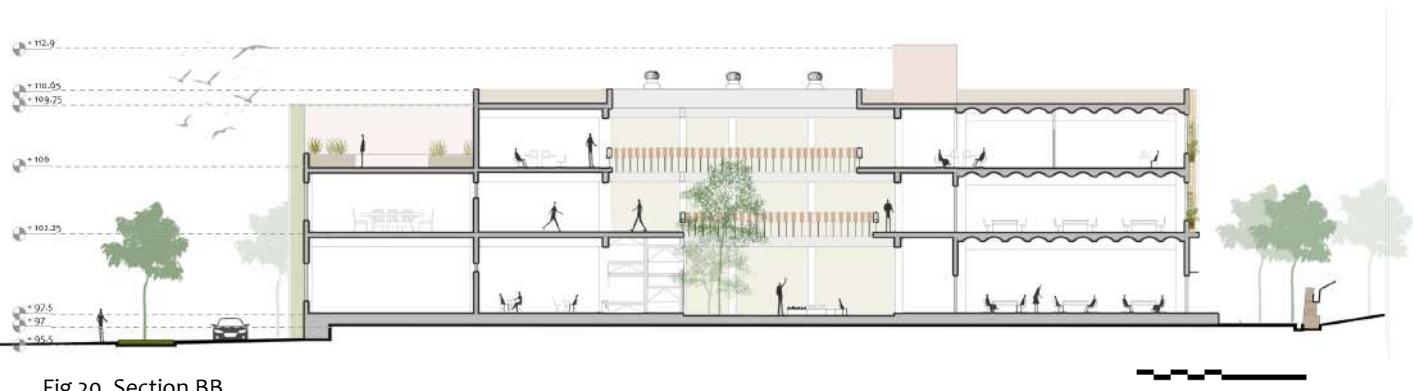


Fig 20. Section BB



7.B. ENERGY PERFORMANCE

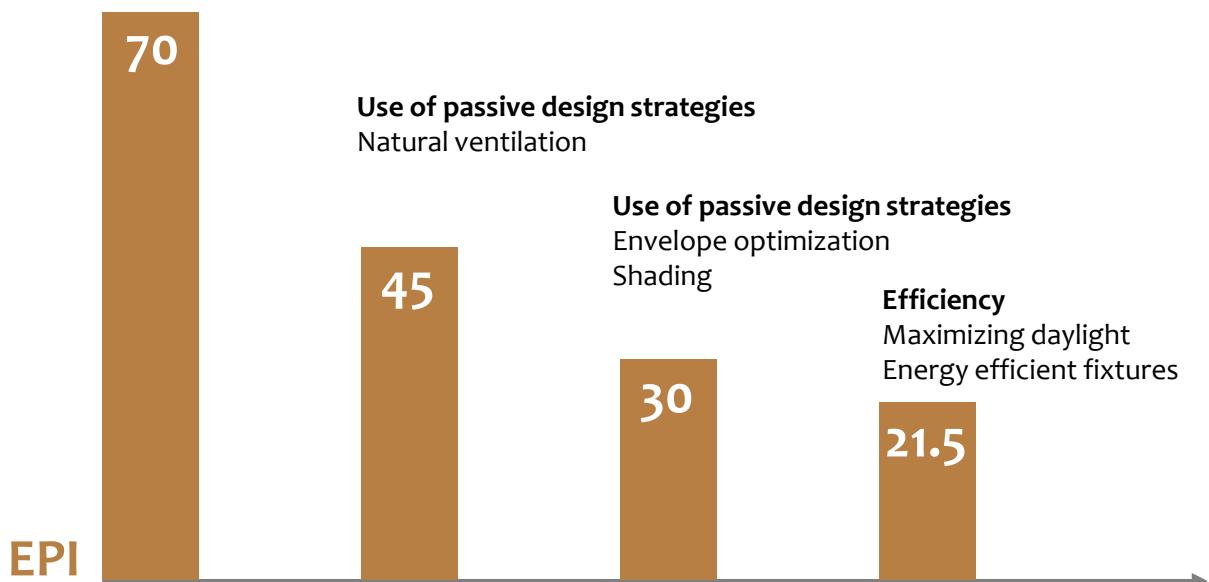


Fig. 21 : Reduction of EPI using various strategies

BUILDING ENVELOPE OPTIMISATION

Solar radiation simulations helped identify areas of the building that are subjected to excessive solar radiation and heat gain, resulting in discomfort or increased cooling loads. This has been used to design shading devices for each façade to reduce solar heat gain and glare, while allowing for ample daylighting to maximize natural lighting in the building.

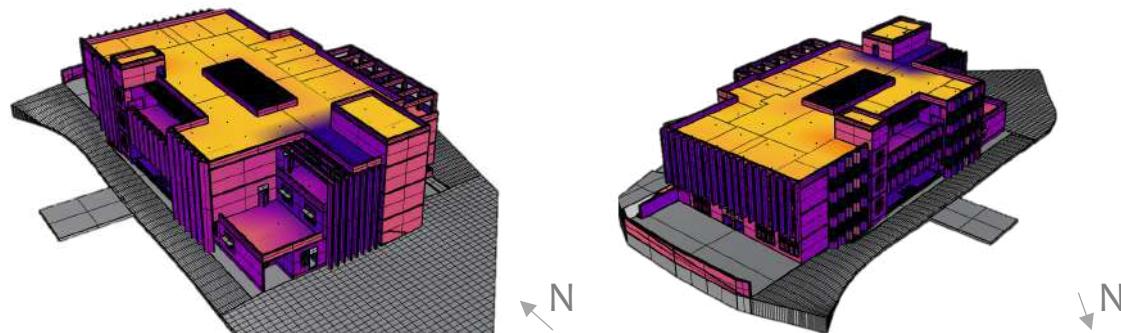


Fig. 22 : Solar Radiation simulation

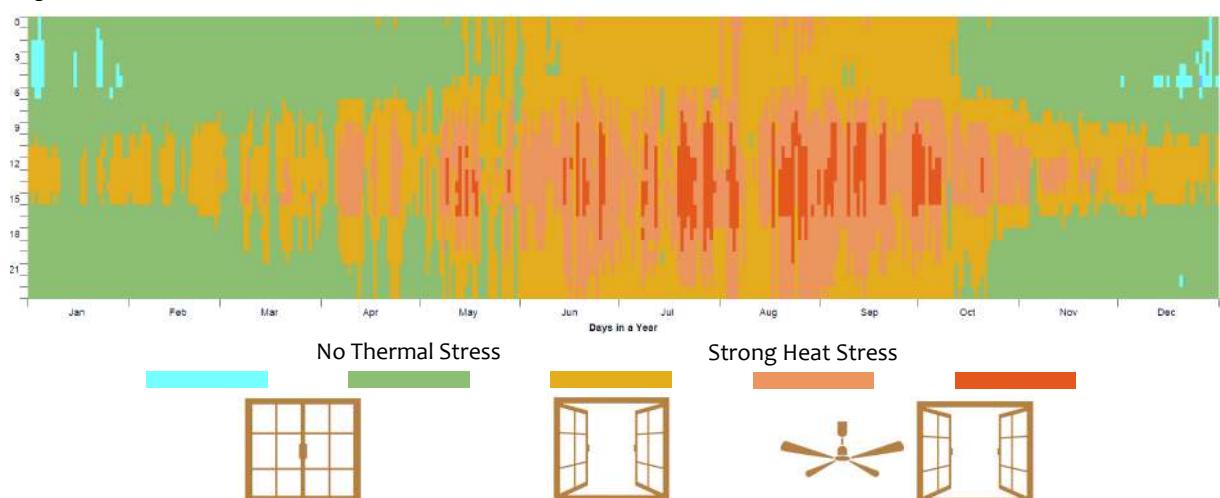
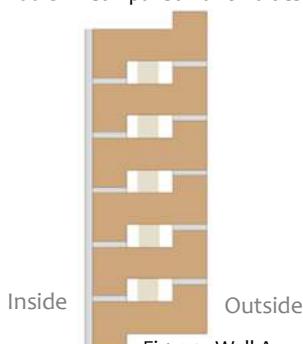


Fig. 23 : Thermal comfort strategies based on UTCI



COMPONENT	BASE CASE	PROPOSED CASE
Wall	200 mm AAC block wall U-value : 0.31 W/m²K	200mm th. Z-shaped Earth blocks with 80 mm air gap and 40 mm Bamboo reinforcement with 10 mm plaster on the interior. U-value : 0.31 W/m²K
Slab	150 mm RCC slab U-value : 1.25 W/m²K	150 mm RCC slab with Fly ash concrete, Bamboo reinforcement and recycled steel U-value : 0.88 W/m²K
Window	4 mm Clear glass U-value : 4.8 W/m²K	Double glazed unit consisting of 2mm Polycarbonate and 6mm air gap. U-value : 3.6 W/m²K

Table ii : Comparison of U-values of materials



The walls are made up of Z-shaped Earth blocks, which create an air gap of 80 mm. This air gaps provides insulation and reduces heat gain in summers and heat loss in winters. Although AAC blocks have the same U-value, earth blocks have been considered owing to the embodied carbon content in AAC blocks. For windows, polycarbonate sheets (earthquake resistant) with air gap for insulation have been used for glazing.

Fig. 24 : Wall Assembly

ENERGY EFFICIENT FIXTURES

LPD	BASE CASE (W/m ²)	PROPOSED CASE (W/m ²)
Workshops	17.1	6
Office	10	5
Meeting rooms	11.5	5
Kitchen	12.1	4
Toilets	7.7	2
Storage	6.8	2
Corridors/ Staircases	5.5	2

Table iii : Comparison of Lighting power densities

The lighting loads for base case are based on LPD given in ECBC 2017 guidelines for various spaces. The proposed light fixtures are Ceiling Mounted LED Battens of 36W and Ceiling LED Downlight 10W, 100 lumen output per Watt. To enhance air flow along with natural ventilation, fans with BLDC motor have been proposed as they consume 60% less energy compared to standard ceiling fans.

(Refer to appendix for detailed calculations).

FIXTURE	DESCRIPTION
	Crompton LED Batten 36W, 100 lumens per Watt
	Crompton LED Downlight 10W, 100 lumens per Watt
	Atomberg Efficio Energy Efficient Ceiling Fan with BLDC Motor
	Atomberg Efficio Energy Saving Exhaust Fan with BLDC Motor
	Wind Operated Turbo Ventilator

Table iv : Details of fixtures



SOLAR POWER GENERATION

LOADS	Annual Energy Consumption(kWh)
Lighting load	18645
Equipment load	64957
Ventilation load	7713
TOTAL	91315
Total built up area	4240
EPI achieved	21.5

Table v : EPI calculation with loads

The load calculations are based on a working period of 8 hours for 313 days in a year for a normal scenario and for a period of 4 days during a disaster.

(Refer to appendix for detailed calculations)

The lighting loads have been reduced by 50% as it is met with adequate daylight, SDA = 50%. The solar energy potential has been calculated for various tilt angles (lat. $\pm 15^\circ$) and an optimum angle of 27° is considered. As per base case calculations, about 68% of energy requirements can be met using solar panels. With the proposed case, 100% can be achieved using solar energy.

Along with solar panels, energy is also generated using gym equipment and the power of prayer – Buddhist prayer wheels.

(Refer to appendix for detailed calculations)

MONTH / TILT ANGLE	42.09°	12.09°	27°
January	9503	7880	8934
February	8700	7744	8439
March	8998	8688	9156
April	7361	8048	7886
May	6988	8225	7783
June	5595	6839	6353
July	5951	7066	6644
August	7182	8205	7884
September	6361	6641	6660
October	10234	9208	9990
November	9855	8117	9245
December	8195	6689	7654
TOTAL	94924	93528	96628

Table vi : PV panels annual energy generation at different angles

Solar panel modules

Capacity : 445 Watts

Efficiency : 17.10%

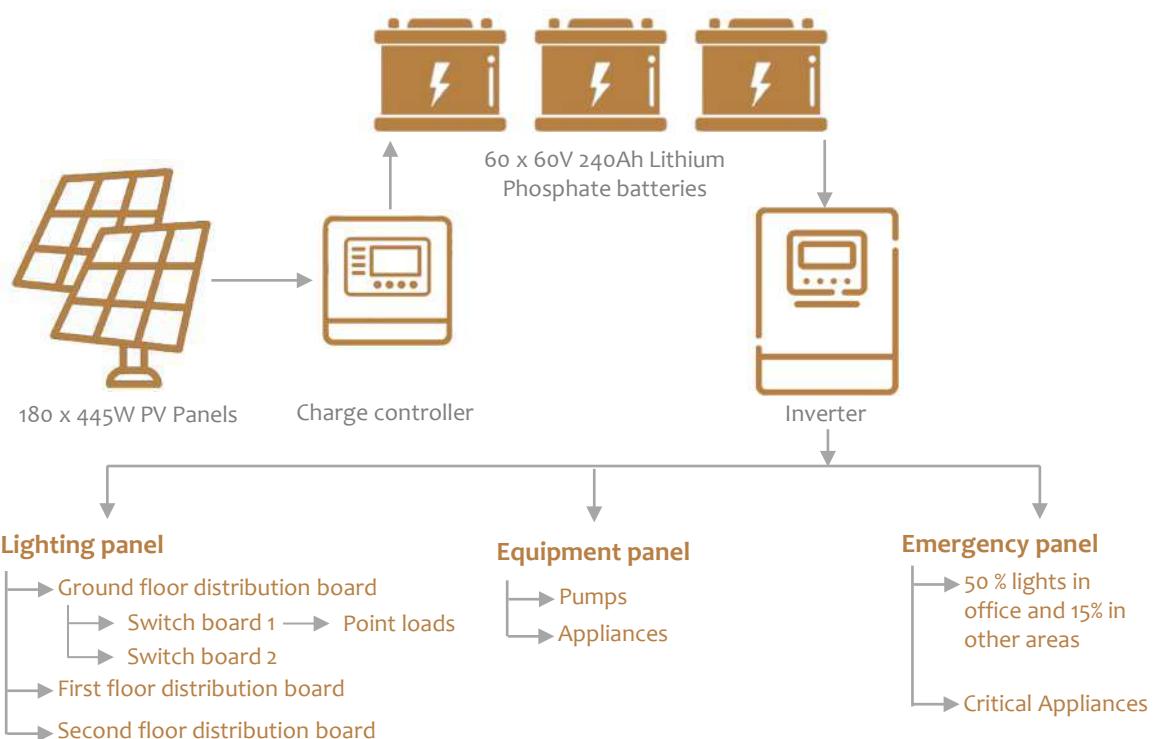
Dimensions : 2063 x 1026 x 35 mm

Solar Cells: Monocrystalline

Number of cells: 144 cells

Plant size : 80.1 kW

Annual energy generation : 96628 kWh



7.C. WATER PERFORMANCE

SOURCE OF WATER

The main sources of water for our building are rainwater, municipal water and treated grey water. The region receives an annual precipitation of 91.8mm per annum hence making it the major source of water. **Surplus rainwater** is given back to the grid making it a **net zero positive building**.

Owing to seasonal variations municipal water is taken during the months of November, December, January, February to curb the deficiency. (refer table 2)

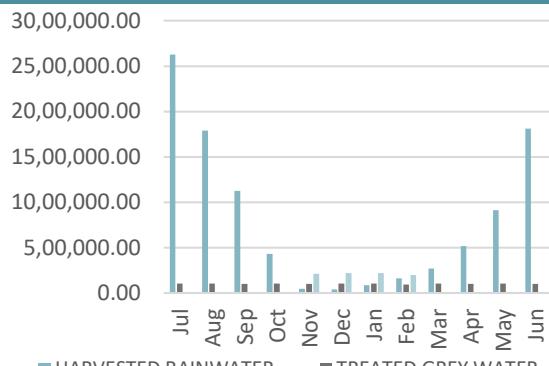


Fig. 26 : Harvested rain water vs. treated grey water

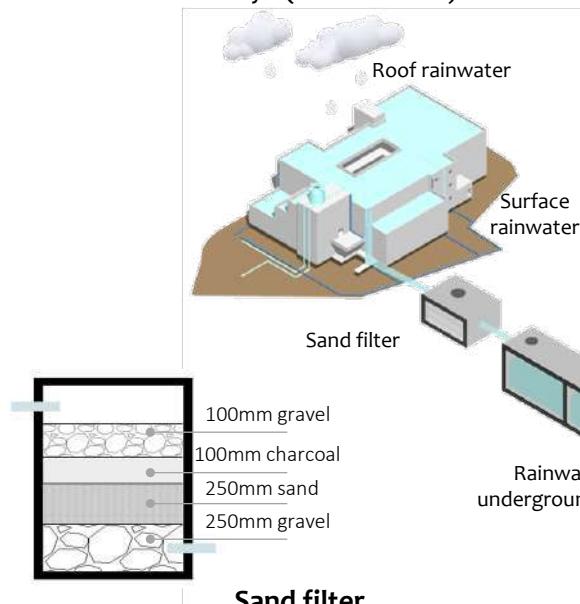
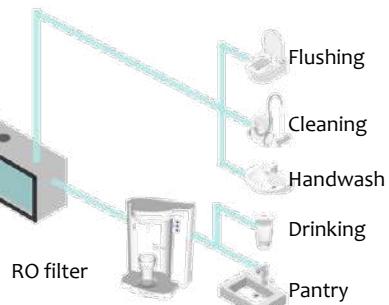


Fig. 27 : Rainwater harvesting schematic

The rainwater collected is primarily filtered by sedimentation process which removes the debris and prevents the growth of pathogens and bacteria. Later it undergoes acid neutralization process in the UGT



WATER CONSUMPTION AND REDUCTION (BASE CASE VS PROPOSED CASE)

NON-DISASTER TIMES



Fig. 28 : Base case vs. proposed case - non disaster times

With the usage of efficient water fixtures the water consumption has been brought down from **45lpd to 25lpd** during normal times (refer table 3,4&5)

Base case water demand = 52,56,000 lpa

Proposed case water demand = 24,54,480 lpa

Therefore reduction by 51.2%

DISASTER TIMES



Fig. 29 : Base case vs. proposed case - disaster times

Along with the usage of efficient water fixtures and by rationing water, the consumption has been brought down from **135 lpd to 70 lpd** (refer table 6,7,8 & 9)

Base case water demand = 1,63,04,760 lpa

Proposed case water demand = 1,23,13,308 lpa

Therefore reduction by 51.8%



WATER TREATMENT AND REUSE

NON-DISASTER TIMES

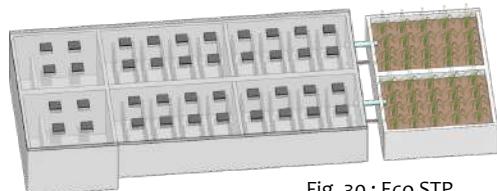


Fig. 30 : Eco STP

ECO STP -It is an eco-friendly sewage treatment system which uses **anaerobic bacteria**. It works **independent from power supply**.

Treated grey water is only used for irrigation

Treated grey water = 12,25,305lpa

Irrigation demand = 5,77,221lpa

(refer table 10)

DISASTER TIMES

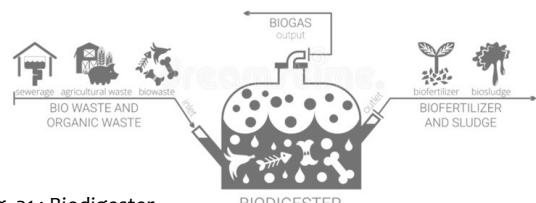


Fig. 31 : Biogester

BIO-DIGESTERS - Human excreta is treated in the holding tank using **anaerobic bacteria**. The by product generated(biogas) is used for heating water during disasters

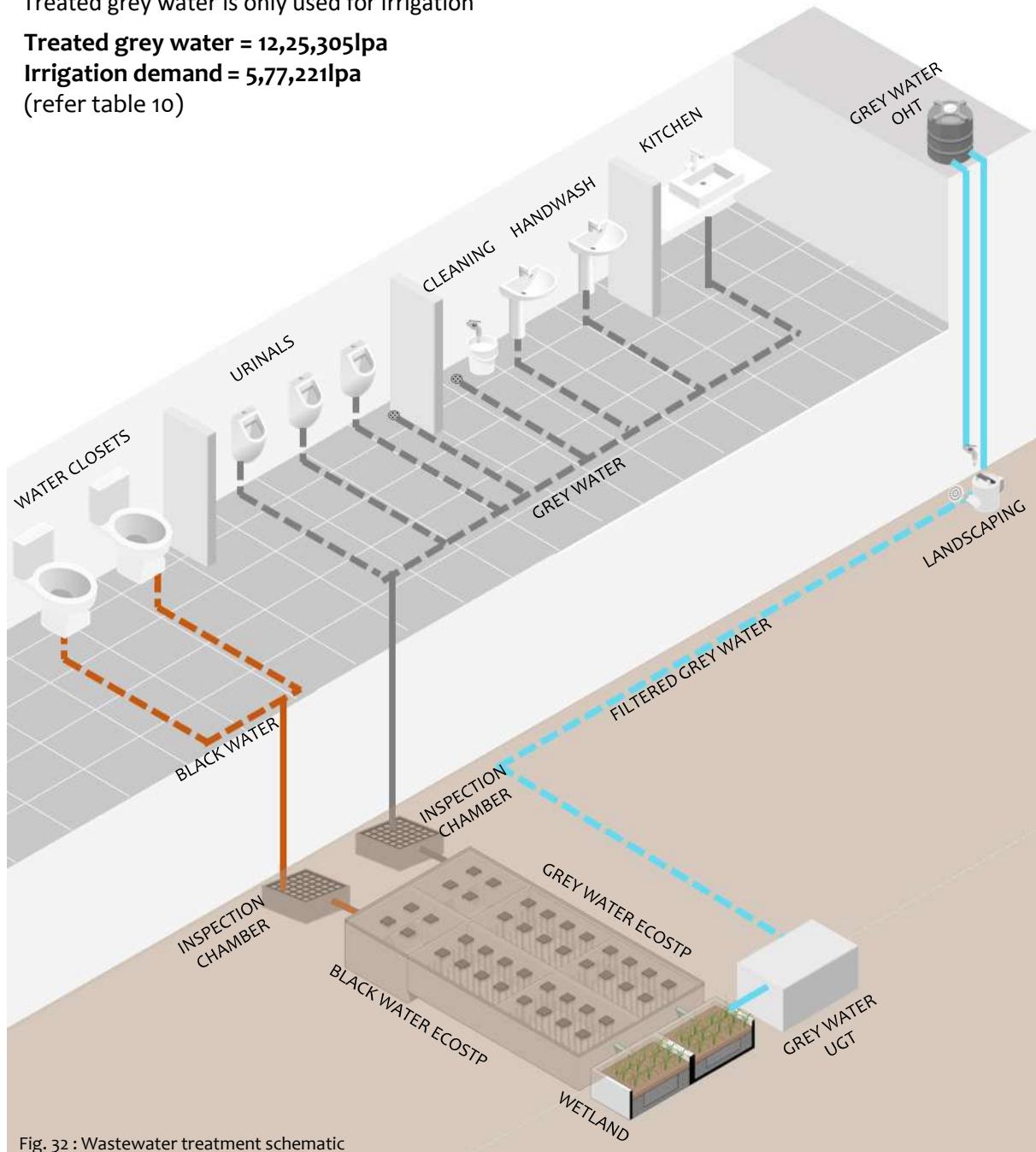


Fig. 32 : Wastewater treatment schematic

Rainwater harvested 98,20,133 litres/annum	Municipal water 8,52,000 litres/annum	Treated grey water 10,07,400 litres/annum	Water given to grid 72,80,453 litres/annum
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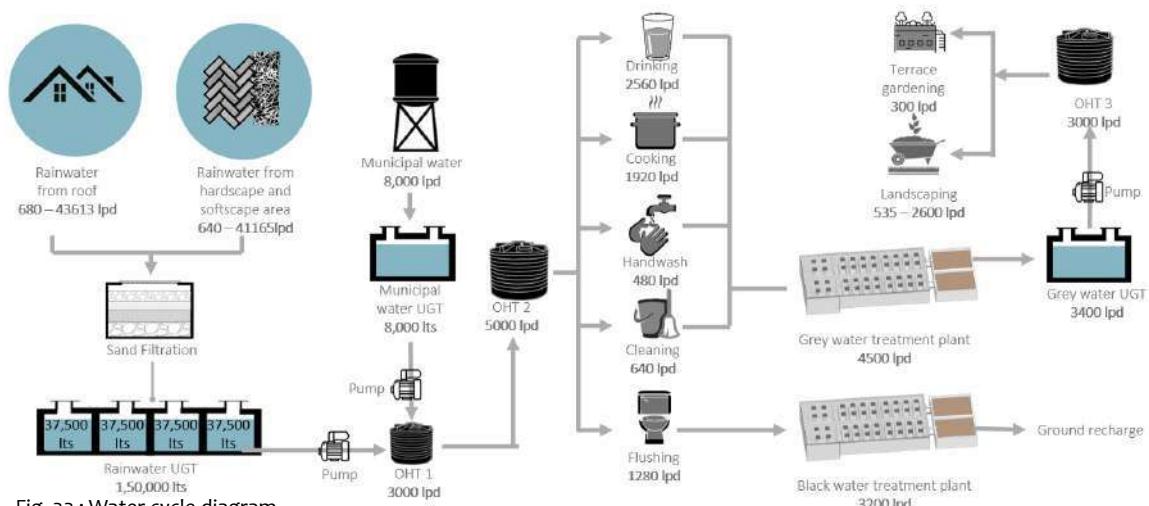


Fig. 33 : Water cycle diagram

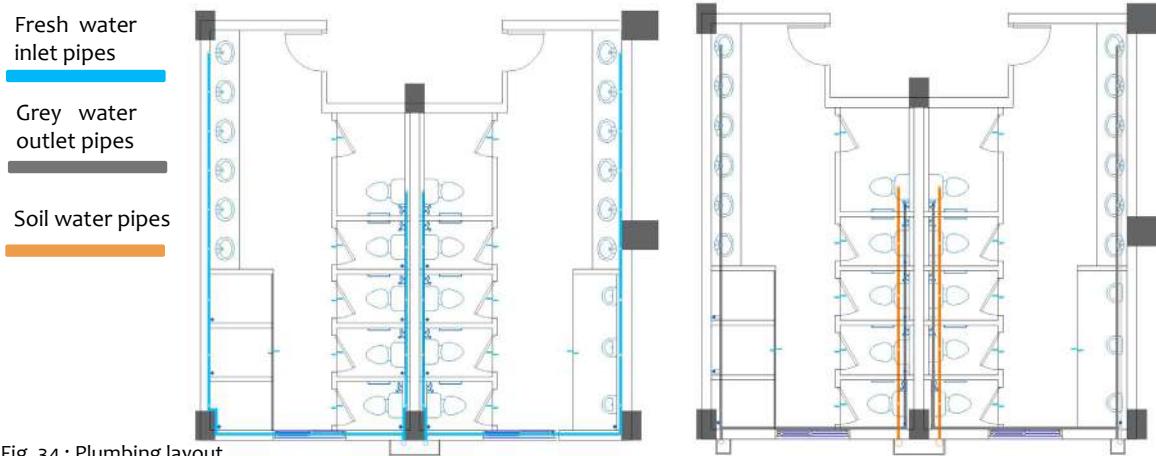


Fig. 34 : Plumbing layout

OPTIMISATION OF ON-SITE WATER STORAGE

The site has a 1,50,000 lts capacity water tank to provide resilience for 4 days for 460 refugees in the event of a disaster. Water is sent to the municipality grid only after the tanks at site are completely filled, hence providing resilience at all times. So throughout the year water keeps circulating and does not stagnate beyond 3 days

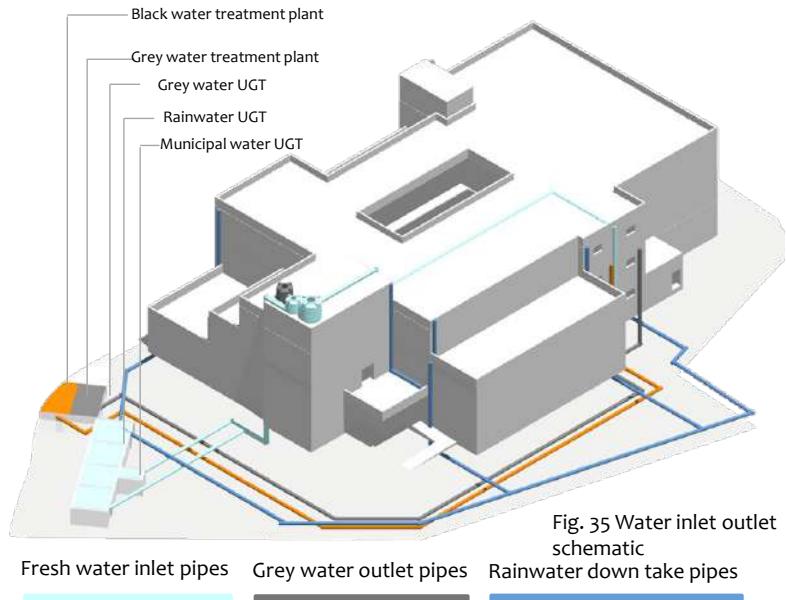


Fig. 35 Water inlet outlet schematic

8.D. EMBODIED CARBON

Low embodied carbon materials are an essential component of sustainable construction practices, aimed at reducing the carbon footprint of the built environment. The use of low embodied carbon materials has become increasingly important as the construction industry is responsible for a significant proportion of global greenhouse gas emissions. Using local materials, fly ash-based products, rapidly renewable materials, recycled and recyclable materials we intend to mitigate the impact of climate change and create a more sustainable future.

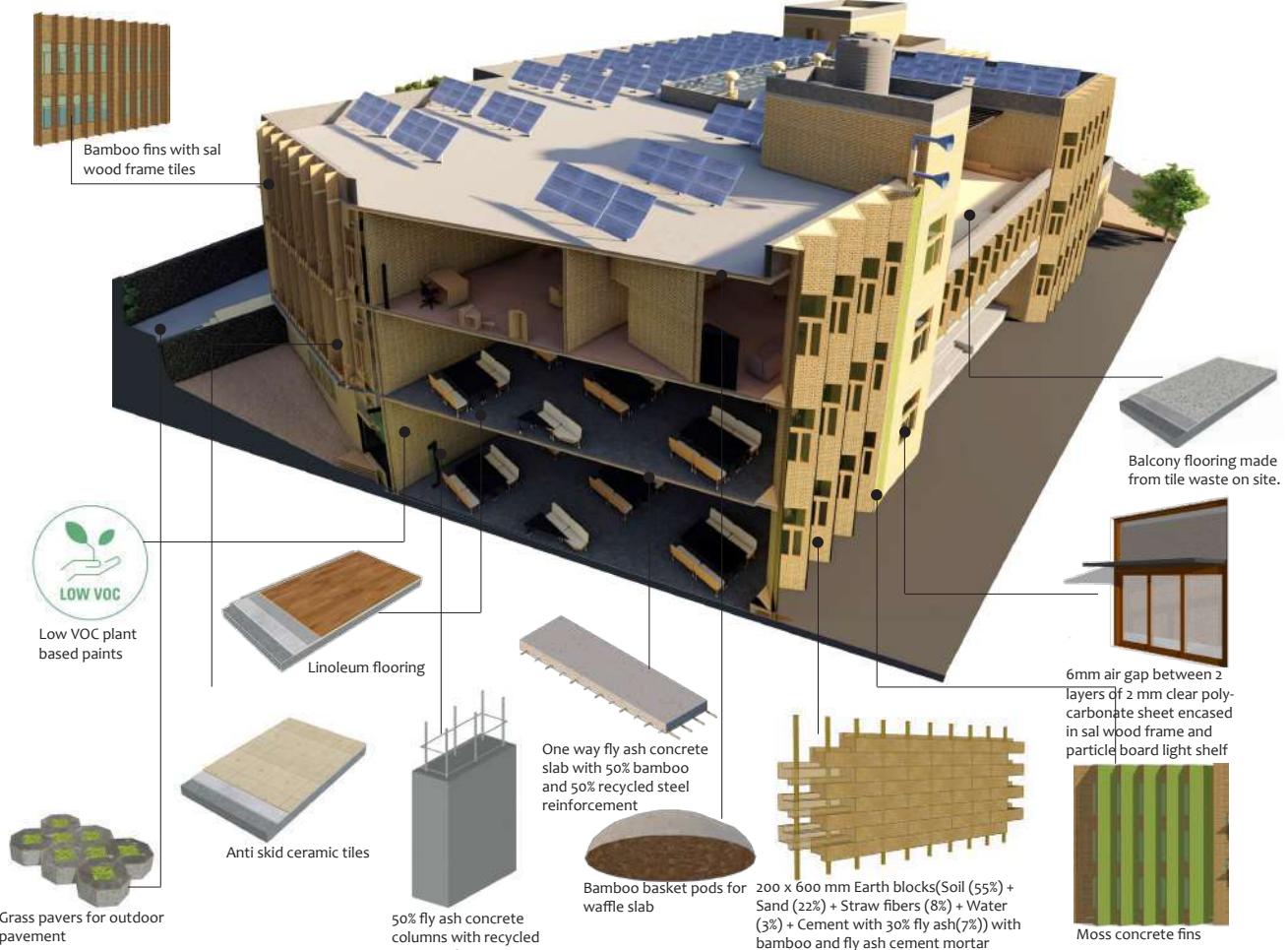


Fig. 36 Building materials and systems

Low impact design approach is achieved by:

Use of locally sourced materials

Use of recycled (steel, particle board) and recyclable materials (steel, earth block, bamboo pods, polycarbonate)

Use of rapidly renewable and natural materials (bamboo, wood).

Reducing cut and fill

Planting 2 sal trees on site or as ICSR for every tree cut for making window frames.

Optimized design mix (fly ash concrete, earth blocks)

Reduction in construction waste in the entire life cycle of the building

Use of less water during construction by use of fly ash based materials and earth blocks.

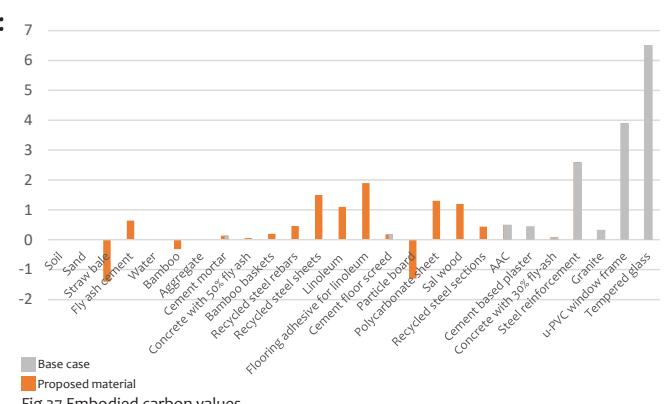


Fig 37 Embodied carbon values



Fig 38 Percentage in reduction of embodied carbon of materials vs. conventional materials

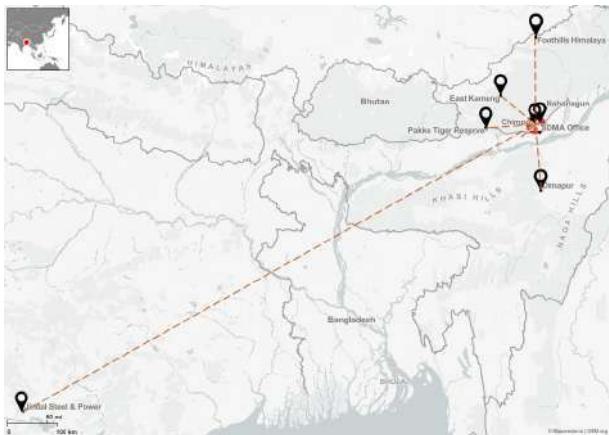


Fig 39 Sourcing of materials

All materials apart from recycled steel are available within 300km radius. Recycled steel is bought from Jindal steel and power, Chhattisgarh, located 1850 kms away from site. Material suppliers are located within 30kms radius from site, hence, reducing the embodied carbon emission due to transportation. (Refer section 9.4 for detailed calculations and embodied carbon summary sheet)

WALLS - EARTH BLOCKS - 600 x 200 x 155 mm

Composition – Soil (55%) + Sand (22%) + Straw fibers (8%) + Water (3%) + Cement with 30% fly ash (7%)

Choice of material – Soil contains least amount of embodied carbon and it is available on site. Sand and cement can give it more strength and hence make the block resistant to seismic forces. Straw fibres can act as a binder to hold the different elements together. All the materials are available close to the site, hence reducing the embodied carbon emission due to transportation.

Each block will have two 40 diameter voids for a bamboo insertion which holds the blocks together in case of shear and lateral thrust. 10mm aggregate can be used to secure the bamboo in place.

Mortar - Cement mortar with fly ash

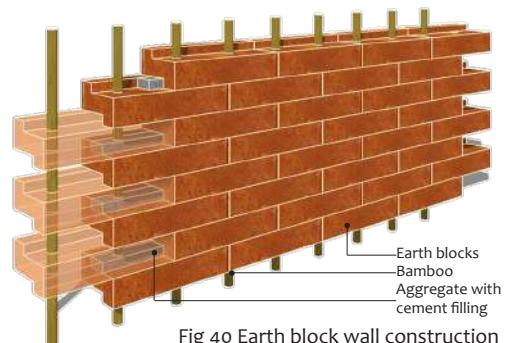


Fig 40 Earth block wall construction

FLOORING - LINOLEUM SHEETS

Its flexibility and durability make it a good choice for earthquake prone areas. It is made from natural, renewable materials such as linseed oil, wood flour, and jute which are non-toxic and biodegradable, and hence have a low environmental impact and low embodied carbon which makes it a sustainable choice for building construction and design. It is also easier to maintain, hence reducing the need for harsh chemicals or cleaning agents that can have a negative environmental impact.

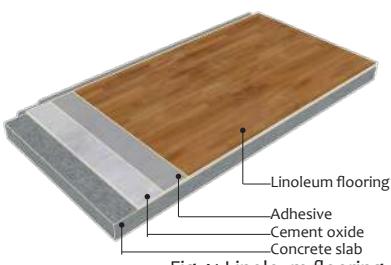


Fig 41 Linoleum flooring

COLUMNS AND BEAMS

Recycled steel ties – To hold bamboo together and provide structural support. According to a 2018 report from the World Steel Association, the average embodied carbon value of recycled steel is 0.46 kg CO₂ eq per kg of steel which is significantly lower than that of virgin steel, because the process of recycling steel uses significantly less energy and produces fewer emissions compared to the production of virgin steel.

Concrete with fly ash – Fly ash reduced the amount of cement content in concrete. According to a 2018 report by the World Business Council for Sustainable Development, embodied carbon value of concrete with 30% fly ash replacement is approximately 295 kg CO₂ eq per cubic meter, while that with 50% fly ash replacement is estimated to be around 200 kg CO₂ eq per cubic meter, which is half the value of conventional concrete i.e., 400 kg CO₂ eq per cubic meter.

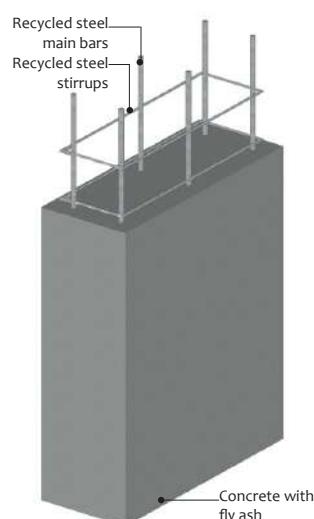


Fig 42 Fly ash concrete column



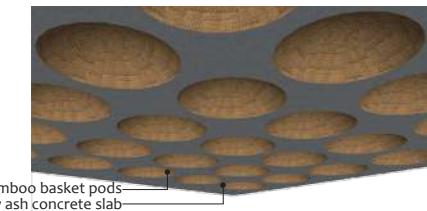


Fig 43 Waffle slab

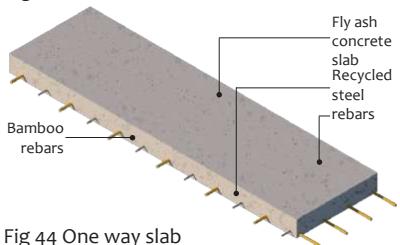


Fig 44 One way slab

SLABS - WAFFLE SLABS AND ONE WAY SLABS

Waffle slabs are built using weaved bamboo basket pods, fly ash concrete, bamboo bars and recycled steel stirrups.

Bamboo basket pods - Bamboo baskets tend to have a lower embodied carbon value than PVC waffle pods. Bamboo is a highly renewable material that grows quickly and sequesters carbon as it grows. The embodied carbon value of bamboo baskets is estimated to be in the range of 0.1 to 0.3 kg CO₂ eq per kg of bamboo, while that of PVC waffle pods is between 1.5 to 2.5 kg CO₂ eq per kg of PVC. Exposed bamboo basket pods also brings in the element of vernacularity and aesthetics.

One way slabs - Recycled steel reinforcement is alternated with bamboo reinforcement to reduce the carbon content and dead load of the slab.

FENESTRATIONS - POLYCARBONATE WITH SAL WOOD FRAMES

Sal wood - It is estimated that the embodied carbon value of Sal wood is 1.1 to 1.3 kg CO₂ eq per kg of wood which is lower than that of many building materials like steel or aluminum. However, it's also important to consider the environmental impact of sourcing Sal wood. Hence, twice the number of trees cut will be planted on the site and through social forestry.

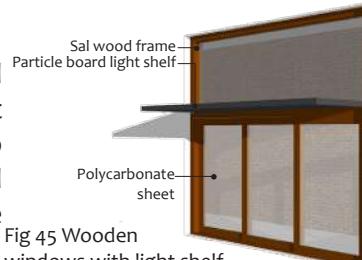


Fig 45 Wooden windows with light shelf

Particle board light shelves with reflective coating - The embodied carbon value of particle board is lower than that of solid wood, as the manufacturing process for particle board typically involves using smaller pieces of wood that might otherwise go to waste, and the process involves compressing and bonding the wood particles together using adhesives. This process can use less energy and produce less waste than the process of producing solid wood.

Poly carbonate - It is suitable for use in earthquake prone areas and has a lower embodied carbon footprint than traditional glass. A life cycle assessment study conducted by the University of Bath and commissioned by the European Union found that the embodied carbon value of polycarbonate sheets ranges from 1.1 to 1.5 kg CO₂ eq per kg of material.

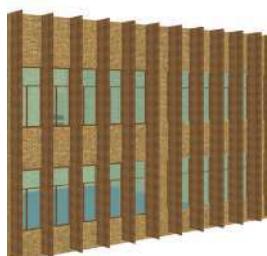


Fig 46 Bamboo fins

FINS - WOODEN FRAME WITH BAMBOO PANEL

Bamboo - It is cost effective, sustainable and renewable. Studies from Delft university of technology state that bamboo is a carbon sequestering material with an embodied carbon value of -0.313 kg CO₂ eq. It can be easily found nearby, hence reducing embodied carbon emissions due to transportation.

Type - *Bambusa tulda* is a fast-growing bamboo species which is known for its strength, durability, and resistance to pests and diseases.

Source - The plantation in Chimpur village serves as a source of bamboo and helps in generating income for the locals through the sale of bamboo. Bamboo harvesting and trade are regulated by the local Forest Department.

Bamboo treatment plant - *Bambusa tulda* bamboo treatment is typically done by specialized bamboo treatment plants. One such facility is located in the nearby town of Naharlagun, around 10 km from Itanagar.



Fig 47.Bamboo processing



Fig 48 Moss concrete fins

(Refer appendix section 3 – material quantities and embodied carbon calculations)



8.E. ENGINEERING AND OPERATIONS

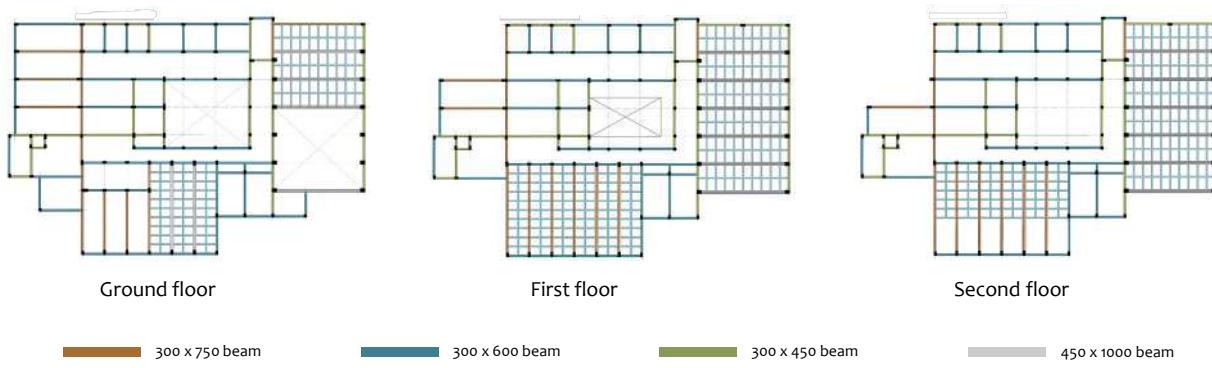


Fig 49. Structural plans with Column position and Beam layout

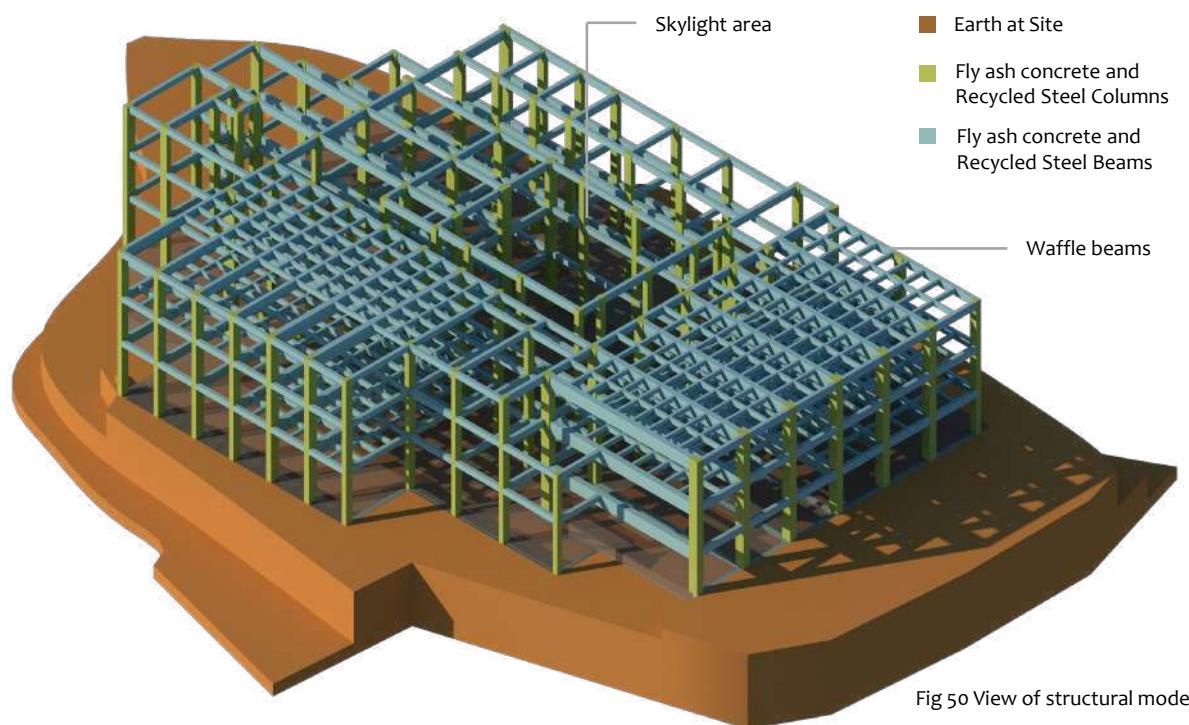


Fig 50 View of structural model

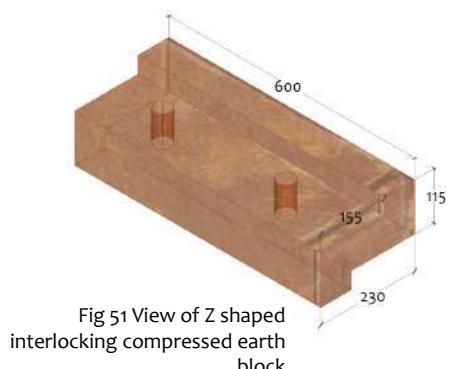
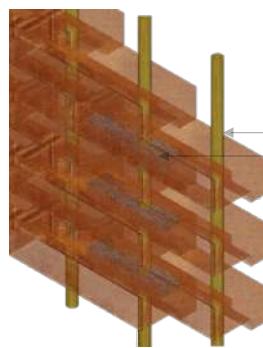


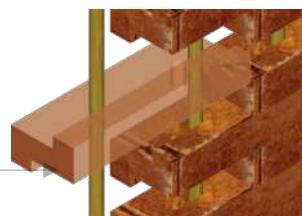
Fig 51 View of Z shaped interlocking compressed earth block

Other than the interlocking of blocks, bamboo culms gives additional reinforcement by piercing through these blocks



Z shaped interlocking compressed earth blocks

Fig 52 Construction of walls



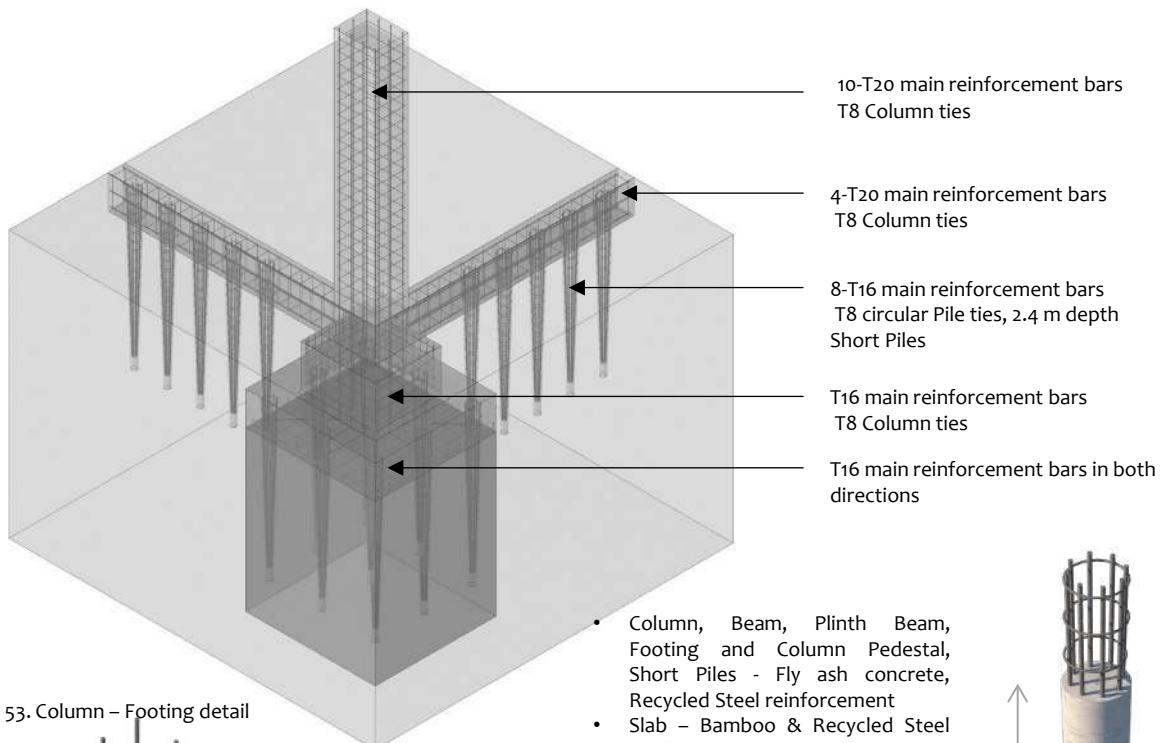
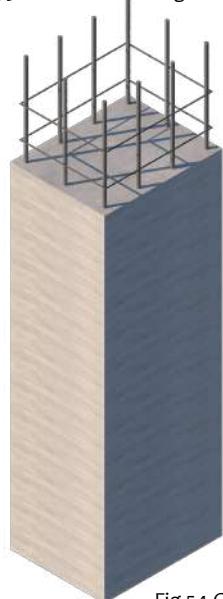


Fig 53. Column – Footing detail



To make the Concrete mix robust, strong, and environmentally friendly, Fly Ash Concrete is used. The addition of fly ash to concrete improves its crack resistance, which is significant in seismic events. Fly ash also increases the concrete's workability and cohesiveness, allowing for improved consolidation and densification during placement. This results in a more homogeneous and consistent construction that can handle earthquake forces better. As compared to standard concrete, fly ash reduces the rate of shrinkage and creep over time, which can help lessen the risk of structural damage from long-term stress and strain.

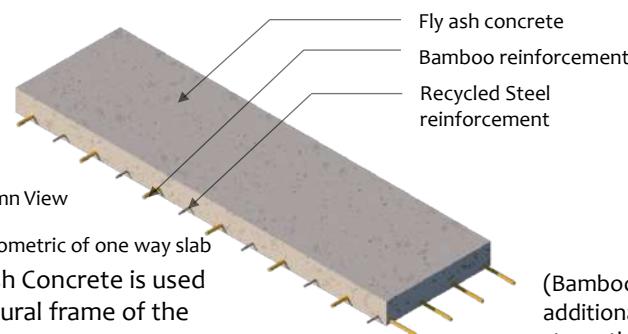


Fig 56. Isometric of one way slab

Recycled Steel and Fly Ash Concrete is used mainly to build the structural frame of the building

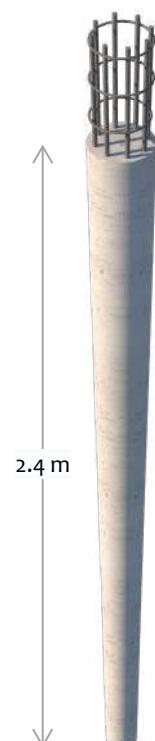


Fig 55. Short Pile View



Fig 57. Views of Solar panels supported by recycled steel sections

(Bamboo Reinforced Slab with Steel as additional reinforcement for Structural strength and cost-economy)

- Panel size - 2063 x 1023 mm x 35 mm
- Tilt angle - 27 degrees, 144 Cells 445 W each panel

The 27 degree tilt angle strikes a good balance between maximizing solar energy production and minimizing seasonal variations.



WAFFLE SLAB SYSTEM

Waffle slab system was chosen to avoid columns in the middle of Gym area, Seminar hall area and Office, and also due to their ability to distribute the load over a wide area. Wicker baskets are used as waffle pods as a sustainable and eco-friendly option. It also help to support local artisans and promote traditional crafts and for its unique aesthetic value to the construction project.

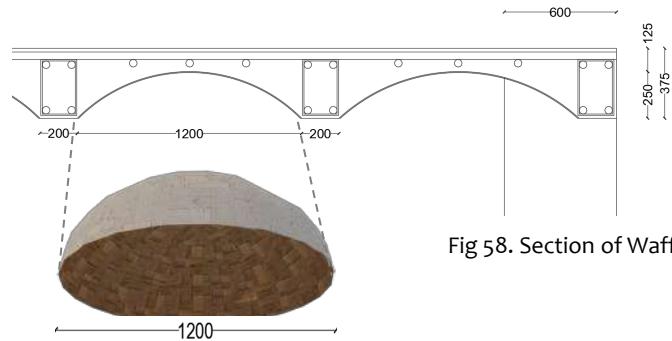


Fig 58. Section of Waffle slab

Wicker basket is coated with a layer of cement paste before pouring Fly ash concrete to make it non-permeable

SOLID WASTE MANAGEMENT

TYPE	MATERIAL	ACTION PLAN
NON BIODEGRADABLE WASTE	Non biodegradable plastic and PVC generated from the building	Collected by waste management facilities equipped with collection, treatment and disposal
BIODEGRADABLE WASTE	Kitchen waste and landscaping waste	Biodegradable slurry is supplied to bio digestor manually to generate biogas which will be utilized as cooking fuel
RECYCLABLE WASTE	Cardboard, paper and office waste	Collected by recycling management facilities equipped with collection, treatment and disposal
TOXIC WASTE	Batteries and E-waste, construction waste	Collected by toxic waste management facilities equipped with collection, treatment and disposal
BIOWASTE	Sanitary pads, first aid medical waste during disaster times from the gym-converted-field hospital	Collected by medical waste management facilities equipped with collection, treatment and disposal

Table vii Solid waste management action plan

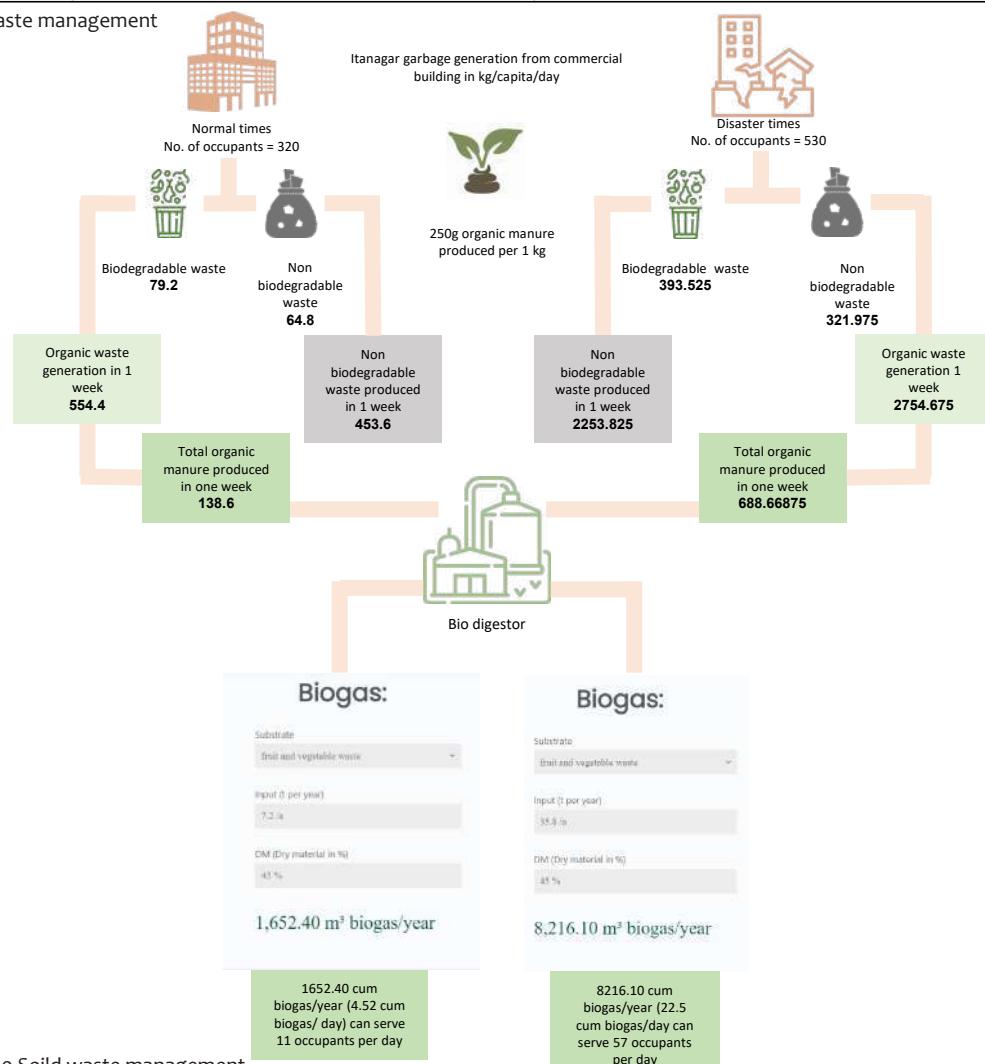


Fig. 59 Soild waste management

8.F. RESILIENCE



Fig 60. Resilience cycle

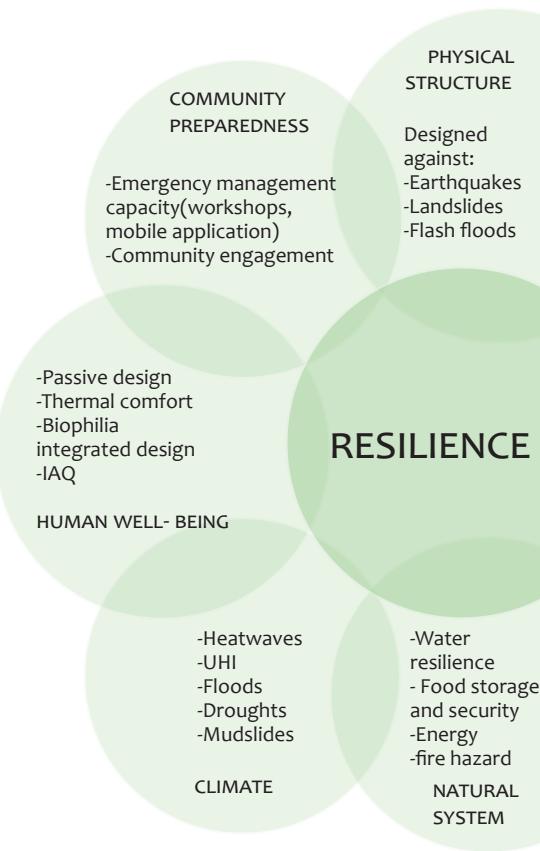


Fig 61. Resilience strategies

Fig 62. Pre-disaster plan

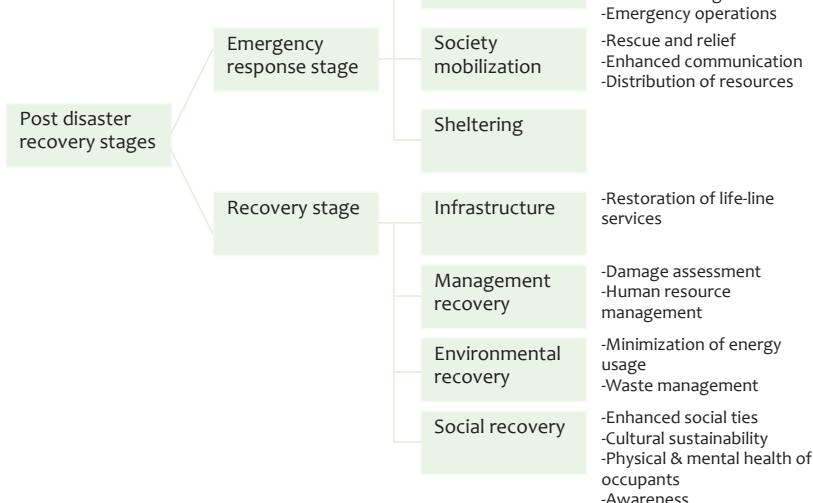


Fig 63. Post disaster recovery plan

The building is flexible and resilient during man-made disasters, epidemics, earthquakes by functioning as a refuge or a field hospital where 460 people are accommodated during a disaster, 209 people could be accommodated during conflict and 122 people could be accommodated during pandemic. The ground and 1st floor houses refugees, with convertible furniture. The second floor continues to function as an office for state disaster management, helping monitor and coordinate relief works during the disaster.

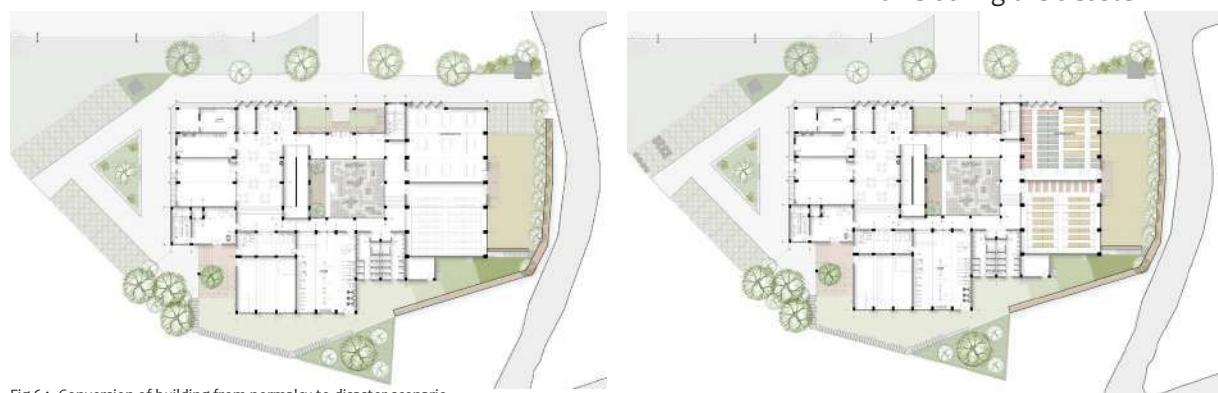


Fig 64. Conversion of building from normalcy to disaster scenario

EARTHQUAKE RESILIENCE

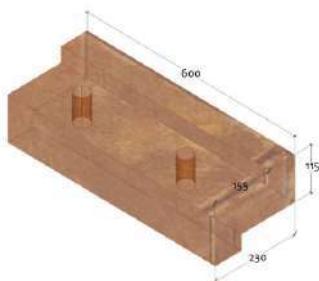


Fig 65. Z-shaped earth block

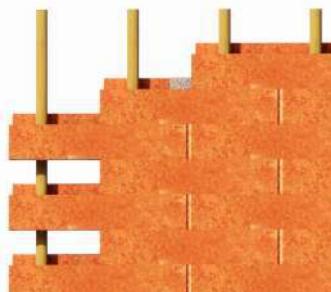


Fig 66. Bamboo reinforced blocks



Fig 67. Pile foundation

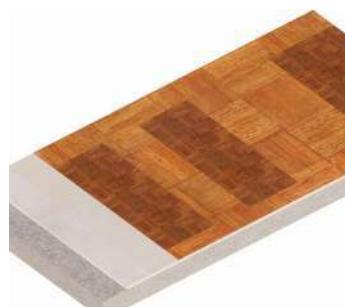


Fig 68. Linoleum flooring

1. Z-shaped earth blocks: The form of the 600X230X155mm CSEB blocks is designed in such a way that they interlock with each other, thus providing more rigidity to the structure.

2. Bamboo reinforced walls: The CSEB blocks are reinforced with 40mm diameter bamboo which holds the blocks together in case of shear and lateral thrust, thus making the wall strong and steady in times of an earthquake.

3. Pile foundation: 2400mm deep and 230mm diameter short piles are used to hold the building in place in case of an earthquake. Long piles are avoided since they might break during an earthquake event.

4. Linoleum flooring: It is used for shock resistance during disasters

CLIMATE RESILIENCE

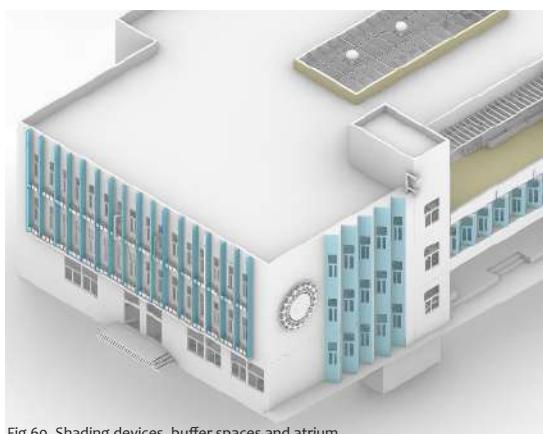


Fig 69. Shading devices, buffer spaces and atrium

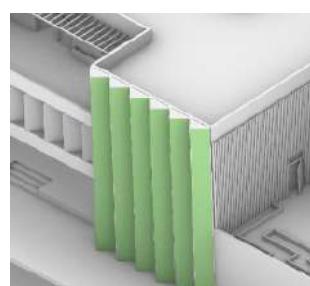


Fig 70. Figure showing moss concrete wall



Fig 71. Vegetation in the site

Resilience against heatwaves could be avoided through passive design approaches like the use of shading devices, envelope optimization, light shelves (that bring in diffused light), terraces (which act like buffer spaces) and stack effect (through atrium). On Northwest, to block the west sun, a sawtooth form has been used with windows facing North. On Northeast, vertical fins have been used to reduce glare in the morning, while on the Southwest, vertical fins are used to reduce glare in the evenings. Visually light materials and colours are used to reduce the heat gain.

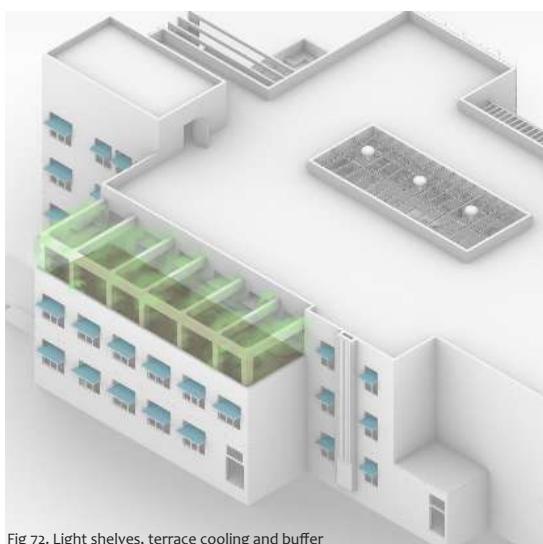


Fig 72. Light shelves, terrace cooling and buffer

Biophilic design with local vegetation is integrated to improve air quality. Moss walls are also used to increase oxygen content. The vegetation also strengthens the soil and prevents mudslides. It can mitigate climate risks by assisting in thermal regulation by providing cooling effects through evapotranspiration and reducing drought and floods through increased soil water retention and absorption.

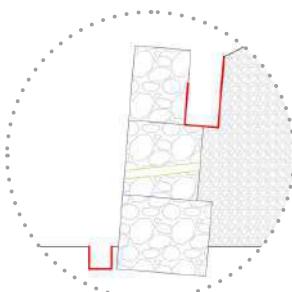


Fig 73. Detail of gabion wall

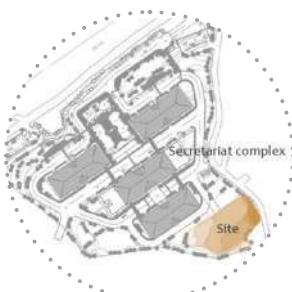


Fig 74. Elevated site

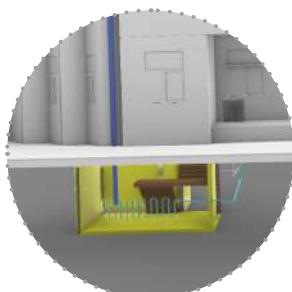


Fig 75. Detail of food storage



Fig 76. Biogester

Landslide resilience: 3m high and 1m thick gabion wall is provided on the south east side to protect from landslides. 1mX2mX1m baskets are used.

Flood resilience: Site is located at a higher platform to reduce the risk of floods. The planting of vegetation around the periphery also helps to retain excess water in times of floods. The plinth is raised by 600mm and the drainage system is also planned properly throughout the site.

Food security and storage: Rationing of food and water during disaster(storage of rice, pulses, vegetables and medicines (if required) in a storage chamber of 3mX3.5m located below the staircase near the main entry.Food is stored for 530 occupants, for 4 days. Vegetables are grown on site come in handy in times of emergency.

Waste disposal:

The waste generated from the site does not end in a landfill. It is either re-purposed or given to people who will reuse it. Bio digestor is used to generate biogas from kitchen waste which is given back to the kitchen as cooking fuel.

Construction waste and first aid medical waste during disaster that is produced from the field hospital are collected by waste management facilities that specialize in collection, treatment and disposal.



Fig 77. Therapeutic garden view

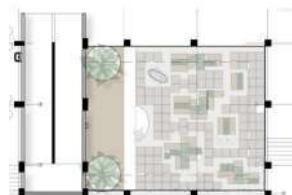


Fig 78. detail of courtyard



Fig 79. Prayer wheel railing

SOCIAL RESILIENCE

Certain design strategies have been adapted social resilience which includes people supporting each other socially and building a sense of community.

Community and therapeutic gardens are provided for community activities and interaction. Courtyard area with patterned floor for community games.



Fig 80. view of community terrace



Fig 81. View of courtyard



Fig 82. Movie screening in courtyard

Prayer wheels are used as an architectural element to promote the belief in almighty which would bring people together. Movie screening also happens(with the energy generated from prayer wheels) in the courtyard area to engage the community.

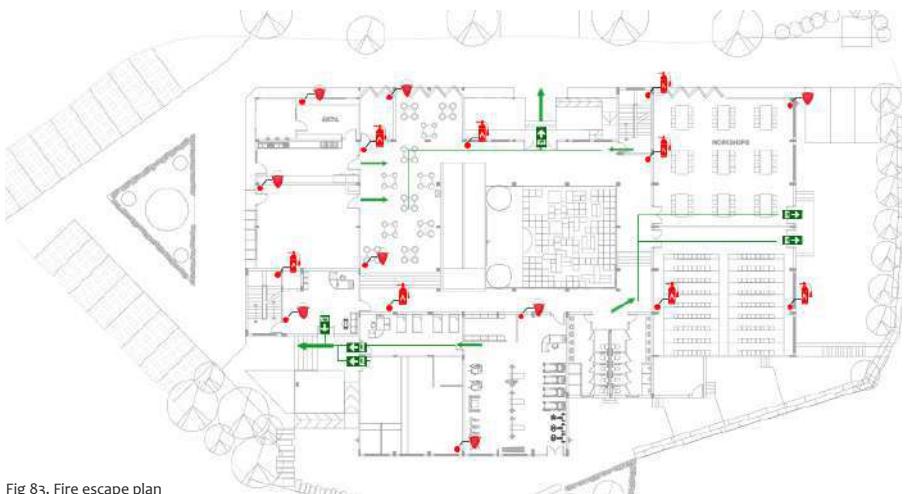


Fig 83. Fire escape plan

FIRE RESILIENCE

Resilience against fire hazard is provided by the demarcation of fire escape route. Fire extinguishers, hooters and fire buckets are placed in easily accessible corridors and spaces. Multiple fire exits are provided to avoid the overcrowding of people. 2 hour fire rated doors are provided.

8.G. HEALTH AND WELL BEING

The building is designed for a naturally ventilated operation . It is naturally ventilated for 98 % of operational hours assisted with ceiling fans . This would help in achieving 100% comfortable operational hours for the occupants throughout the year. (As per ASHARE55 ,NBC2016 for warm and Humid climate)

The layout and orientation of the building is optimized for better cross ventilation of usable spaces and operable openings are provided to maximize the air flow movement as well as maximize daylit spaces. To reduce solar heat gain on western and southern facade ,**terraces are introduced which acts as a buffer zones** . The WWR on N,E,S,W facade is 24% , 14.2 % , 22% and 22.5% respectively .

Table viii Area of opening calculation for Double side opening room – cross flow (WORKSHOP)

Options	Room H	Room L	Room D	Room Volume	ACH	Flow Rate	Wind Velocity	Discharge Coeff	Windward Pressure coefficient	Leeward Pressure coefficient	Minimum Area of Opening	Area of Opening achieved
	m	m	m	m^3	ACH	m^3/s	m/s				m^2	m^2
	H	L	D	V	ACH	q	U	C _d	C _{p1}	C _{p2}	A	A
1	3.75	14	13	682.5	12	2.275	1.3	0.6	0.1	-0.1	9.22	15.45

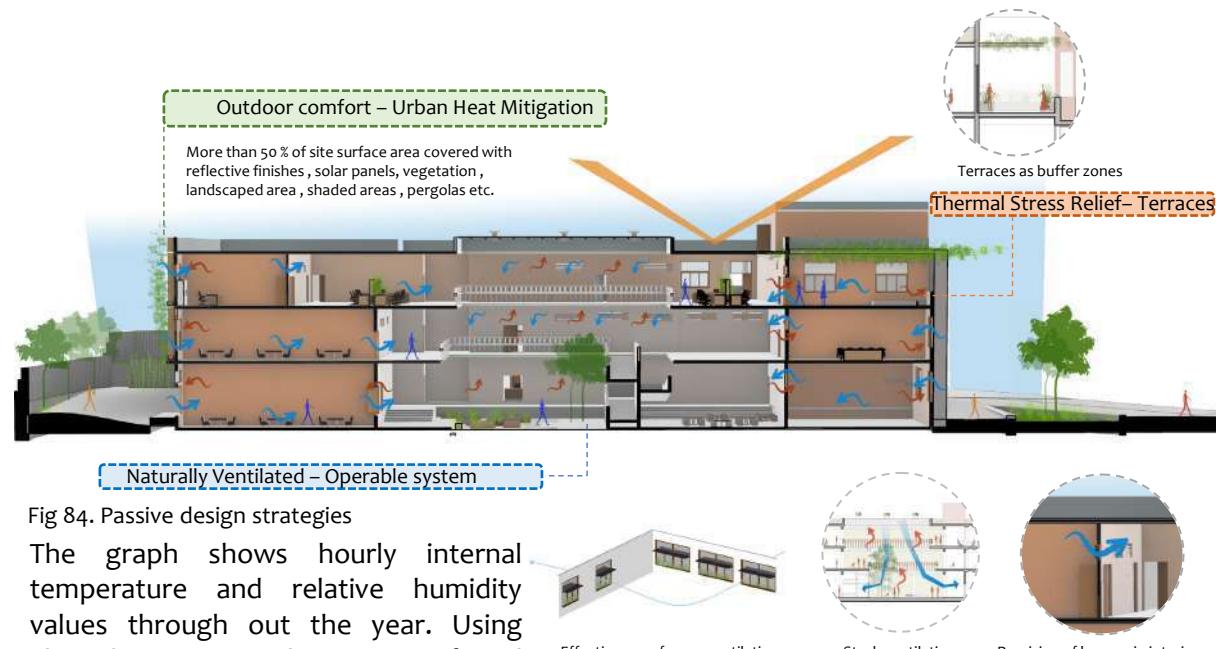


Fig 84. Passive design strategies

The graph shows hourly internal temperature and relative humidity values through out the year. Using algorithms given under NBC, it is found to be **thermally comfortable 98% of the time without the use of mechanical ventilation**

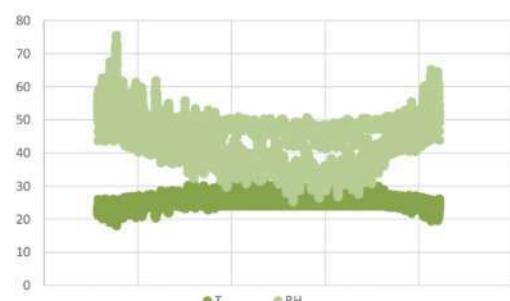


Fig. 85 Hourly internal temperature and relative humidity throughout the year

The below graph shows the operative temperature lies within the maximum and minimum temperature of comfort band as per IMAC.

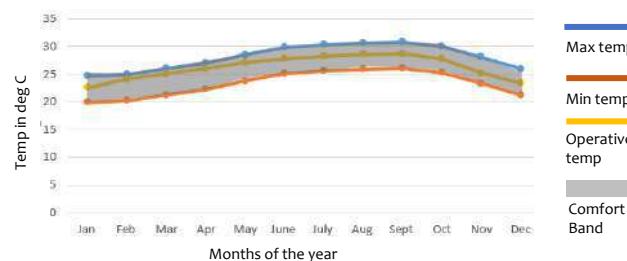


Fig. 86 Graph derived from Simulation data



INDOOR AIR QUALITY

The choice of Low VOC building finishes i.e use of **natural organic paints which has no VOC helps in reducing the CO₂** content in the indoor environment in office spaces. **Provision of planter boxes which helps in absorbing the dust, reduce humidity and accelerate air speed.** 12 ACH is maintained for Office spaces (as per NBC).

VISUAL COMFORT

The different orientations of the building are optimized for maximum daylight by using the appropriate opening size, type and shading devices .Given the requirement of large spans for spaces such as workshops, seminar halls, etc. **light shelves have been used to help penetrate light much deeper.** The light shelf is made up of particle board with metal cladding having 80% reflectivity. The portion above is a fixed window while the portion below is a sliding window. Fins and angular shading in northeast and western façade to **reduce glare and heat gain** .For the visual comfort of occupants **planter box along the façade has been designed in such a way that it is visible from work plane level ,750 mm above FFL.**

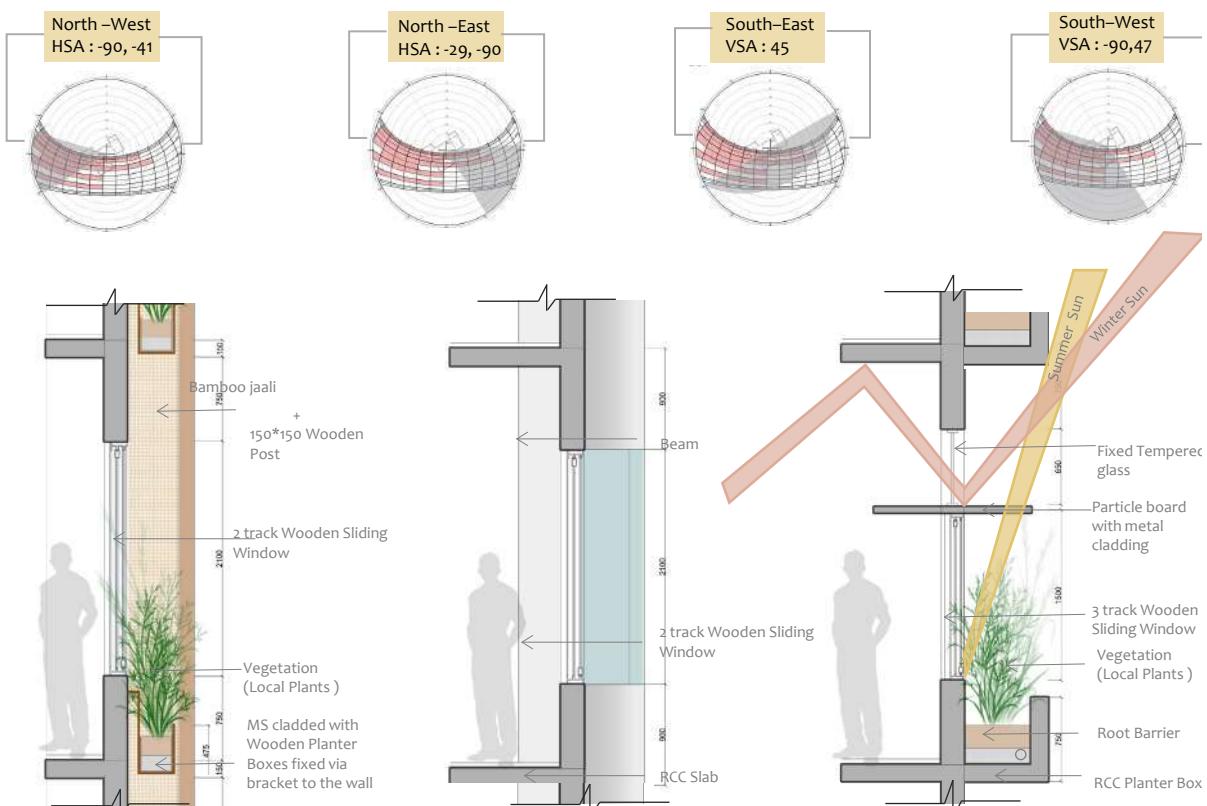


Fig.87 Window detail section :North-Eastern facade

Fig.88 Window detail section : Western facade

Fig.89 Window detail section : South-Eastern facade



Fig.90 Window detail Plan :North-Eastern facade

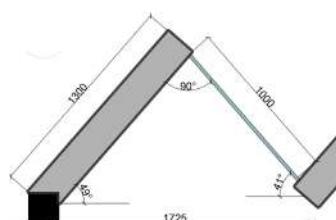


Fig.91 Window detail Plan : Western facade

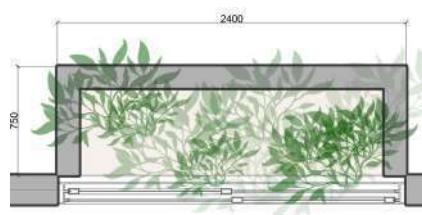


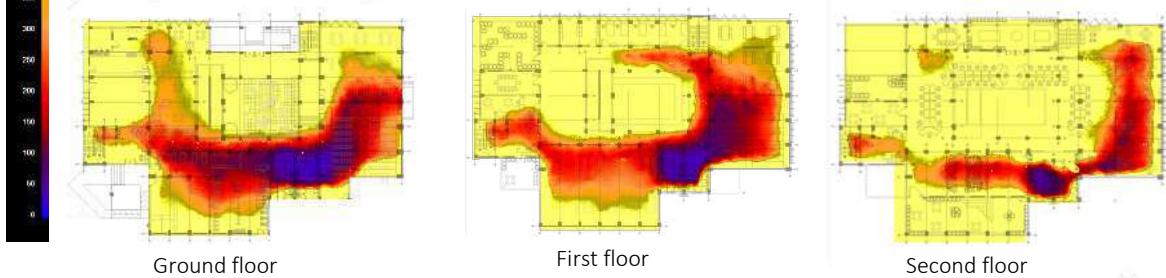
Fig.92 Window detail Plan : South-Eastern facade

The building connects outdoor flora and fauna by providing adequate views to achieve direct line of sight to vision glazing and uninterrupted view upto 8m to the surroundings (GRIHA IEQ CREDIT)



As we seen in the simulations ,use of operable windows with light shelves helps to **distribute daylight deeper** and most of the usable spaces can **use maximum daylight** to carry out different functions and activity. The only spaces which does not receive daylight can be addressed by using artificial lighting to meet NBC requirements .

Fig.93 Daylight simulation and day light factor conducted for March with intermediate sky



SOCIAL AND EMOTIONAL WELL -BEING

Biophilia integrated design is proposed by bringing the outside in –which unifies man-made and natural environments and has the potential to transform the nature of new workspace design by promoting health and wellbeing in office settings.



Fig.94 Biophilic aspects

These help in improving air quality and maintain humidity levels providing thermal and visual comfort of the occupants



8.H. INNOVATION

The Power of Prayer

It is natural for all people to beseech the almighty for help during emergencies. Given that a large majority of the Arunachala's are Buddhists, we proposed that the railings in the courtyard area on the first and second floor be constructed using the Buddhist Prayer Wheels. These will function like dynamos, when used, and help generate power for the building. It will also give the refugees a sense of purpose in life during disasters, and dissipate the feeling of hopelessness - specially if they are told about the purpose of the wheels in detail. This idea can be marketed in different areas of Buddhist significance.

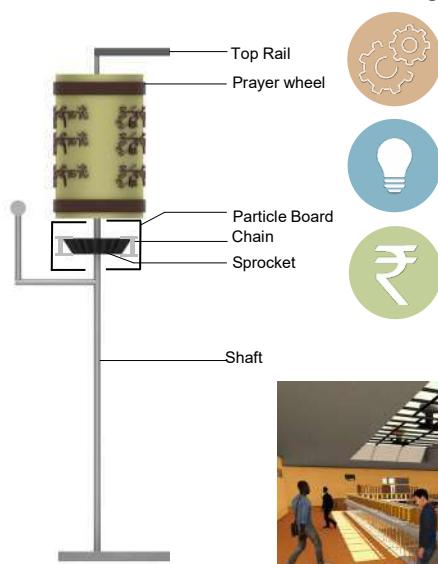


Fig.95 Detailed Section of the Prayer Wheel Railing



Fig .96 Prayer wheel Railings

Technology Readiness Level

Applied research is done and practical application has been found for the prayer wheel setup. Preliminary testing has been established in laboratory environment. (Prototype in progress)

Innovation Readiness Level

The prayer wheel railing has been integrated in the design for the intended application. The cost estimates and ROI calculations have been done.

Costs and benefits

The proposed innovation has potential to reduce greenhouse gas emissions as it generates electricity for the building. The entire setup generates 50 KWh per year, assuming it runs for half an hour per day, which is enough energy to light a 10 watt LED bulb for 5840 hours.

During disaster times, the energy generated using the Prayer Wheel (and gym equipment) is utilized to operate movie screenings in the courtyard to promote social well-being of the refugees. Additionally the presence of prayer wheels add immeasurable emotional value to the project and the refugees in times of distress.(Refer section 9.7 for cost details and energy calculations)

The Roll Toilet

Taking inspiration from an architecture sheet container, the design of the roll toilet consists of six circular sections made of uPVC working on a slide, twist and lock mechanism. The module acts as an enclosure with an attachable door which can be collapsed and stored. The innovation can be marketed to different industries which require collapsible toilet enclosures to save on storage space.

Module size – 1.2 dia x 2.1 m high

Material used – uPVC

Quantity – 24 modules
(18 Indian toilets and 6 western toilets)



Technology Readiness Level

Applied research is done and practical application has been found for the roll toilet. Preliminary testing has been established in laboratory environment. (Prototype in progress)



Innovation Readiness Level

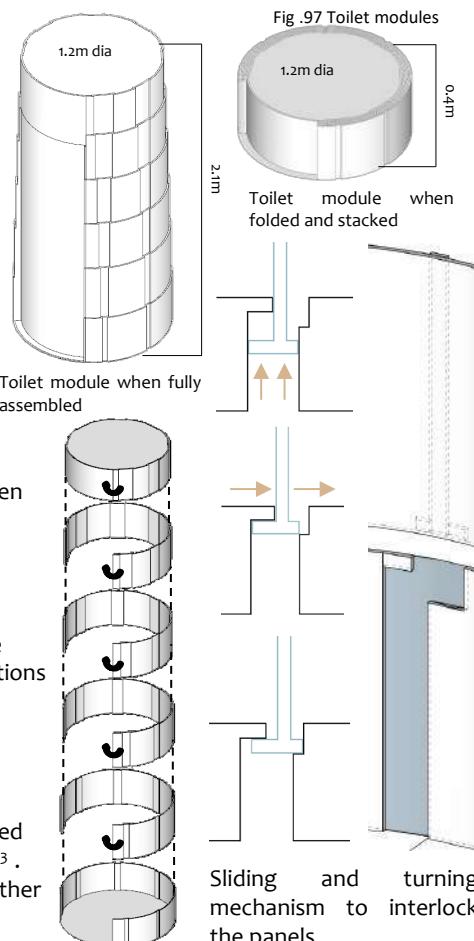
The roll toilets have been integrated in the design for the intended application. The cost estimates and ROI calculations have been done.



Costs and benefits

The design of the roll toilets is original and solves the problem of storage. Each unit costs 15,000 rupees, and in comparison to a rectangular portable toilet it can be stored in a volume of 0.45 m^3 while the other takes up to 2.78 m^3 . This means we can store 5 roll toilets stacked on one another in place of 1 rectangular portable toilet.

Inspiration

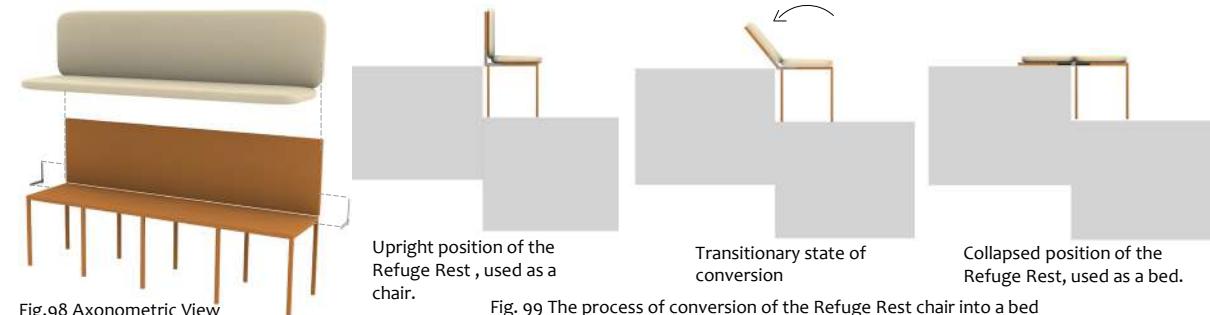


Convertible and Collapsible beds

1. Refuge Rest

Location: Auditorium

The site has a steep slope on the South-East side, which made it ideal for locating an auditorium on the natural gradient. The seating for 128 people in the auditorium can be converted to 28 beds by folding the backrest back against the higher auditorium step. The auditorium steps, consequently do not follow the standard raking, given the nature of the problem and the need of the project.



Technology Readiness Level

For this innovation, applied research is done and practical application has been found. (Refer section 9.7 for hardware details)

Innovation Readiness Level

The Refuge Rest has been integrated in the design for the intended application. The cost estimates have been done.



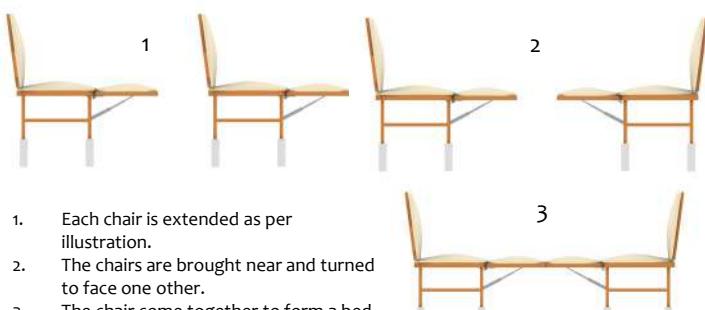
Costs and benefits

The design of the refuge rest solves the need of collapsible beds required in the project. Each chair costs 44,430 rupees and can be converted into a bed in less than 1 minute.

2. Serenity Chair

Location: Workshop

The building will shelter 460 refugees during disaster and hence 460 beds are required. The Auditorium provides 28 beds. The design of the Workshop Chairs evolved due to the need of more beds. The mechanism consists of the pad below the normal chair which can be swung up and locked, and 2 chairs (each 2 seater) in total can be converted to 1 bed. This results in the formation of 82 beds, which are located in the workshops and the small conference room on the first floor. The tables in the workshop will have legs that may be swung up and locked to function as makeshift stretchers in case of need, or stacked flat against a wall, when not needed.





Technology Readiness Level

The Serenity Chair has applied research done and practical application has been found. (Refer section 9.7 for hardware details)



Innovation Readiness Level

The Serenity Chair has been integrated in the design for the intended application. The cost estimates have been done.



Costs and benefits

Each Serenity Chair costs 64,050 rupees. The design of the chair provides convertible beds which can be assembled within 5 minutes (considering maximum distance between two chairs in the workshop).



Fig .104 Serenity Chair converted to beds during disaster times

3. Oasis Bed

Inspired by architecture students sleeping on mill boards, the idea of bunk beds made out of cardboards was proposed. These have been used before, most notably at the BIEC, Bangalore, during Covid times, but not as Bunks. The Auditorium and workshop provide $28+82 = 110$ beds. We have proposed 82 beds of this category, which can sleep 164 people. These beds can be stored flat, under the stage of the Seminar Hall (First Floor), or in the Store Room (Ground Floor), and deployed when needed. We then proposed 186 inflatable mattresses which can be kept on the floor, near the other beds, for use by the last few refugees. This brings us up to the committed number of 460. The flooring in the building will be marked with coloured linoleum, which will look like a design element during normal times, but in time of emergency, can serve as a marking for quick bed deployment.



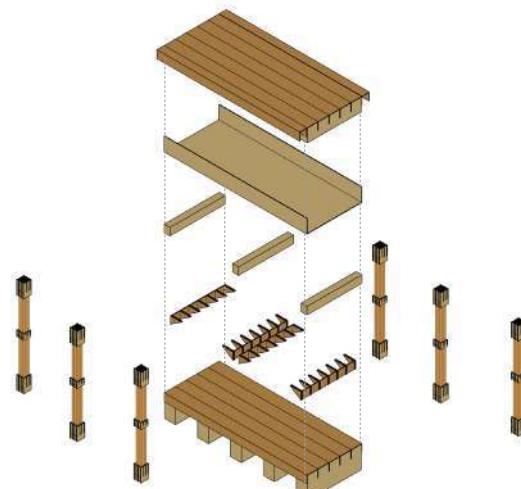
Front View



Side View



Oasis Bed Views



Axonometric View

Fig .105 Oasis bed details



Technology Readiness Level

The technology of oasis bed is in basic research. The details of its various parts has been worked out which are all made using 12mm, 2mm and 6mm thick cardboard.



Innovation Readiness Level

The Oasis Bed has been integrated in the design for the intended application. The cost estimates have been done.



Costs and benefits

The design of the Oasis Bed provides collapsible beds which are completely made of cardboard making them lightweight and easily portable. Each bunk bed costs 12,595 rupees which is much cheaper than its counterparts. In the present market, average wooden bunk bed of similar dimensions costs 37,000 rupees which is 34% costlier. The Oasis Bed can further be dismantled and stored in much lesser space than a wooden bunk bed.



8.I. AFFORDABILITY

S.No.	Particulars	Baseline Estimate (Project Partner / SOR basis)			Proposed Design Estimate		
		Amount	%	Amount (INR per sqm)	Amount	%	Amount (INR per sqm)
1	Land				Not available and not considered for both cases		
2	Civil Works	54,813,640	80.50%	24801.83	62,000,334	49.87%	14804.28
3	Interior Works	25,668,411	28.43%	11656.86	33,992,336	27.23%	8116.60
4	MEP Works	8,192,046	9.07%	3720.28	23,391,042	18.74%	5585.25
5	Landscape & Site Development	656,364	0.73%	297.62	3,027,727	2.43%	722.95
6	Contingency	600,750	0.67%	272.82	1,816,636	1.46%	433.77
	TOTAL HARD COST	89,730,211	99.40%	40749.41	124,228,075	98.51%	29662.86
7	Pre Operative Expenses	-	-%	-	-	-%	-
8	Consultants	-	-%	-	-	-%	-
9	Labor cess	546,136	0.60%	248	605,545	0.49%	144.59
	TOTAL SOFT COST	546,136		248	605,545		144.59
	TOTAL PROJECT COST	90,276,347		40,997	124,833,620		29,807
	BUILT UP AREA (IN SQM)				2,202		4,188
	PROPOSED TO BASELINE %		72.7057				
	DIFF FROM BASELINE %		27.2943				

Table ix. Base case vs Proposed Case Cost Estimate (Refer appendix for detailed calculations)

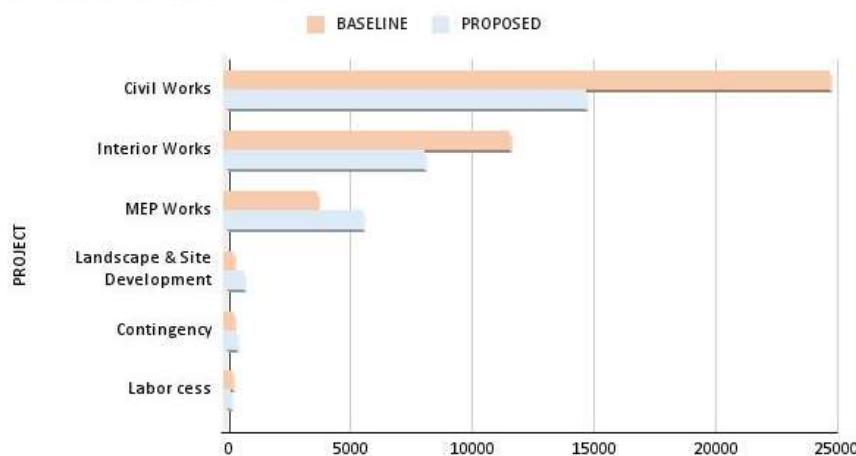
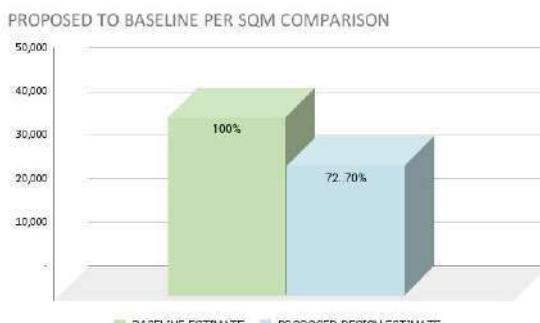


Fig. 106 Cost per sqm sorted by Category of Construction comparison



- Base line construction estimate is **40,997 Rupees / Sq.m**
- The proposed design estimate is **29,807 Rupees/ Sq.m**
- The proposed design cost per Sq.m is **72.70 %** of the Baseline cost

Fig.107 Cost per Sqm comparison

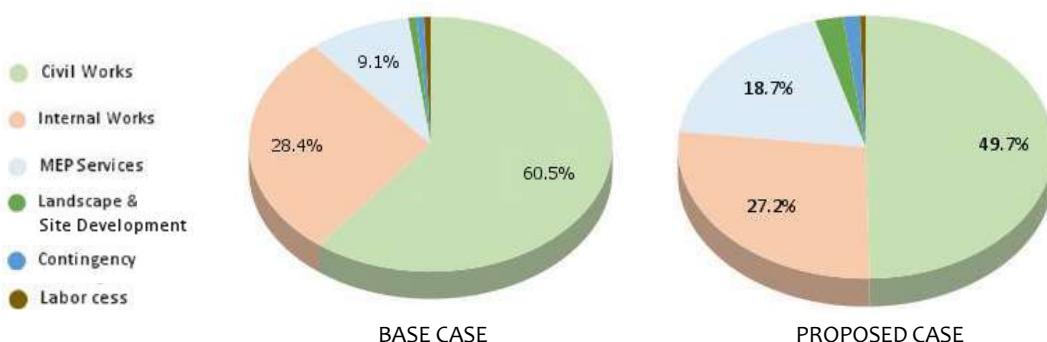


Fig. 108 Split of Construction cost comparison



BUILDING CONSTRUCTION TIMELINE

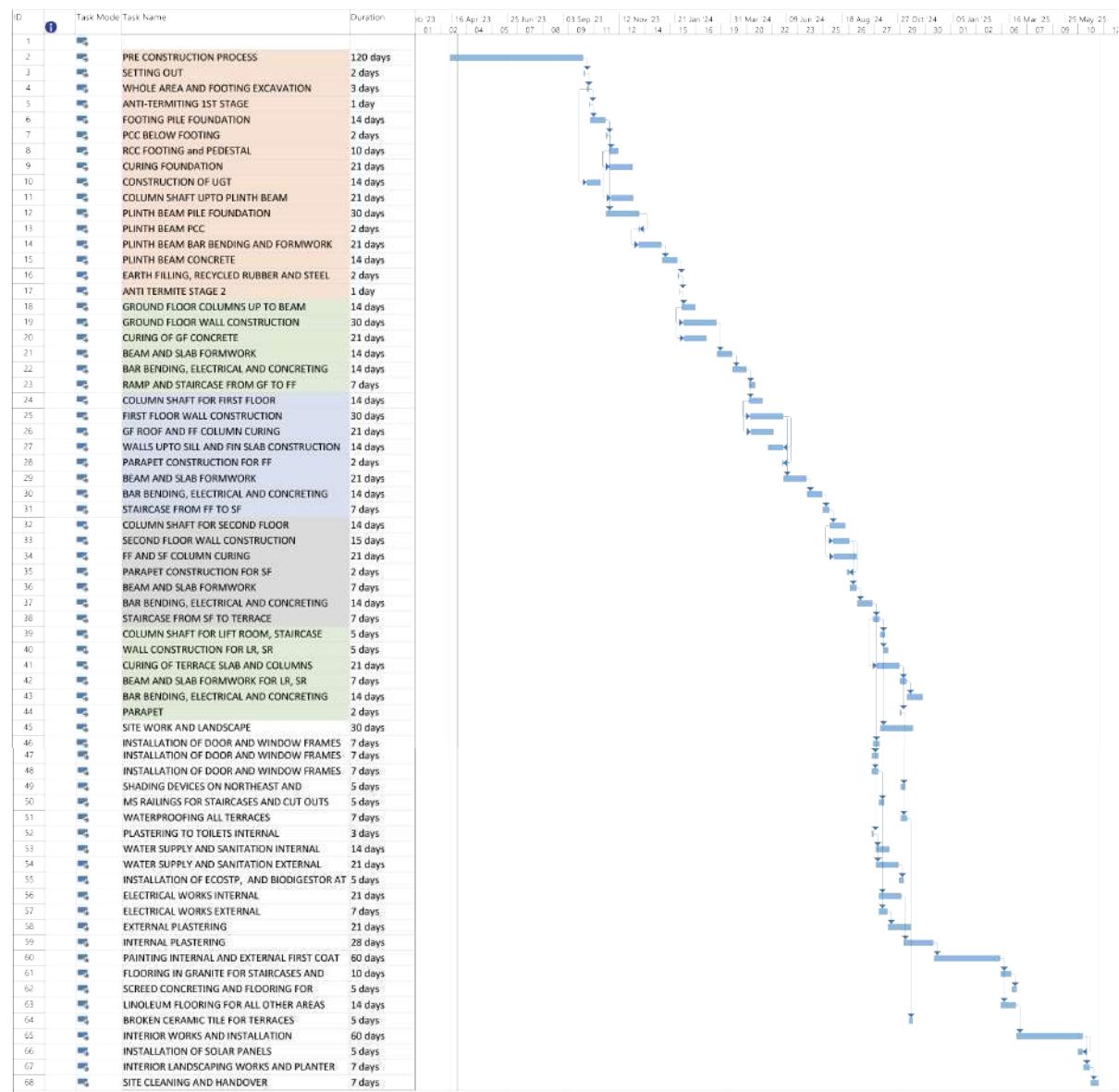


Table x. Building Construction Timeline

BUILDING CONVERSION TIMELINE

STEPS	VOLUNTEERS	No. of furniture	TYPOLOGY	TIME TAKEN PER ONE PERSON	TOTAL TIME	100 mins	30 mins	36 mins
CLEARING RUBBLE AND CREATING SMOOTH ENTRY EXTERNAL	10	0		10	100			
VOLUNTEER SETTING UP THE CIRCULATION SPACES INTERNALLY	10	0		3	30			
REGISTRATION AND ALLOCATION	4	530		1	133			
TOTAL NO OF VOLUNTEERS	24							
STEPS	VOLUNTEERS	No. of furniture	TYPOLOGY	TIME TAKEN PER ONE PERSON	TOTAL TIME	100 mins	30 mins	36 mins
GROUND FLOOR								
INSTALLATION OF PORTABLE TOILETS	4	10		10	25			
CONVERSION OF SEMINAR HALL	4	28	chairs to beds	1	7			
	3	9	bunk beds	5	15			
CONVERSION OF WORKSHOPS (gf)	2	18	chairs to beds	1	9			
	4	12	bunk beds	5	15			
	4	24	mattresses transfer	5	30			
CONVERSION OF EQUIPMENT ROOM (gf)	4	18	bunk beds	5	25			
TOTAL NO OF VOLUNTEERS	25							
FIRST FLOOR								
CONVERSION OF CORRIDORS (first floor)	7	46	mattresses transfer	5	33			
	4	23	bunk beds	5	29			
CONVERSION OF WORKSHOPS (ff)	2	18	chairs to beds	1	9			
	4	17	bunk beds	5	21			
	4	24	mattresses transfer	5	30			
CONVERSION OF CONFERENCE ROOM (ff)	4	8	bunk beds	5	10			
CONVERSION OF SEMINAR HALL (ff)	2	42	chairs to bed	1	21			
	5	36	bunk beds	5	36			
CONVERSION OF GYM TO FIELD HOSPITAL	4	18	field hospital	1	3			
TOTAL NO OF VOLUNTEERS	36							

Table xi. Building Conversion Timeline

- We have prepared a Construction timeline that determines when the shelter will be ready to use in case of an emergency. The sooner the shelter is constructed, the better prepared the community will be in the event of a disaster. This is done to ensure that the project stays on schedule and within budget, helps in allocating resources efficiently.
- We want to communicate the timeline to the community, so that the residents can stay informed about the project's progress and be involved in the process.
- The construction of the project would get completed in 770 days as per the above timeline.
- The Conversion Timeline is prepared to show number of volunteers needed to convert the building in the event of disaster, depending upon the criticality of the situation.
- When the building is under conversion in the event of disaster, the initial registration of people etc can be completed under 2 hours 15 minutes. The Ground floor, given 25 volunteers can be ready for occupation in 30 minutes. Similarly, First floor can be ready in 33 minutes.



8.J. VALUE PROPOSITION

PROJECT PARTNER BENEFITS



- Climate resilient
- Earthquake resilient
- Climate Resilient
- 86,63,797 litres of rainwater harvested/annum
- 30% is consumed , rest given off to the grid
- Reduction in operation cost because of using eco-STP, rainwater harvesting, solar panels
- Passive strategies have been used reducing the EPI by 47%



- Using convertible furniture which can be replicated in other buildings
- During disaster, battery storage can sustain the building for 4 days
- Increasing the comfort of the occupants by designing shading devices such that the interior spaces are lighted up even when the lights aren't switched on
- Reduction in transportation costs by using locally available materials

Fig 109. Project partner benefits

USER BENEFITS



- Integrating greenery in the office spaces to increase the productivity of the workers
- Privacy to the office users as they are placed on the topmost floor
- Outsiders can enter the building from the exterior itself instead of entering the building every time



Fig 110. User benefits

MOBILE APPLICATION

The team aims to design an application that is not only focused on the particular building being designed but also try and help the general public as well. The app acts as an alert as well as an awareness app, alerting the users during times of disaster and guiding them to safer places and spreading awareness about different disasters and how to take precautions against them. At the same time, the app is working even during non-disaster times, providing activities and notifications that help raise awareness but also help keep the mind active

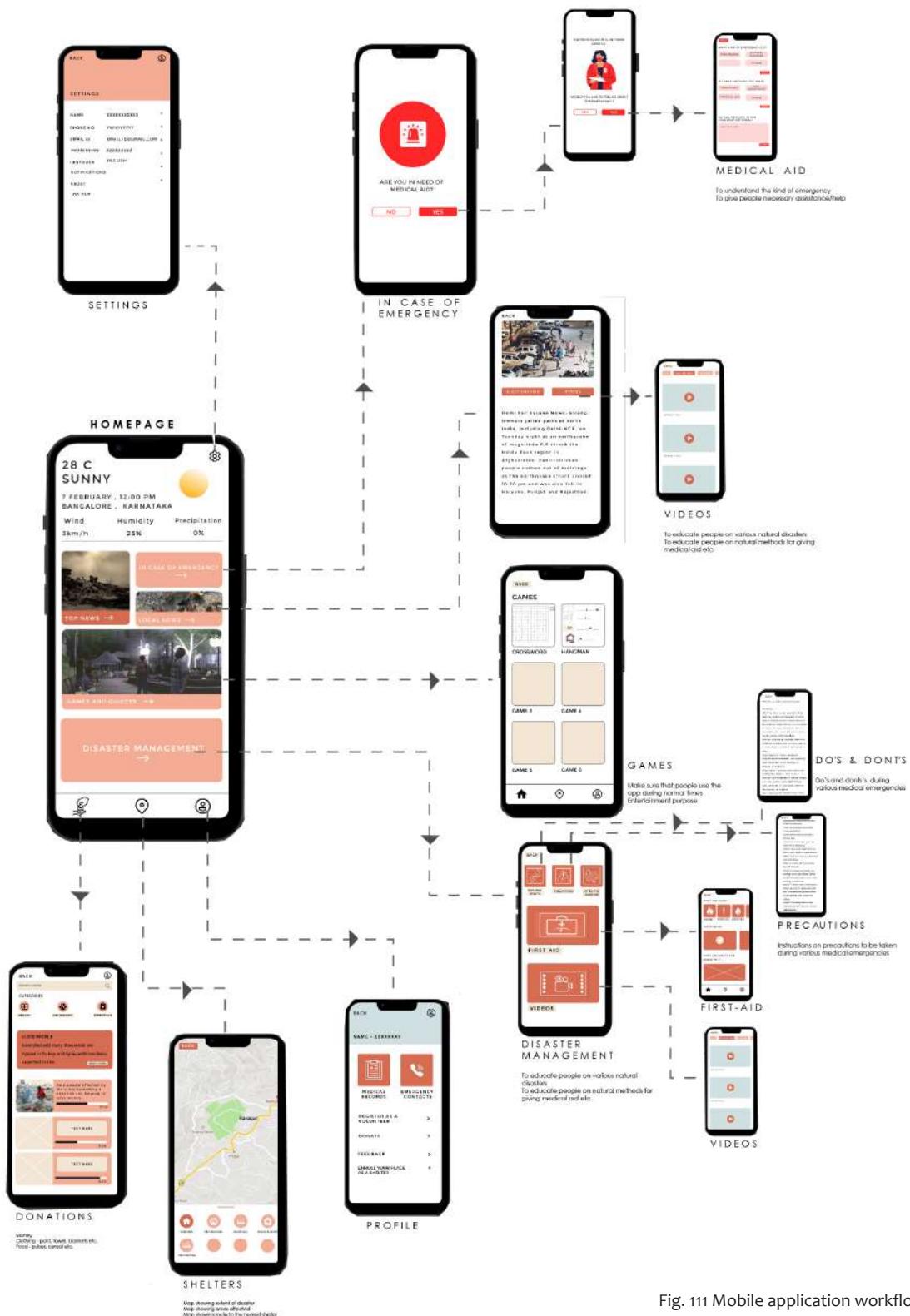


Fig. 111 Mobile application workflow



**STRONGER TOGETHER,
RESILIENT FOREVER**

NORMAL TIMES

PROJECT AIKYAM



DISASTER TIMES

Fig. 112 Value proposition poster



9. APPENDIX

9.1 BUILDING AREA PROGRAM

UNDER NORMAL CIRCUMSTANCES - NON DISASTER PERIOD		UNDER EMERGENCY CIRCUMSTANCES - DISASTER PERIOD	
SPACES	AREA (sq.m)	SPACES	AREA (sq.m)
BUSINESS (OFFICE)	1173	BUSINESS (OFFICE)	1173
Designations:		Designations:	
Deputy Secretary + P.A	23	Deputy Secretary + P.A	23
Under secretary + P.A	30	Under secretary + P.A	30
Commissioner Room +P.A + Visitors room	80	Commissioner Room +P.A + Visitors room	80
Joint Secretary room +P.A	30	Joint Secretary room +P.A	30
Director + P.A	45	Director + P.A	45
Minister's room + P.A	52	Minister's room + P.A	52
Commissioner Room +P.A	45	Commissioner Room +P.A	45
Open Offices	550	Open Offices	550
Conference Hall	40	Conference Hall	40
Meeting Room	30	Meeting Room	30
Peon Station + staff room	25	Peon Station + staff room	25
Department Room	60	Department Room	60
State Alert and Warning system	65	State Alert and Warning system	65
Record Room : Archives	15	Record Room : Archives	15
Store room	25	Store room	25
Control room	8	Control room	8
Facility Management Room	50	Facility Management Room	50
EDUCATION (HEALTH TRAINING CENTRE)	948	REFUGE SHELTER	948
Workshop spaces X2 : medical + precautionary	170x2	Shelter Rooms	820
Seminar Hall (Ground Floor)	200		
Seminar halls (First Floor)	280		
Equipment store(for disaster) : stretchers,etc + portable toilet	65	Equipment store(for disaster) + Bunk beds	65
Dormitory for visitors	63	Dormitory for visitors	63
COMMON SPACES	1239	COMMON SPACES	1239
Wellness centre	40	Wellness centre	40
Day Care centre	28	Shelter room	28
Gym	140	Gym	140
Space for SBI Bank	100	Space for SBI Bank	100
Food Store	50	Food Store	50
Food Court / dining	140	Food Court / dining	140
Kitchen	50	Kitchen	50
Utility space (washing ,etc.)	50	Expanded to kitchen	50
Toilets + Bath	75x3	Toilets + Bath	75x3
Locker room	16	Lockers for valuables	16
Staircase area	(25x2)x 3 floors	Staircase area	(25x2)x 3 floors
Lift shaft	3	Lift shaft	3
Service Room	32	Service Room	32
Parking	215	Toilets	215
HARDSCAPE AREA	1214	TERRACED AREA	1435
Parking	215	First Floor terraces	35 + 86
Driveway	660	Second Floor terraces	142 + 42 + 63
Entance plazas	35 + 39	Second Floor Roof	1067
Paved Area for workshops	265	LANDSCAPE AREA	1580

Table1 Building area programme

 Spaces with same functionality
 Spaces with changing functionality

The entire building will be non conditioned, i.e., mechanically ventilated with HLVS fans and natural ventilation will happen through passive design strategies like increased window to wall ratio and use of landscape.



9.2 ARCHITECTURE DRAWINGS

TERRACE LANDSCAPE DESIGN

Figure i - Office balcony with pergola



OFFICE BALCONY WITH PERGOLA

Allows for a break out space from the office with elements that help reduce stress and help build connections between people.

2



OFFICE BALCONY ON THE FRONT FACADE

Introduces greenery into the space and helps look out into the Civil Secretariat complex.

Figure iii - Balcony from the break room view



BALCONY FROM THE BREAK ROOM

Continuation of the balcony directly under it, to visually connect the office workers to the community in their breaks.

3



BALCONY WITH COMMUNITY GARDENING

The terrace is planned like a maze to introduce the aspect of play within the community, while also growing vegetables. The spacing between planter boxes help make enough space for picnic-like gatherings

Figure ii - Office balcony on the front facade

Figureiv - Balcony with community gardening



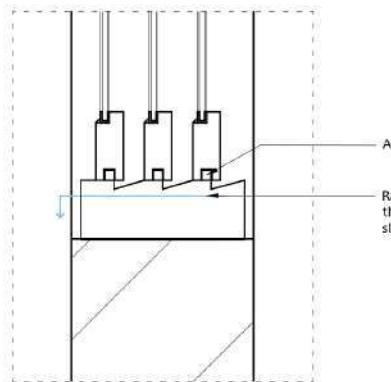
Figure v - Building front view elevation



9.4 ENGINEERING DRAWINGS

FENESTRATION DRAWINGS

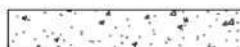
Figure vi - Weep hole detail



Weep hole detail

Aluminium channel

Rain water Weep hole within the 125x65 mm Sal wood sliding shutter frame



Sal wood frame 65x65 mm

Beadings

2 mm Polycarbonate sheet on either sides with 6 mm air gap in between

Reflective finish
Aluminium sheet

Light Shelf - 50 mm Particle board

125x65 mm Sal wood frame
30x75 mm Sal wood sliding shutter frame

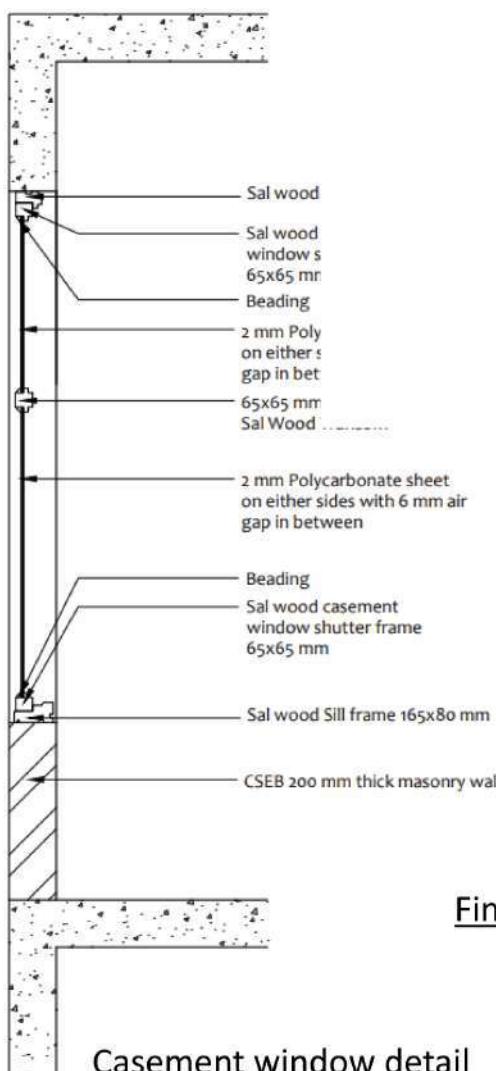
2 mm Polycarbonate sheet on either sides with 6 mm air gap in between

125x65 mm Sal wood sliding shutter frame with rain water weep hole

CSEB masonry wall

Sliding Window,
Light Shelf detail

Figure vii - Sliding window, light shelf detail



Casement window detail

Figure viii - Casement window detail

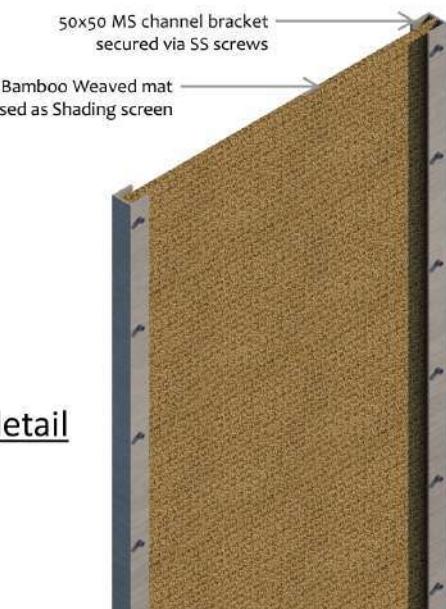


Figure ix - Fin detail (Shading device)



PLUMBING LAYOUTS

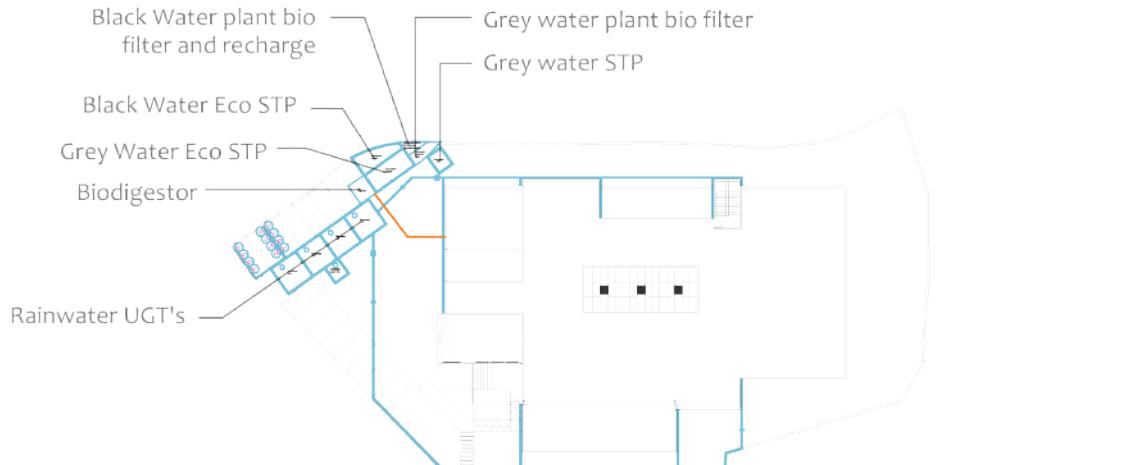
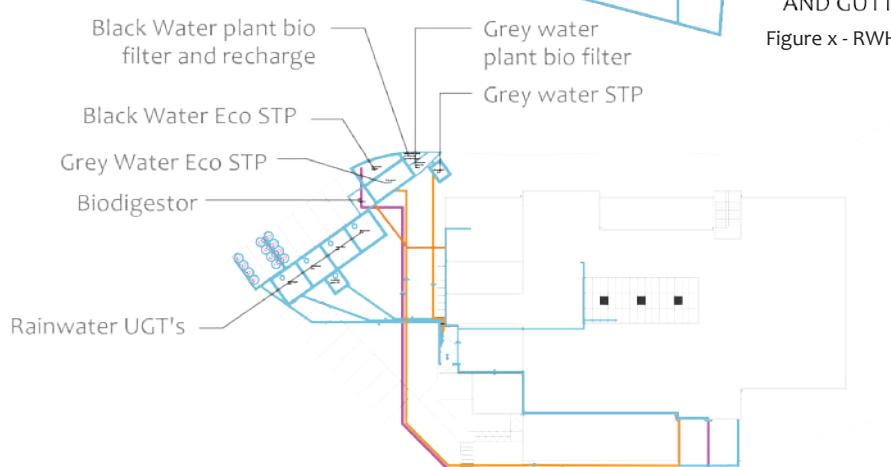


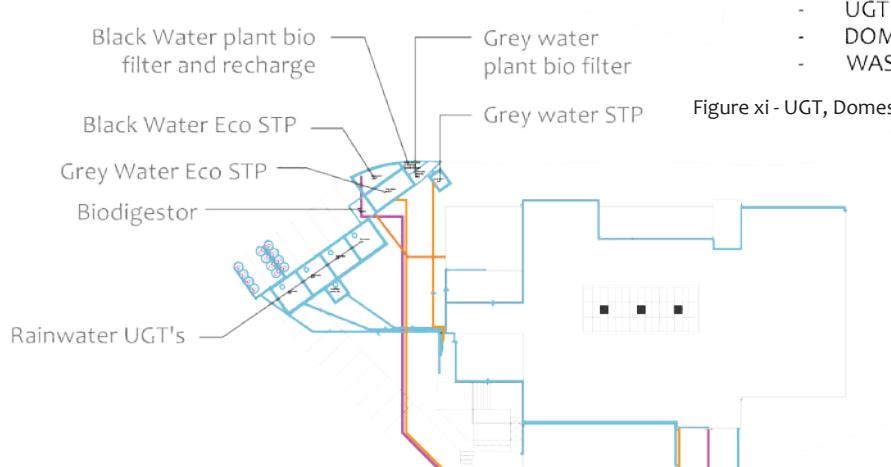
Figure x - RWH downtime pipe layout



THE LAYOUT CONTAINS:

- UGT TO OHT PIPES
- DOMESTIC WATER SUPPLY PIPES
- WASTE WATER PIPES TO UGT

Figure xi - UGT, Domestic W/S, Waste water pipe layout



PIPE LAYOUT FOR LANDSCAPING
Figure xii - Pipe layout for landscaping



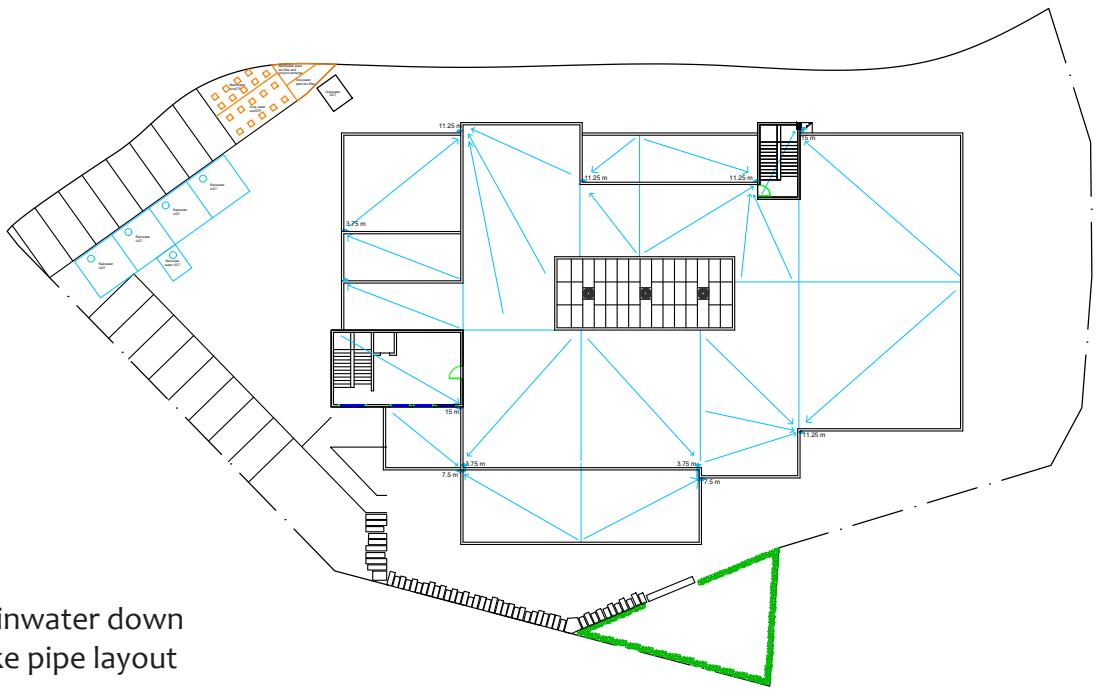
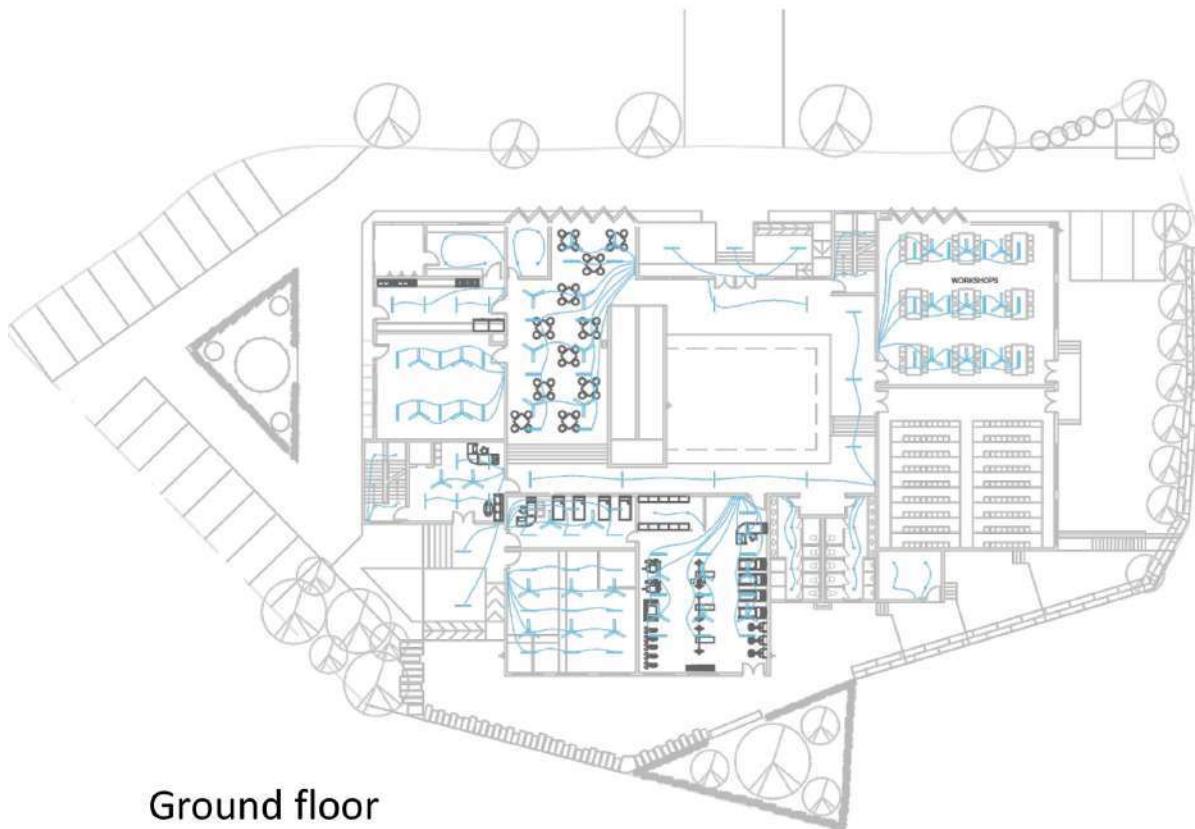


Figure xiii - Rainwater down take pipe layout

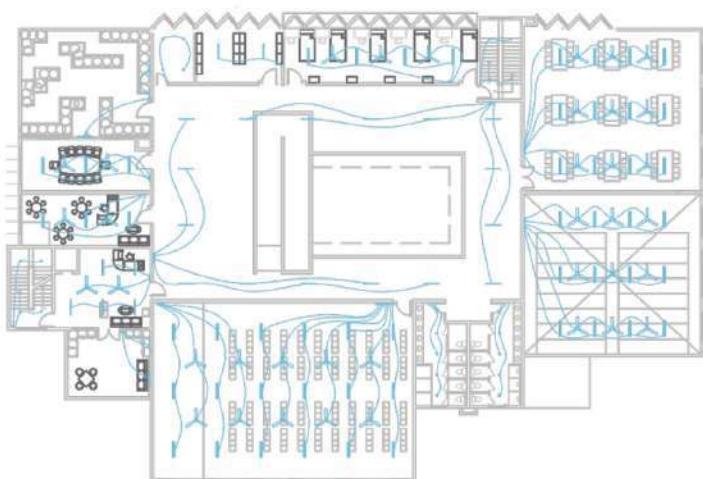


ELECTRICAL AND SOLAR PANEL LAYOUT



**Ground floor
Electrical layout**

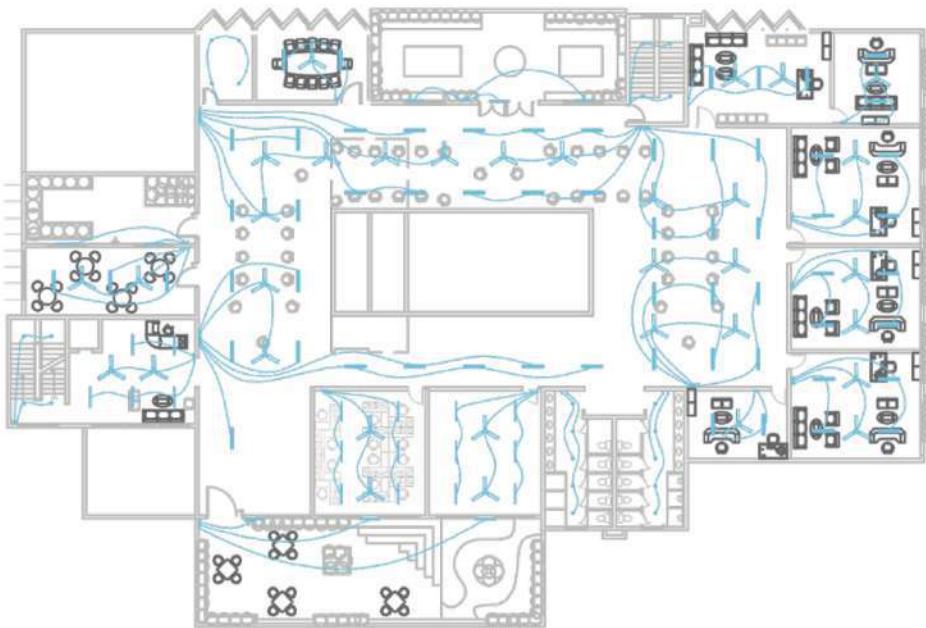
Figure xiv - Ground floor electrical layout



**First floor
Electrical layout**

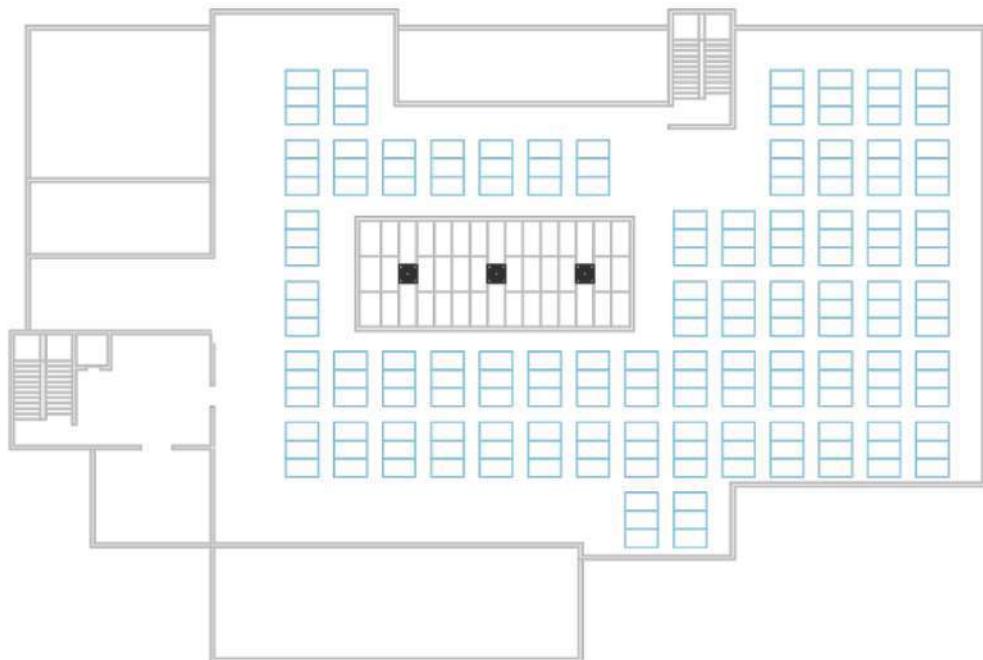
Figure xv - First floor electrical layout





Second floor Electrical layout

Figure xvi - Second floor electrical layout



Terrace floor Solar panel layout

Figure xvii - Terrace floor solar panel layout



9.5 OUTLINE SPECIFICATION OF RELEVANT BUILDING SYSTEMS

01

Pile foundation : use of short piles, the piles are bored below both the plinth beam as well as to the footing

02

Waffle slab system : locally available wicker baskets are used as pods for the waffle

03

Compressed Stabilised Earth Blocks : Walls are made up of CSEB, interlocking of these blocks are done to provide more resilience against disasters, bamboo poles are also inserted at regular intervals for extra stability of the building

04

Footing : The refill mix for the footing is made up of excavated earth, recycled rubber pieces and steel fibres to absorb earthquake vibrations

05

Eco STP : one of the sustainable methods to treat wastewater. The system contains 3 RDF chambers, a plant bio filter, with zero electricity requirement

06

Rainwater harvesting : reliable source of water during normal times and also disaster. By using rainwater harvesting system the building is reducing its demand on the municipal water supply completely.

07

LED light fixtures : Led light fixtures are extremely energy efficient, and use 90% less power than the traditional light sources. This results in lower energy bills and reduced environmental impact. They have a much longer lifespan hence, reducing the operational cost of the building. Generates less heat than traditional lighting sources, thus, keeping the interiors cool.

08

Energy Generation : Solar panels have been implanted on the roof top of the building, gym equipment and prayer wheels are the other sources of electricity generation.

09

Brush Less DC Fans : BLDC fans are more efficient at moving air and can produce a higher air flow rate with less noise, resulting in better performance and comfort.



Figure xviii - Outline Specification Of Relevant Building Systems

9.7 ENERGY PERFORMANCE

SPACES	AREA (sq.m)	Lpd (W/m ²)	Lighting power allowance	LPA (kWh per year)
BUSINESS (OFFICE)	1500			
State Alert and Warning system	65	10	650	1627.6
Record Room - archives	15	10	150	375.6
Control room	8	10	80	200.32
Facility Management Room	50	10	500	1252
Open Offices	550	10	5500	13772
Store room	25	6.8	170	425.68
Conference Hall	40	11.5	460	1151.84
Meeting Room	30	11.5	345	863.88
Peon Station + staff room	25	10	250	626
Department Room	60	10	600	1502.4
Designations:				
Deputy Secretary + P.A	23	10	230	575.92
Under secretary + P.A	30	10	300	751.2
Commissioner Room +P.A + Visitors room	80	10	800	2003.2
Joint Secretary room +P.A	30	10	300	751.2
Director + P.A	45	10	450	1126.8
Minister's room + P.A	52	10	520	1302.08
Commissioner Room +P.A	45	10	450	1126.8
	1173			
EDUCATION (HEALTH TRAINING CENTRE)	2000			
Workshop spaces X2 : medical + precautionary	400	17.1	6840	17127.36
Seminar Hall (Ground Floor)	200	11.5	2300	5759.2
Seminar halls (First Floor)	280	11.5	3220	8062.88
Equipment store(for disaster) : stretchers,etc + portable toilet	65	6.8	442	1106.768
	945			
COMMON SPACES	1191			
Wellness centre	40	9.4	376	941.504
Day care center	28	10	280	701.12
Gym	140	13.7	1918	4802.672
Food Store	50	6.8	340	851.36
Food Court / dining	140	14.1	1974	4942.896
Kitchen	50	12.1	605	1514.92
Utility space (washing ,etc.)	50	6.8	340	851.36
SBI bank	100	12.6	1260	3155.04
Toilet + bath	225	7.7	1732.5	4338.18
Lift shaft	3	5.5	16.5	41.316
Staircase lobby	150	5.5	825	2065.8
Parking	215	2.2	473	1184.392
Total	3309		22469	86881.288



Table 2 Lighting calculation - Base case

SPACE		AREA (SQ.M)	LUX LEVEL	Fixture Type	NUMBER OF FIXTURES	TOTAL WATTAGE
NORMAL	DISASTER TIME					
GROUND FLOOR						
Workshop	Shelter room	180	300	LED Battens	24	864
Seminar hall	Shelter room	180	300	LED Battens	24	864
Toilet storage	Toilet storage	20	100	LED Downlight	4	40
Toilets	Toilets	64	100	LED Downlight	10	100
Gym	Field hospital extention	144	300	LED Battens	20	720
SBI bank	SBI bank	100	300	LED Battens	9	324
Wellness center	Field hospital	42	300	LED Battens	6	216
Reception	Reception	44	300	LED Battens	5	180
Staircase 1	Staircase 1	21	100	LED Downlight	4	40
Equipment storage	Shelter room	86	300	LED Battens	12	432
Kitchen	Kitchen	42	200	LED Battens	4	144
Food storage	Food storage	26	100	LED Downlight	4	40
Utility	Utility	16	100	LED Downlight	4	40
Electrical room	Electrical room	16	100	LED Downlight	4	40
Food court	Food court	135	300	LED Battens	16	576
Staircase 2	Staircase 2	21	100	LED Downlight	4	40
Corridor	Corridor	195	100	LED Battens	9	324
Office entrance	Office entrance	34	100	LED Battens	2	72
Main entrance	Main entrance	66	100	LED Battens	3	108
FIRST FLOOR						
Workshop	Shelter room	180	300	LED Battens	24	864
(Seminar hall)	(Shelter room)	0				
Toilets	Toilets	64	100	LED Downlight	10	100
Seminar hall 2	Shelter room	288	300	LED Battens	36	1296
Reception	Reception	44	300	LED Battens	5	180
Staircase 1	Staircase 1	21	100	LED Downlight	4	40
Daycare	Daycare	42	300	LED Battens	6	216
Conference room	Shelter room	42	300	LED Battens	6	216
Electrical room	Electrical room	16	100	LED Downlight	4	40
Archives	Archives	34	200	LED Battens	2	72
Dormitory	Dormitory	64	300	LED Battens	8	288
Staircase 2	Staircase 2	21	100	LED Downlight	4	40
Corridor	Corridor	390	100	LED Battens	16	576
Terrace 1	Terrace 1	34			2	72
Terrace 2	Terrace 2	66			2	72
SECOND FLOOR						
Commissioner	Commissioner	78	300	LED Battens	10	240
Minister	Minister	56	300	LED Battens	8	192
Under Secretary	Under Secretary	48	300	LED Battens	8	192
Deputy Secretary	Deputy Secretary	50	300	LED Battens	8	192
Joint Secretary	Joint Secretary	26	300	LED Battens	4	96
Toilets	Toilets	64	100	LED Downlight	10	100
State alert room	State alert room	48	300	LED Battens	6	144
Department room	Department room	48	300	LED Battens	6	144
Reception	Reception	44	300	LED Battens	5	120
Staircase 1	Staircase 1	21	100	LED Downlight	4	40
Break room	Break room	42	300	LED Battens	6	144
Electrical room	Electrical room	16	100	LED Downlight	4	40
Meeting room	Meeting room	34	300	LED Battens	4	96
Staircase 2	Staircase 2	21	100	LED Downlight	4	40
Open office	Open office	540	300	LED Battens	70	1680
Terrace 3	Terrace 3	142			3	108
Terrace 4	Terrace 4	42			2	72
Terrace 5	Terrace 5	64			3	108



Table 3 Lighting calculation - Proposed case

EQUIPMENT	QUANTITY	WATTAGE	HOURS	NO OF DAYS	TOTAL (kWh)
Laptop	120	50	8	313	15024
Projector	6	150	4	313	1126.8
Telephone	20	5	8	313	250.4
Refrigerator	5	300	24	365	13140
Printer	8	300	2	313	1502.4
Microwave	4	800	2	313	2003.2
Water purifier	7	70	24	313	3680.88
Water pumps	2	1500	0.5	365	547.5
Water pumps	1	750	0.5	365	136.875
Lift	1	1000	8	313	2504
6A sockets	50	100	8	313	12520
16A sockets	20	1000	2	313	12520
					64956.055
VENTILATION					
Ceiling fans	108	28	8	313	7572.096
Exhaust fan	7	16	4	313	140.224
					7712.32
LIGHTING					
LED Battens	384	36	8	313	34615.296
LED Downlights	78	10	8	313	1953.12
External lights	12	24	8	313	721.152
					37289.568
				SDA = 50% (50% reduction)	18644.784

Table 4 Load calculation - Normal scenario

EQUIPMENT	QUANTITY	WATTAGE	HOURS	NO OF DAYS	TOTAL (kWh)
Laptop	120	50	16	1	96
Projector	2	150	1	1	0.3
Telephone	10	5	8	1	0.4
Refrigerator	1	300	24	1	7.2
Printer	2	300	2	1	1.2
Microwave	1	1	1	1	0.001
Water purifier	7	70	24	1	11.76
Water pumps	2	1500	0.5	1	1.5
Water pumps	1	750	0.5	1	0.375
Lift	1	1	1	1	0.001
6A sockets	50	100	16	1	80
16A sockets	10	1000	1	1	10
					208.737
VENTILATION					
Ceiling fans	54	28	12	1	18.144
Exhaust fan	7	16	4	1	0.448
					18.592
LIGHTING					
LED Battens office	54	36	12	1	23.328
LED Battens other	40	36	8	1	11.52
LED Downlights	39	10	16	1	6.24
					41.088

Table 4 Load calculation - Disaster scenario



EQUIPMENT	QUANTITY	WATTAGE	HOURS	DAYS	ENERGY PRODUCED ANNUALLY (kWh)
Treadmill	4	100	5	365	730
Training bench	3	100	5	365	547.5
Elliptical	3	100	5	365	547.5
Stationary bike	5	100	5	365	912.5
Chest press machine	1	68	5	365	124.1
Arm curler machine	2	50	5	365	182.5
				TOTAL=	2861.6

Table 5 Energy generation using gym equipment

	Number of prayer wheels	Energy generated (W)	Energy generated in a year (kWh)
First floor atrium	52	1.16	22.0168
Second floor atrium	66	1.16	27.9444
			49.9612

Table 6 Power of Prayer - Energy generation from Buddhist prayer wheels
(Assumption – The prayer wheel are rotated for 30 minutes everyday)

Natural ventilation calculation :

Algorithm used as per NBC Part 8, Natural ventilation (5.6.1.1)

Q = KAV

Example – Workshop

K = Coefficient of effectiveness = 0.3

V = Wind speed, in m/h 4.5 km/h = 4500 m/h

A = 2 two track sliding Windows (3.6m x 1.4m), 2 three track sliding windows (2.4m x 1.4m)

A = $(2 \times 3.6 \times 1.4 \times 0.5) + (2 \times 2.4 \times 1.4 \times 0.3)$

A = 5.04 + 2.016

A = 7.056 sq.m

Q = 0.3 x 7.056 x 4500

Q = 9525.6 cum/h

Volume of room = 720

(Floor area = 200 sq.m, Height = 3.6 m)

ACH achieved = 9525.6/720 = **13.23**



9.6 ENERGY SIMULATION INPUTS

Input Parameters	Units	Proposed Design values	
General			
Building area	m ²	4240	
Conditioned Area	m ²	-	
Electricity Rate	INR/kWh	7	
Natural Gas Rate	INR/GJ		
Building Occupancy Hours		Normal time - 9:00 am to 5:00 pm , During disaster - 24 hours	
Average Occupant Density	m ² / person		
Internal Loads			
Interior Average Lighting Power Density	W/m ²	4.4	
List of Lighting Controls			
Average Equipment Power Density	W/m ²	17.1	
Minimum OA Ventilation (Building Average)	l/sec.m ²		
Envelope			
Roof Assembly U value	W/m ² .K	0.88	
Roof Assembly SRI			
Average Wall Assembly U value	W/m ² .K	0.31	
Window to Wall Area Ratio (WWR)	%		
Windows U value	W/m ² .K	3.6	
Windows SHGC			
Windows VLT	%		
Infiltration rate	ac/h		
Describe Exterior Shading Devices		A sawtooth shaped wall for the Northwest façade to let in diffused north light and block west sun, Vertical fins on south east and northeast facades, Windows with light shelves on south west	
HVAC System		Not Applicable	
Service Hot Water			
SHW Type and Description			
Output Parameters	Units	Proposed Design Values	
Proposed EUI (Total)	kWh/m ² / yr	215	
EUI Breakdown by End Use			
Heating	kWh/m ² / yr	-	
Cooling	kWh/m ² / yr	-	
Fans	kWh/m ² / yr	1.8	
Pumps	kWh/m ² / yr	0.2	
Heat rejection	kWh/m ² / yr	-	
Service Hot Water	kWh/m ² / yr	-	
Lighting	kWh/m ² / yr	4.3	
Equipment	kWh/m ² / yr	15.2	
Total Envelope Heat Gain (Peak)	W/m ²		
Cooling Load of Conditioned Area	SF/Tr	-	
Building Electric (Peak)	W/m ²		
Annual Operating Energy Cost	INR/m ²		
Annual Unmet Hours		30	
Cooling Capacity		-	
Annual Hours of Comfort without Air Conditioning		8730	
Monthly Energy Performance		Generation	Consumption
January	kWh	8934	6763
February	kWh	8439	7124
March	kWh	9156	7564
April	kWh	7886	7896
May	kWh	7783	8013
June	kWh	6353	8178
July	kWh	6644	8493
August	kWh	7884	8145
September	kWh	6660	8053
October	kWh	9990	7506
November	kWh	9245	6872
December	kWh	7654	6708
		96628	91315



Table 7 - Input parameters

9.7 WATER PERFORMANCE

Table 8 - Base Case per capita consumption

	Function	Per Capita daily consumption	Number of occupants	Daily consumption (Litres)	Total daily consumption (Litres)
Non - disaster times	Office and Training center	45	320	14400	14400
Disaster times	Office	45	72	3240	44640
	Community resilience shelter	90	460	41400	

Table 9 - Sources of water

Months	Rainfall (mm)	Effective rain (mm)	Harvested rainwater(lpm)	Generated black water(lpm)	Generated Grey water(lpm)	Filtered grey water(lpm)	Municipal water(lpm)
July	969	964	26,28,153	69440	138756	104067	
Aug	662	657	17,91,179	69440	138756	104067	
Sep	418	413	11,25,962	67200	134280	100710	
Oct	163	158	4,30,755	69440	138756	104067	
Nov	22	17	46,347	67200	134280	100710	211200
Dec	20	15	40,895	69440	138756	104067	218240
Jan	36	31	84,515	69440	138756	104067	218240
Feb	64	59	1,60,852	62720	125328	93996	198880
Mar	104	99	2,69,904	69440	138756	104067	
Apr	195	190	5,17,997	67200	134280	100710	
May	340	335	9,13,311	69440	138756	104067	
June	669	664	18,10,263	67200	134280	100710	
Total		98,20,133				1225305	8,46,560

Table 10 - Non disaster times - water consumption

Quantity in lts for 320 people	Quantity in lts/person	Occupant's Activity	PROPOSED CASE	
			Quantity in lts/person	Quantity in lts for 320 people
1600	5	Handwash	1.5	480
2560	8	Drinking	8	2560
2560	8	Pantry	6	1920
3648	3.8	Urinal	0	0
1920	6	WC flushing	4	1280
832	2	Cleaning	2	640
1280	4	Others	0	0
Total = 14400LPD				Total = 7076LPD



Table 11 - Base case - total domestic water demand

Filtered grey water	Irrigation demand	Month	Days in month	Harvested rainwater (l)	Total domestic water demand (l)
1,16,064.00	4,228.96	Jul	31	2,628,153.20	4,46,400.00
1,16,064.00	4,228.96	Aug	31	1,791,179.10	4,46,400.00
1,12,320.00	4,092.55	Sep	30	1,125,961.90	4,32,000.00
1,16,064.00	10,572.41	Oct	31	430,755.40	4,46,400.00
1,12,320.00	10,231.37	Nov	30	46,347.10	4,32,000.00
1,16,064.00	10,572.41	Dec	31	40,894.50	4,46,400.00
1,16,064.00	21,144.82	Jan	31	84,515.30	4,46,400.00
1,04,832.00	19,098.55	Feb	28	160,851.70	4,03,200.00
1,16,064.00	21,144.82	Mar	31	269,903.70	4,46,400.00
1,12,320.00	20,462.73	Apr	30	517,997.00	4,32,000.00
1,16,064.00	10,572.41	May	31	913,310.50	4,46,400.00
1,12,320.00	10,231.37	Jun	30	1,810,263.20	4,32,000.00

Table 12 - Proposed case - total domestic water demand

Filtered grey water	Irrigation demand	Month	Days in month	Harvested rainwater (l)	Total domestic water demand (l)
1,04,067.00	4,228.96	Jul	31	2,628,153.20	2,18,240.00
1,04,067.00	4,228.96	Aug	31	1,791,179.10	2,18,240.00
1,00,710.00	4,092.55	Sep	30	1,125,961.90	2,11,200.00
1,04,067.00	10,572.41	Oct	31	430,755.40	2,18,240.00
1,00,710.00	10,231.37	Nov	30	46,347.10	2,11,200.00
1,04,067.00	10,572.41	Dec	31	40,894.50	2,18,240.00
1,04,067.00	21,144.82	Jan	31	84,515.30	2,18,240.00
93,996.00	19,098.55	Feb	28	160,851.70	1,97,120.00
1,04,067.00	21,144.82	Mar	31	269,903.70	2,18,240.00
1,00,710.00	20,462.73	Apr	30	517,997.00	2,11,200.00
1,04,067.00	10,572.41	May	31	913,310.50	2,18,240.00
1,00,710.00	10,231.37	Jun	30	1,810,263.20	2,11,200.00

Table 13 - Disaster times - water consumption

Quantity in lts for 460 people	Quantity in lts/person	Occupant's Activity	PROPOSED CASE	
			Quantity in lts/person	Quantity in lts for 460 people
11500	25	Bathing	25	11500
6440	14	Washing	14	6440
2300	5	Drinking	5	2300
2300	5	Cooking	5	2300
4244	3.8	Urinal	0	0
2760	6	WC flushing	4	1840
4600	10	Washing utensils	10	4600
4600	10	Cleaning	10	4600
Total = 39800LPD				Total = 33,280LPD

During a disaster

- Only 14 lts per person is considered for laundry since only clothes like bedsheets, pillowcases would be washed in emergency times
- Similarly only 25 lts is provided for bathing



Table 14 - Disaster times - water consumption - office

BASE CASE		Occupant's Activity	PROPOSED CASE	
Quantity in lts for 72 people	Quantity in lts/person		Quantity in lts/person	Quantity in lts for 72 people
360	5	Handwash	1.5	108
576	8	Drinking	5	360
576	8	Pantry	5	360
820.8	3.8	Urinal	0	0
432	6	WC flushing	4	288
	2	Cleaning	2	144
Total = 2910LPD				Total = 1260LPD

Table 15 - Base case vs Proposed case

Total domestic water demand (l)	Month	Days in month	Harvested rainwater (l)	Total domestic water demand (l)
13,83,840.00	Jul	31	23,18,684.14	10,45,072
13,83,840.00	Aug	31	15,80,265.02	10,45,072
13,39,200.00	Sep	30	9,93,378.16	10,11,360
13,83,840.00	Oct	31	3,80,033.29	10,45,072
13,39,200.00	Nov	30	40,889.66	10,11,360
13,83,840.00	Dec	31	36,079.11	10,45,072
13,83,840.00	Jan	31	74,563.49	10,45,072
12,61,080.00	Feb	28	1,41,911.17	9,43,936
13,83,840.00	Mar	31	2,38,122.13	10,45,072
13,39,200.00	Apr	30	4,57,002.06	10,11,360
13,83,840.00	May	31	8,05,766.79	10,45,072
13,39,200.00	Jun	30	15,97,101.94	10,11,360

Table 16 - Irrigation demand

Month	Days in month	Irrigation seasonal factor (%)	Irrigation demand	Water use	Area(m ²)	Litres/day
Jul	31	20%	16653	Irrigation (max) : {m ³ x l/m ³ }	1580	1.7
Aug	31	20%	16653			
Sep	30	20%	16116			
Oct	31	50%	41633			
Nov	30	50%	40290			
Dec	31	50%	41633			
Jan	31	100%	83266			
Feb	28	100%	75208			
Mar	31	100%	83266			
Apr	30	100%	80580			
May	31	50%	41633			
Jun	30	50%	40290			
		Total irrigation demand (l) =	577221			



Type of fixture					
Specifications	Jaquar Sink Cock with Regular Swinging Spout	Jaquar sensor faucet	Jaquar Allied Hand Shower	Hindware ultra low flush toilet	Parryware Astute Waterless Urinal
Flow rate (lpm/lpf)	6	6	4	4	0
Cost (INR)	2000	4600	1587	13000	11830

TANK SIZES

UNDER GROUND WATER STORAGE

Tank 1 - Rainwater tank
Capacity = 1,50,000 lakh liters = 150 m³
Size - 25 x 3 x 2 m(L x B x H)

Tank 2 - municipal water tank
Capacity = 7500 liters = 7.5 m³
Size - 2.5 x 2 x 1.5 m(L x B x H)

Tank 3 - filtered grey water tank
Capacity - 3000 lts = 3 m³
Size - 2.1 x 1.8 x 1.2 m(L x B x H)

OVERHEAD WATER STORAGE

Tank 1 - Domestic water tank
Capacity - 5000 * 1 day storage = 5m³
Size - 1.8 x 2.2m (Dia x H)

Tank 2 - Municipal water tank
Capacity - 3000 * 1 day storage = 3m³
Size - 1.5 x 1.72m (Dia x H)

Tank 3 - recycled grey water tank
Capacity - 3000 * 1 day storage = 3m³
Size - 1.5 x 1.72m (Dia x H)

SEWAGE TREATMENT PLANT

For a 7.7 kld
Stage 1 - 20 sqm
Stage 4 - 9 sqm

For separating grey and black water 10% additional space
Stage 1 - 22 sqm
Stage 4 - 10 sqm

PIPE RATES

RW down take pipes
Finolex PVC 160mm dia, 12m long pipes - 150 rs/m

Soil pipe
Finolex PVC 110 dia, 6m long pipes - 185 rs/m

Grey water pipe
Finolex PVC 75 dia, 6m long pipes - 130 rs/m

Water inlet pipe
Astral CPVC 50 dia, 5m long pipes - 2380 rs/m

RO WATER PURIFIER - 17000 rs



2 HP Texmo Submersible Pump

Number Of Stages	Multi Stage Pump
Motor Horsepower	2 HP
Brand	Texmo, Deccan Ekki, Kirloskar, Sharp tech, Kissan
Usage/Application	water
Type	Borewell



Texmo SHR 4 (1 HP)
Domestic Water pump

Brand Name :	Texmo
Phase :	Single Phase
Model No :	SHR 4
Type of Product :	Self Priming Monoblock Pump
Voltage :	180-230 V
Frequency :	50 Hz



9.8 SUMMARY OF COST ESTIMATION SHEET

Table 17 - Base case estimate

BASE CASE ESTIMATE		DESCRIPTION	QUANTITY	UNITS	RATE	TOTAL COST
CIVIL WORKS	EARTHWORK	1) The rates quoted for various items in this section shall be deemed to include for : i) Setting Out works ii) Site clearing such as removing grass and vegetation iii) Bailing out or pumping out subsurface/ rain water in excavation iv) Taking Block Levels prior to the excavation of soft rock/hard rock for measurement v) Providing Shoring, Strutting for protecting the sides of the foundation wherever required 2) The classification of soil shall be as per B.I.S provisions.				
	WHOLE AREA EXCAVATION		1835.00	cu.m	240.60	441,501
	FOOTING	Earthwork in excavation in foundation and trenches etc. in all kinds of soil (excluding soil containing 50% or more of shingle or small size boulders up to 30 cm size, saturated soil and rock), lift of up to 1.5m and stacking the excavated soil not more than 3 m clear from the edge of the excavation and returning the stacked soil in 15 cm layers, when required into plinth	180.00	cu.m	240.60	43,308
	PLINTH BEAM	same as above	62.00	cu.m	240.60	14,917
	REFILL	Supply and filling in and around the plinth, trenches, sides of foundations, under floors, low lying areas etc., in layers not exceeding 150 mm thick including breaking clods, watering, compacting each layer with heavy Rammers (and at inaccessible places Supply and filling in and around the plinth, trenches, sides of foundations, under floors, low lying areas etc., in layers not exceeding 200 mm thick including breaking clods, watering, compacting each layer with heavy Rammers (and at inaccessible places with wooden/steel rammers) to achieve 90 to 95% proctor density at optimum moisture content, all leads and lifts, balling/pumping out of water to keep site dry while back filling; costs includes conveyance of all materials, labour, machinery etc. complete as directed, with: a) Approved good quality excavated earth available at site.	290	cu.m	190.00	55,100
	ANTITERMITE	Column Pits, Wall Trenches, Plinth Filling, Junction of Wall and Floor, Expansion Joints, Surroundings of Pipes, Conduits, along the Perimeter of the Building and all joints in floors, etc. complete, as per the instructions of the Engineer in Charge. (For Billing, only GROUND FLOOR Plinth Area of the building shall be measured), and in accordance with IS 6313 Part II, 1971, and any amendments thereof. The Work shall be carried out through a pest control agency approved by the Architect/Employer, as for example, Pest Control (India) Ltd., Stages and Dosages of Chemicals used to be as follows: a) Excavated Walls, Column Pits, etc. and at junctions of walls : 1 ltr/linear meter. b) Before laying PCC 1:4:8 below floors after refilling and compaction of the earth : 5 ltr. / Square Meter. c) Along external wall perimeter upto a depth of 300 mm : 4.5 ltr/linear meter.	367	sq.m	100	36700
	PCC	Providing and laying in position plain cement concrete of specified grade including the cost of centering and shuttering for ALL WORKS UPTO PLINTH LEVEL, including sub grade preparation, levelling, all leads & lifts, rough finishing at the top surface, curing etc., with:				
	FOOTING	PCC 1:4:8 (1 cement: 4 river sand: 8 graded stone aggregate 40 mm nominal size) below foundation and flooring,	15.00	cu.m	4,759.90	71,399
	FLOORS		294.00	cu.m	4,759.90	1,399,411
	SILL CONCRETE	For Plain window sills	5.00	cu.m	10,884.50	54,423
	FLAGGING	PCC 1:3:6 (1 cement: 3 river sand: 6 graded stone aggregate mm nominal size)	1924	cu.m		2,195,284
	TOILET	PCC 1:3:6 (1 cement: 3 river sand: 6 graded stone aggregate)	21	cu.m	6817	143,157
	RCC	Providing and laying in position R.C.C. of following grades in				
	FOOTING	Reinforced concrete work in foundations, footings, bases of columns etc. and mass concrete excluding cost of centring, shuttering and reinforcement in M20 (1 cement: 1.5 coarse sand: 3 stone aggregate 20 mm nominal size).	128.00	cu.m	7180.2	919,066
	PEDESTAL		54.00	cu.m	8179	441,666
	COLUMN	Reinforcement cement concrete work in columns, pillars, piers, abutments, post and struts etc up to floor two level including finishing and plastering the exposed surface with cement mortar 1: 3 (1 cement: 3 fine sand) of thickness not exceeding 6 mm to give a smooth and even surface but excluding cost of centring, shuttering, and reinforcement	73.00	cu.m	9063.4	661,628
	PLINTH BEAM	surface but excluding cost of centring, shuttering and reinforcement.	18.00	cu.m	6358.7	114,457
	BEAMS	M20 (1 cement: 1.5 coarse sand: 3 stone aggregate 20 mm nominal size)	155.00	cu.m	8966	1,389,730
	LINTELS		9.00	cu.m	8,966.00	80,694

STAIRCASES	Reinforced cement concrete work in stair cases (excluding landing) including finishing and plastering the exposed surface with cement mortar 1: 3 (1 cement : 3 fine sand) of thickness not exceeding 6 mm to give a smooth and even surface, preparing of the top surface and finishing, nosing upto floor two level but excluding the cost of centring, shuttering and reinforcement with M20 (1 cement : 1.5 coarse sand : 3 stone aggregate 20 mm nominal size).	82.00	cu.m	10051.9	824,256
OHT 1 - DOMESTIC		10,000.00	litre	7	70,000
OHT 2 - MUNICIPALWATER		13000	litre	7.00	91,000
SUMP TANK		27000	litre	6.00	162,000
SHEAR WALLS		131	cu.m	7,884.00	1,032,804
RETAINING WALL		23.00	cu.m	7,884.00	181,332
PLAIN SLAB		495.00	cu.m	6423.35	3,179,558
MASONRY	1) The rates are inclusive of providing and removing scaffolding wherever required, and curing 2) In case of Brick/Concrete Block masonry, the thickness of mortar joints should not exceed 10 mm. 3) Testing of Bricks and Concrete Blocks shall be carried out as and when required and test results shall be produced. 4) Rate should be inclusive lead and lift of all necessary materials to required level				
	Providing and constructing AAC blocks in cement 1:4 for all leads and lifts	576.00	cu.m	5,190.00	2,989,440
SHUTTERING	Centring and shuttering including strutting, propping etc, and removal of form work for walls, columns and beams				
WALL		5,007.00		670	3,354,690
COLUMNS		588.00	sq.m	348.50	204,918
BEAMS		4,789.00	sq.m	474.80	2,273,817
REINFORCEMENT (4KG/SQFT)	Reinforcement for RCC work including bending, binding and placing in position complete.				
STEEL		176160	kg	86.60	15,255,456
PLASTERING	The rate quoted shall include the cost of: i) Providing & removing the scaffolding wherever required, and curing ii) Providing arpit mesh for a width of 150 mm at the junctions of masonry walls and RCC works at all heights. iii) Making grooves, patties & drip moulds in chajjas and slab projections. iv) In case of columns & beams only exposed faces shall be considered for plastering under columns and beams v) The rate quoted shall include the cost of chipping and finishing the wall surface after skirting is completed.				
EXTERIOR WALLS	15 mm Cement Plaster - 1:4 (1 cement : 4 fine sand)inclusive of waterproof compound mix	399.00	sq.m	172.70	68,907
INTERIOR WALLS	12 mm Cement Plaster - 1:6(1 cement : 6 fine sand)	1,937.00	sq.m	146.00	282,802
PARAPET	15 mm Cement Plaster - 1:4 (1 cement : 4 fine sand)inclusive of waterproof compound mix	100.00	sq.m	172.70	17,270
CEILING	6 mm Cement Plaster - 1:6 (1 cement : 4 fine sand)inclusive of waterproof compound mix	3,383.00	sq.m	130.80	442,496
PAINTING	The rate quoted shall include the cost of: i) Providing & removing the scaffolding wherever required, and curing ii) Providing arpit mesh for a width of 150 mm at the junctions of masonry walls and RCC works at all heights. iii) Making grooves, patties & drip moulds in chajjas and slab projections. iv) In case of columns & beams only exposed faces shall be considered for plastering under columns and beams v) The rate quoted shall include the cost of chipping and finishing the wall surface after skirting is completed.				
EXTERIOR WALLS	Emulsion Paint	399.00	sq.m	161.46	64,423
INTERIOR WALLS	Emulsion Paint	1,937.00	sq.m	158.00	306,046
PARAPET	Emulsion Paint	119.00	sq.m	161.46	19,214
CEILING	Emulsion Paint	3,383.00	sq.m	158.00	534,514
FLOORING	1) The rate includes provision of selected flooring material DELIVERED AT SITE, including cost of loading / unloading and transport. 2) All necessary protective measures like covering the floor with supply and spreading of P.O.P with polythene sheet below P.O.P and removing and cleaning of the same 3) If the bed mortar thickness increases beyond the specified thickness then the level difference shall be made up by providing screed concrete				
GRANITE	For all areas and spaces	2569	sqm	1200	3,082,800
CERAMIC TILES	For all toilets	112	sqm	795.5	89,096
CONCRETE	For Basements	367	sqm	6638	2,436,146



ROOFING	Providing INTEGRAL CEMENT BASED WATER PROOFING treatment over RCC roof terrace by spreading cement slurry over the RCC slab and laying 100 mm thick average thickness using table moulded half bricks and proprietary water proofing compound , at all levels. This is to be mixed with cement and sand to Proprietary Firm's composition, laid to required gradient to have easy flow of rain water, and top finished with water proof jointless Plaster finished smooth with wooden trowels with false marking of 300 sq.mm This includes rounding off of junctions of walls and slabs. The treatment should carry 10 years of performance guarantee. The rate includes complete items, including labour and materials and any initial treatment for filling up honeycombs and crevices in the RCC slabs if found necessary. The rate shall be for finished area treated including vertical surfaces.				
WATERPROOFING		376	sq.m	430.9	162,018
MISCELLANEOUS					
MS HANDRAILS	For Staircases	127.80	rmt	128.40	16,410
DOORS	Alluminium Door	75.00	no	8,333.00	624,975
LIFT	Installation of lift per landing and lift equipment	2.00	no	1,400,000.00	2,800,000
AIR CONDITION	Capacity - 1.5 TON	7.00	no	43,999.00	307,993
AIR CONDITION	Capacity - 2 TON	8.00	no	56,990.00	455,920
FALSE CEILING	12 MM POP	1,493.00	sq.m	1,388.00	2,072,284
KITCHEN COUNTER	In kitchen	8.00	sq.m	4,000.00	32,000
GLASS	Curtain Wall	484.40	sqm	5,545.00	2,685,998
	Window	322.56	sqm	1,335.00	430,618
TOTAL OF CIVIL WORKS					54,613,640



Table 18 - Proposed case project estimate

PROPOSED CASE ESTIMATE					
CIVIL WORKS	DESCRIPTION	QUANTITY	UNITS	RATE	TOTAL COST
EARTHWORK	1) The rates quoted for various items in this section shall be deemed to include for : i) Setting Out works ii) Site clearing such as removing grass and vegetation iii) Balling out or pumping out subsurface/ rain water in excavation iv) Taking Block Levels prior to the excavation of soft rock/hard rock for measurement v) Providing Shoring, Strutting for protecting the sides of the foundation wherever required 2) The classification of soil shall be as per B.I.S provisions.				
WHOLE AREA EXCAVATION		1758.04	cu.m	240.60	422,984
FOOTING	Earthwork in excavation in foundation and trenches etc. in all kinds of soil (excluding soil containing 50% or more of shingle or small size boulders up to 30 cm size, saturated soil and rock), lift of up to 1.5m and stacking the excavated soil not more than 3 m clear from the edge of the excavation and returning the stacked	1,403.47	cu.m	240.60	337,675
PLINTH BEAM	Same as above	289.28	cu.m	240.60	69,601
REFILL	Supply and filling in and around the plinth, trenches, sides of foundations, under floors, low lying areas etc., in layers not exceeding 150 mm thick including breaking clods, watering, compacting each layer with heavy Rammers (and at inaccessible places Supply and filling in and around the plinth, trenches, sides of foundations, under floors, low lying areas etc., in layers not exceeding 200 mm thick including breaking clods, watering, compacting each layer with heavy Rammers (and at inaccessible places with wooden/steel rammers) to achieve 90 to 95% proctor density at optimum moisture content, all leads and lifts, balling/pumping out of water to keep site dry while back filling; costs includes conveyance of all materials, labour, machinery etc. complete as directed, with: a) Approved good quality excavated earth available at site.	2467.44	cu.m	190.00	468,814
ANTITERMITIC	Column Pits, Wall Trenches, Plinth Filling, Junction of Wall and Floor, Expansion Joints, Surroundings of Pipes, Conduits, along the Perimeter of the Building and all joints in floors, etc. complete, as per the instructions of the Engineer in Charge. (For Billing, only GROUND FLOOR Plinth Area of the building shall be measured), and in accordance with IS 6313 Part II, 1971, and any amendments thereof. The Work shall be carried out through a pest control agency approved by the Architect/Employer, as for example, Pest Control (India) Ltd., Stages and Dosages of Chemicals used to be as follows: a) Excavated Walls, Column Pits, etc. and at junctions of walls : 1 ltr./linear meter. b) Before laying PCC 1:4:8 below floors after refilling and compaction of the earth : 5 ltr. / Square Meter. c) Along external wall perimeter upto a depth of 300 mm : 4.5 ltr./linear meter.	1494.9	sq.m	50	74,745
FOUNDATION	PILE FOUNDATION - Incides cost of PRE FABRICATION , SURVEY TEAM TOPOGRAPHY AND PILE MARKING - TOOLS AND PLANS NEEDED				
PRE CAST SHORT PILES		1594	no.	6801	10,840,794
PCC	Providing and laying in position plain cement concrete of specified grade including the cost of centering and shuttering for ALL WORKS UPTO PLINTH LEVEL, including sub grade preparation, levelling, all leads & lifts, rough finishing at the top surface, curing etc., with:				
FOOTING	PCC 1:4:8 (1 cement: 4 river sand: 8 graded stone aggregate 40 mm nominal size) below foundation and flooring.	26.14	cu.m	4,759.90	124,424
FLOORS		164.90	cu.m	4,759.90	784,908
SILL CONCRETE	For Plain Window Sills	4.67	cu.m	10,884.50	50,831
TOILET	PCC 1:3:6 (1 cement: 3 river sand: 6 graded stone aggregate 40 mm nominal size) below foundation and flooring.	18.95	cu.m	6,817.00	129,169
RCC	Providing and laying in position R.C.C of following grades in components and locations as given below, including the cost of all materials (including admixtures approved by consultants), preparation, laying compacting and curing of concrete ,with all leads, lifts, vibrating where ever necessary, curing as directed and including the cost of shuttering / centering but excluding the cost of reinforcement steel which shall be quoted separately.The design mix may be prepared at site by weight - batching or obtained as ready mix concrete from source approved by the Engineer in charge/architect/owner. Difference in rates for readymix and site mix concrete per cubic metre shall be mentioned. Permissible Limit of Concrete Quantity by manual mix at single pour shall not be more than 6 cum.				
FOOTING	Reinforced concrete work in foundations, footings, bases of columns etc. and mass concrete excluding cost of centring, shuttering and reinforcement in M20 (1 cement: 1.5 coarse sand: 3 stone aggregate 20 mm nominal size).	431.76	cu.m	7180.2	3,100,123
PEDESTAL		179.94	cu.m	8179	1,471,729
COLUMN	Reinforcement cement concrete work in columns, pillars, piers, abutments, post and struts etc up to floor two level including finishing and plastering the exposed surface with cement mortar 1: 3 (1 cement: 3 fine sand) of thickness not exceeding 6 mm to give a smooth and even surface but exluding cost of centring, shuttering, and reinforcement	262.07	cu.m	9063.4	2,375,263
PLINTH BEAM	Reinforced cement concrete work in lintels, beams and bresumers up to floor level including finishing and plastering the exposed surface with cement mortar 1: 3 (1 cement: 3 fine sand) of thickness not exceeding 6 mm to give a smooth and even surface	108.48	cu.m	6358.7	689,792
BEAMS		143.46	cu.m	8966	1,286,262



LINTELS	but excluding cost of centering, shuttering and reinforcement, M20 (1 cement: 1.5 coarse sand: 3 stone aggregate 20 mm nominal size)	4.68	cu.m	8,966.00	41,943
STAIRCASES	Reinforced cement concrete work in stair cases (excluding landing) including finishing and plastering the exposed surface with cement mortar 1: 3 (1 cement: 3 fine sand) of thickness not exceeding 6 mm to give a smooth and even surface, preparing of the top surface and finishing, nosing upto floor two level but excluding the cost of centring, shuttering and reinforcement with M20 (1 cement: 1.5 coarse sand : 3 stone aggregate 20 mm nominal size).	13.36	cu.m	10051.9	134,293
RAMP	Similar to above but for RAMP from Ground to First Floor only	7.94	cu.m	6358.7	50,475
UGT - TANK 1 (RAINWATER)		150	cu.m	6,891.00	1,033,650
UGT - TANK 2 (MUNICIPAL WATER TANK)		7.5	cu.m	6,891.00	51,683
UGT - TANK 3 (FILTERED GREY WATER)		5	cu.m	6,891.00	34,455
STP		7.70	kLd	-	385,000
BIO DIGESTOR		8216	litres		25,000
UG FOOD STORAGE		13.55	cu.m	6,891.00	93,352
UG FOOD STORAGE PIPE		2.67	sqm	800.00	2,136
WAFFLE SLAB		168.78	cu.m	6723.84	1,134,850
PLAIN SLAB		855.02	cu.m	6423.35	5,492,112
MASONRY	1) The rates are inclusive of providing and removing scaffolding wherever required, and curing 2) In case of Brick/Concrete Block masonry, the thickness of mortar joints should not exceed 10 mm. 3) Testing of Bricks and Concrete Blocks shall be carried out as and when required and test results shall be produced. 4) Rate should be inclusive lead and lift of all necessary materials to required level				
COMPRESSED STABILIZED EARTH BLOCKS	Providing and constructing SCEB blocks in cement 1:4 for all leads and lifts inclusive of cost of bamboo reinforcement (bamboo shall be measured and paid for separately)	602.20	cu.m	1,667.00	1,003,867
SHUTTERING	Centring and shuttering including strutting, propping etc. and removal of form work for columns and beams				
COLUMNS		1,973.88	sq.m	348.50	687,897
BEAMS		3,857.16	sq.m	474.80	1,831,380
REINFORCEMENT	Reinforcement for RCC work including bending, binding and placing in position complete.				
STEEL		230340	kg	86.60	19,947,444
BAMBOO		10084	m	27.80	280,335
PLASTERING	The rate quoted shall include the cost of: i) Providing & removing the scaffolding wherever required, and curing ii) Providing arista mesh for a width of 150 mm at the junctions of masonry walls and RCC works at all heights. iii) Making grooves, patties & drip moulds in chajjas and slab projections. iv) In case of columns & beams only exposed faces shall be considered for plastering under columns and beams v) The rate quoted shall include the cost of chipping and finishing the wall surface after skirting is completed.				
EXTERIOR WALLS	15 mm Cement Plaster - 1:4 (1 cement : 4 fine sand)inclusive of waterproof compound mix	72.89	sq.m	172.70	12,588
INTERIOR WALLS	12 mm Cement Plaster - 1:6(1 cement : 6 fine sand)	1,745.14	sq.m	146.00	254,791
PARAPET	15 mm Cement Plaster - 1:4 (1 cement : 4 fine sand)inclusive of waterproof compound mix	259.31	sq.m	172.70	44,783
CEILING	6 mm Cement Plaster - 1:6 (1 cement : 4 fine sand)inclusive of waterproof compound mix	4,603.28	sq.m	130.80	602,109
PAINTING	The rate quoted shall include the cost of: i) Providing & removing the scaffolding wherever required, and curing ii) Providing arista mesh for a width of 150 mm at the junctions of masonry walls and RCC works at all heights. iii) Making grooves, patties & drip moulds in chajjas and slab projections. iv) In case of columns & beams only exposed faces shall be considered for plastering under columns and beams v) The rate quoted shall include the cost of chipping and finishing the wall surface after skirting is completed.				
OIL BOUND DISTEMPER PAINT	For ceiling	4,603.28	sq.m	30.60	140,860
EMULSION PAINT	For internal walls, external walls and parapets	2,077.34	sq.m	161.46	335,407
ENAMEL PAINT	For all metal works for box section	318.20	sq.m	33.50	10,660
	For door and windows	565.79	sq.m	33.50	18,954
WHITE PAINT	For roofs		sq.m	7.00	
POLISHING	The rate quoted shall include rate of polishing inclusive of material				
DOORS AND WINDOWS		565.79	sqm	48.30	27,327
FLOORING	1) The rate includes provision of selected flooring material DELIVERED AT SITE, including cost of loading / unloading and transport. 2) All necessary protective measures like covering the floor with supply and spreading of P.O.P with polythene sheet below P.O.P and removing and cleaning of the same 3) If the bed mortar thickness increases beyond the specified thickness then the level difference shall be made up by providing screed concrete				
LINOLEUM	For all areas in all spaces	4,603.28	sqm	807.31	3,716,274
FLAME GRANITE	For ramp flooring area	52.92	sqm	968.78	51,268
GRANITE	For veranda steps , DA ramp , staircases	117.65	sqm	1200	141,180



CERAMIC TILES	For toilets	189.48	sqm	795.5	150,731
STONE PAVERS	For landscaping	134.08	sqm	2029	272,048
TERRAZO TILES	For all terrace spaces	227.894	sqm	1098.6	250,364
SKIRTING		2893.98	rmt	125	361,748
	For all rooms and corridors				
DADO	In toilets and kitchen	220.73	sq.m	125	27,591
ROOFING	Providing INTEGRAL CEMENT BASED WATER PROOFING treatment over RCC roof terrace by spreading cement slurry over the RCC slab and laying 100 mm thick average thickness using table moulded half bricks and proprietary water proofing compound , at all levels. This is to be mixed with cement and sand to Proprietary Firm's composition, laid to required gradient to have easy flow of rain water, and top finished with water proof jointless Plaster finished smooth with wooden trowels with false marking of 300 sq.mm This includes rounding off of junctions of walls and slabs. The treatment should carry 10 years of performance guarantee. The rate includes complete items, including labour and materials and any initial treatment for filling up honeycombs and crevices in the RCC slabs if found necessary. The rate shall be for finished area treated including vertical surfaces.				
WATERPROOFING		227.894	sq.m	430.9	98,200
MISCELLANEOUS					
MS HANDRAILS	For Staircases	42.66	rmt	128.40	5,478
DOORS AND WINDOWS	1) The rate quoted for the following items in this group shall be for: a) Finishing of the openings / damages done during fixing of the same. b) Providing and fixing hold fast,necessary chipping, and making the surface good after fixing. c) Ensuring the protection of all wooden frame members as necessary, prior to handing over.	565.79	sqm	490.70	277,631
FINS	Built up C Section Bracket	114.55	kg	513.9	58868.2728
	Baamboo Mat	299.60	m	45.00	13,482
LIGHT WEIGHT CEMENT CLADDING WITH MOSS	TYPE 1 - 4.8mx 1.2m	8.64	cu.m	4032	34836.48
	TYPE 2- 4.2m x 0.9m	1.0395	cu.m	2646	2750.517
FALSE CEILING	Made of Plaster Of Paris	338.98	sq.m	951.00	322,370
SKYLIGHTS	Polycarbonate sheet 2 mm	91.80	sqm	800.00	73,440
	Steel framework- Installation cost	515.00	kg	86.67	44,635
KITCHEN COUNTER	Marble counter tops	9.70	sq.m	4,000.00	38,800
WICKER BASKETS	For Waffle slabs, as pods	390	no.	88.00	34,320
PLANTER BOX	Made of wood	32	no.	120.00	3,840
	Made of concrete	4.05	no.	6,423.35	26,015
OHT - TANK 1 (DOMESTIC WATER TANK)		5,000.00	ltr	37,500.00	37,500.00
OHT - TANK 2 (DOMESTIC WATER)		3,000.00	ltr	22,500.00	22,500.00
OHT - TANK (IRRIGATION WATER)		2,000.00	ltr	15,000.00	15,000.00
LABOUR TRAINING	Cost of knowledge transfer (Professional Sum)				15,000
TOTAL OF CIVIL WORKS					62,000,334

MEP WORKS	AS MENTIONED IN THE REPORT				
EQUIPMENT COSTING	AS MENTIONED IN THE REPORT				
SOLAR PANELS		180	no.	21000	3780000
SOLAR PANELS INSTALLATION -PANEL STAND		60	no.	10500	630000
LITHIUM PHOSPHATE BATTERIES		60	no.	250000	1500000
BLDC FANS		108	no.	3270	353160
AIR TURBINE ROOF VENTILATOR		3	no.	4000	12000
EXHAUST FANS		7	no.	2250	15750
PRAYER WHEELS		118	no.	2000	236000
INVERTER		1	no.	237552	237552
LIFT EQUIPMENT		1	no.	550000	550000
SPROCKET		118	no.	300	35400
CHAIN		2	no.	5000	10000
GEARS		2	no.	12000	24000
GDYNAOMO		2	no.	7000	14000
LIGHTING COSTING	AS MENTIONED IN THE REPORT				
LED BATTENS- 36W		384	no.	950	364800
LED DOWNLIGHTS - 10W		78	no.	850	66300
OUTDOOR LIGHTING (TERRACES)		10	no.	950	9500
POINT WIRING FOR SWITCH BOARDS (provisional)		800	no.	750	600000
EARTHING PITS	Providing, installing, testing and commissioning of GI pipe earthing station including excavation, back filling,earthing strips as per code, 38mm internal diameter GI pipe of 2.5 mts long, construction of inspection chamber (CI) - heavy duty, disconnecting linketc., as per IS 3043 Supply & Installation	4	no.	4000	16000
LIGHTING SOCKETS	6A	135	no.	80	10800
FAN POWER SOCKETS	Ceiling fan point controlled by Step type electronic modular regulator	56	no.	80	4480
POWER SOCKETS	6A	50	no.	80	4000
	16A	10	no.	122	1220



WATER PERFORMANCE EQUIPMENT COSTING		AS MENTIONED IN THE REPORT					
RWH PUMP			1	no.	20000	20000	
MUNICIPAL WATER PUMP			1	no.	20000	20000	
IRRIGATION PUMP			1	no.	7000	7000	
ECO STP			1	no.	385000	385000	
DRINKING WATER FILTERS			1	no.	17000	17000	
KITCHEN FAUCET	Installing, testing and commissioning of stainless steel sink manufactured from 1mm thick, stainless steel, ISG high grade indestructible chrome nickel steel with top quality polish, 40mm dia CP waste coupling, with 32mm dia waste pipe up to flour trap below, 15mm dia sink cock with swivel spout wall mounted type, with necessary wall flanges etc. complete. Make : NIRALI / DIAMOND, double pan, 4x2", SS material with complete accessories,		4	no.	2000	8000	
URINALS	Supply, Installing, testing and Commissioning if White glazed Urinals complete with all other required accessories etc.,		3	no.	11830	35490	
WATER CLOSET	Supplying, installing, testing and commissioning of white glazed Floor mounted European water closet with ceramic body cistern as mentioned on the drawings with necessary bend, checknut, stopcock etc., colour solid seat and cover with polythene buffer and flap, CP flanges, CP bolts and nuts, a pair of CI chair bracket with nuts and bolts, wall flanges etc., complete.		30	no.	13445	403350	
WASH BASIN FAUCET			32	no.	4600	147200	
WATER PUMP (1HP)			1	no.	7000	7000	
WATER PUMP (2HP)			2	no.	20000	40000	
RW DOWN TAKE PIPES	FINOLEX PVC - 160mm dia, 12m long pipes		9	no.	150	1350	
SOIL PIPE	FINOLEX PVC - 110 dia, 6m long pipes		90	no.	185	16650	
GREY WATER PIPES	FINOLEX PVC - 75 dia, 6m long pipes		78	no.	130	10140	
WATER INLET PIPES	ASTRAL CPVC - 50 dia, 5m long pipes Supply, installation and commissioning of CPVC ASTM D26 pipes for hot & cold water supply with Malleable Specials such as tees, elbows, check nuts, unions, flanges, nipples, etc		55	no.	2380	130900	
RO WATER PURIFIER			1	no.	17000	17000	
PORTABLE COLLAPSIBLE TOILETS			10	no.	15000	150000	
TOTAL OF PHE WORKS						23,391,042	
INTERNAL/FURNITURE WORKS							
FURNITURE COSTING	1) The rate quoted for the following items in this group shall be for: a) Material cost b) Labor cost						
SMALL SIZED TABLE	Made of WOOD - 1.5mx 1.5m , 0.7m height		20	no.	1535	30700	
RECEPTION TABLE	Made of WOOD - 2400mmx 650mm, 750 hight		4	no.	9499	37996	
CENTRE TABLES	Made of WOOD Frame with GLASS - 900mmx460mm, 480mm heig		11	no.	2425	26675	
LARGE SIZED TABLE	Made of STEEL- 2400mmx 1200mm, 750mm ht		18	no.	8299	149382	
CONFERENCE TABLE	Made of WOOD - 3200mmx1200mm , 750 ht		2	no.	10147	20294	
DESKS	Made of WOOD - 1500mmx 650mm, 750ht		78	no.	6299	491322	
TABLE OR CHILDREN	Made of WOOD - 800dia, 630mm ht		2	no.	4500	9000	
CHAIRS	Made of WOOD - 500mmx 480mm, 450mm ht of seat and 800mm ht of backrest		111	no.	1200	133200	
OFFICE CHAIRS	Fabric/ Faux leather/ Vinyl + Steel base + Cushion		99	no.	4395	435105	
SOFA - 3 SEATER	Made of WOOD Frame with FABRIC		10	no.	12000	120000	
SOFA - 1 SEATER	Made of WOOD Frame with FABRIC		14	no.	8000	112000	
CHAIR FOR CHILDREN	Made of WOOD - 500mmx 480mm, 450mm ht of seat and 800mm ht of backrest		24	no.	1600	38400	
LOCKERS	Made of WOOD - 800mmx450mm, 450ht , 16 door workers locker		7	no.	16000	112000	
WARDROBE CLOSETS	Made of WOOD - 800mmx 450mm, 2100mm ht		19	no.	4000	76000	
SINGLE BEDS	Made of WOOD		5	no.	5000	25000	
HOSPITAL COT	Rexine/ Plastic + Steel + Mattress		4	no.	3850	15400	
AUDITORIUM CHAIRS	Made of Arjuna Wood		2663.68	cu.m	2135	5686956.8	
WORKSHOP CHAIRS	Made of Arjuna Wood		9840	cu.m	2135	21008400	
CARDBOARD BEDS	Bunk Beds made of Cardboard		9389	cu.m	110	1032790	
MATTRESS			5766	cu.m	749	4318734	
GYM							
TREADMILL			4	no.	9275	37100	
TRAINING BENCH			3	no.	1151	3453	
STATIONARY BICYCLE			5	no.	4599	22995	
ELLIPTICAL CROSS TRAINER			3	no.	8490	25470	
CHEST PRESS MACHINE			1	no.	8053	8053	
ARM CURL MACHINE			2	no.	7955	15910	
TOTAL OF INTERNAL WORKS						33,992,335.80	
SITE DEVELOPMENT						3027727	
LABOUR CESS						605545	
ADDED CONTINGENCIES						1816636	
TOTAL OF ESTIMATE OF THE PROJECT						124,833,619.79	



9.9 SUMMARY OF EMBODIED CARBON SHEET

Base case					Proposed case				
Wall					Proposed case				
Material	Volume per block	Blocks per 3439.9 sq.m = 26636	Density	Weight	Material	Volume per block	Blocks per 3439.9 sq.m = 46323	Density	Weight
AAC blocks	0.024	639.264	600	383558.4	Earth block	0.013	602.199	1,324	7,97,378
Cement mortar	0.0012	31.9632	2080	66483.456	22% sand	0.00286	132.48378	1520	201375.3456
Cement plaster		41.27892	1440	59441.6448	55% soil	0.00715	331.20945	1540	510062.553
					3%water	0.00039	18.06597	997	18011.77209
					7%cement	0.00091	42.15393	1440	60701.6592
					8%straw	0.00104	48.17592	150	7226.388
					Bamboo	0.15	465	750	348750
					Cement mortar	0.0009	41.6907	2080	86716.656
Flooring					Area - 2734				
Granite	82.02		2750	225555	Linoleum	7.587		1100	8345.7
Cement screed	82.02		2200	180444	Adhesive	2.529		1200	3034.8
					Cement screed	82.02		2200	180444
					Ceramic tile	2.052			222382.248
Windows									
uPVC	0.150262047		1330	199.848522	Particle board light shelves	0.12		600	72
Glass	0.072449994		2500	181.1249855	Polycarbonate	0.187		1200	224.4
					Sal wood	0.211		720	151.92
Structure									
Column - Base case					Column - Proposed case	262.07			
Steel rebars	3.93105		7850	30858.7425	Steel rebars	3.93105		7850	30858.7425
Steel stirrups	2.09656		7850	16457.996	Steel ties - spacing - 300mm	2.09656		7850	16457.996
Concrete	256.04239		2400	614501.736	Concrete with 50% flyash	256.04239			448074.1825
Concrete beams					Beams	423.63			
Steel rebars	6.35445		7850	49882.4325	I sections	38.44811366		7850	301817.6922
steel stirrups	3.38904		7850	26603.964	Steel rebars	5.7777		750	4333.275
Concrete	413.88651		2000	827773.02	Steel stirrups	3.08144		7850	24189.304
					Concrete with 50% flyash	376.3227463		2000	752645.4927
					Slab	3548.48			
One way slab			Area-532.27		Waffle slab	177.91	Total volume		
Steel bars	5.32272		7850	41783.352	Concrete with 50% flyash	172.39479		2000	344789.58
Concrete	526.94928		2000	1053898.56	Bamboo pods	2.84656		750	2134.92
					Steel	2.66865		7850	20948.9025
					One way slab	531.786	Total volume		
					Bamboo bars	10.63572		750	7976.79
					Steel bars	2.65893		7850	20872.6005
					Concrete with 50% flyash	518.49135		2000	1036982.7
Plinth					Plinth	1649.98	Area-164.99		
Concrete	162.52303		2000	325046.06	Concrete with 50% flyash	162.52303		2000	325046.06
Steel	2.47497		7850	19428.5145	Recycled steel	2.47497		7850	19428.5145
					Total area	5884.16			
Roof									
One way slab					Waffle slab	118.89			
Steel bars	4.329507		7850	33986.62995	Concrete with 50% flyash	114.60996		2000	229219.92
Concrete	408.004493		2000	816008.986	Bamboo pods	1.90224		750	1426.68
					Steel	2.3778		7850	18665.73
					One way slab	215.28			
					Steel bars	1.0764		7850	8449.74
					Bamboo bars	4.3056		750	3229.2
					Concrete with 50% flyash	209.898		2000	419796

Table 19 Material quantities

System Type	Baseline			Proposed				
	Material emissions (kg·CO ₂ e)	Transport 1 (kg·CO ₂ e)	Transport 2 (kg·CO ₂ e)	Total (kg·CO ₂ e)	Material emissions (kg·CO ₂ e)	Transport 1 (kg·CO ₂ e)	Transport 2 (kg·CO ₂ e)	Total (kg·CO ₂ e)
Wall	66.1	0.1	0.0	66.2	-19.3	0.2	0.0	-19.0
Roof	157.2	2.6	0.1	159.9	48.2	2.7	0.2	51.1
Floor	37.5	0.3	0.0	37.8	18.5	0.0	0.0	18.6
Fenestration	5.1	0.0	0.0	5.1	2.3	0.0	0.0	2.4
Structural	182.4	2.3	0.1	184.8	91.5	4.9	0.2	96.7
Grand Total emissions per functional unit (kg·CO₂ e)				453.9	Grand Total emissions per functional unit (kg·CO₂ e)			149.7

Table 20 Carbon emissions per functional unit





Fig xix. Emissions from wall

Baseline - 200 x 600 mm AAC blocks with cement mortar
 Proposed - 200 x 600 mm Earth blocks(Soil (55%) + Sand (22%) + Straw fibers (8%) + Water (3%) + Cement with 30% fly ash(7%) with bamboo and fly ash cement mortar



Fig xx. Emissions from fenestrations

Baseline - 4mm float glass panes with uPVC frame
 Proposed - DGU with 2mm polycarbonate and sal wood frame+particle board light shelves



Fig xxi. Emissions from roof

Baseline - 150mm thick RCC slab
 Proposed - 150mm thick flyash concrete slab with 50% bamboo and 50% recycled steel reinforcement, waffle slab with bamboo basket pods



Fig xxii. Emissions from structure

Baseline - RCC
 Proposed - 50% flyash concrete + recycled steel reinforcement

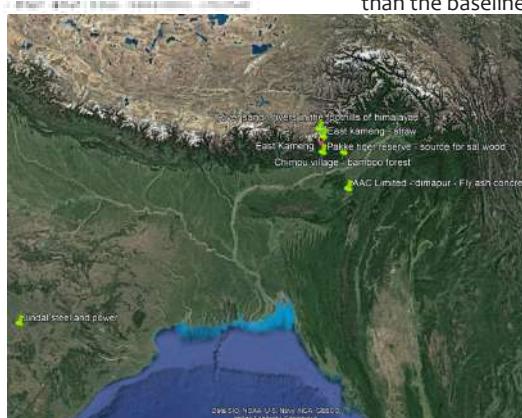


Fig xxiii. Emissions from floor

Baseline - Tan brown 18 mm granite
 Proposed - Laminate sheet, ceramic tiles(washrooms) and its wastage(balconies), green pavers(outdoor)



According to calculations from the EC tool, carbon emission of materials is reducing by 68%. All materials are available within 300km radius but, due to the non availability of recycled steel near Itanagar, emissions due to transportation from the manufacturer to supplier is more than the baseline.



Material	Manufacturer	Distance	Supplier	Distance
Soil	Papumpare	84	Naharlagun	12
Sand	River beds of Himalayas	258	Jhorat	136
Straw bale	East kameng	94.4	Chimpu	4
Fly ash cement	Dimapur	265	Itanagar	5
Water	On site			
Bamboo	Chimpu forest	4	Naharlagun	10
Cement mortar	Dimapur	265	Itanagar	5
Concrete with 50% fly ash	Dimapur	265	Itanagar	5
Bamboo baskets	Chimpu forest	4	Naharlagun	10
Recycled steel rebars	Jindal steel and power, Chattisgarh	1850	Itanagar	3
Linoleum	Jhorat	146	Naharlagun	12
Flooring adhesive	Jhorat	146	Naharlagun	12
Cement floor screed	Dimapur	265	Itanagar	5
Particle board	Naharlagun	10	Itanagar	2
Polycarbonate sheet	Itanagar	32	Itanagar	4
Sal wood	Pakke tiger reserve	140	Naharlagun	10
Recycled steel sections	Jindal steel and power, Chattisgarh	1850	Itanagar	3

Fig xxiv. Sources of materials



9.10 BUILDING OPERATION NARRATIVE

RAIN WATER HARVESTING AND ECOSTP

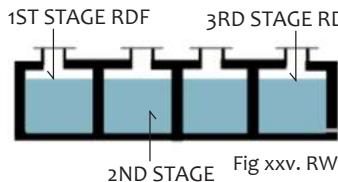


Fig xxv. RWH Operation narrative

RAIN WATER HARVESTING

An on-site rainwater harvesting system has been constructed for effective utilization of rainwater. This system consists of down-take pipes, underground storage tanks, sand filters (for the removal of debris and pathogens). It is further treated in an RO filter for potable uses.

ECOSTP is a reliable and eco-friendly Zero Power, Zero Odour and Zero Chemical Sewage Treatment Technology. It is a treatment system that lasts for generations with no overground space requirements, daily surveillance, treating the wastewater to pollution control board specifications. It is based on gravity and natural principles with no operators. The sewage flows through multiple chambers and the aerobic bacteria decomposes the pollutants. It comprises of three separate chambers with rumen digester filters and a final planted bio filter. Once in 2 years or 4 years the sludge has to be removed. It doesn't need dedicated maintenance personnel unlike in conventional technologies since there are no electro – mechanical components involved. The only maintenance required is de-sludging once in 2 years. However we also do Annual Maintenance Contracts (AMC) We do monthly checks on water, engineer visits and annual desludging.

POWER SAVED	6570 KWH/YEAR
COAL SAVED	5.26 TONNE/YEAR
ANNUAL SAVINGS	65,494
ROI ACHIEVED IN	2 YEARS

BIODIGESTER

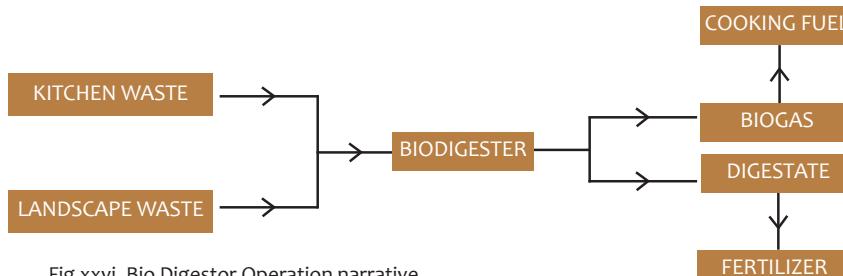


Fig xxvi. Bio Digestor Operation narrative

The aim is to re-purpose majority of the solid waste generated on site or to get it collected by recycling facilities, so that it none of it ends up in the land fill eventually.

The manual procedures involved in supplying kitchen waste to a biodigester are as follows:

- Segregation of waste: The first step is to categorize kitchen waste into separate groups: food, vegetable, and fruit. This is necessary to ensure the proper nutrient balance is maintained in the biodigester.
- Waste collection: After segregating the waste, it should be collected and kept in a container or bin.
- Waste mixing: To make a slurry, it's necessary to combine the kitchen waste with water. This can be accomplished manually by churning the garbage in a container
- The slurry is manually fed into the biodigester
- regular inspection and maintenance instructions

The biodigester should be inspected weekly, for any leaks or signs of damage. The inlet and outlet pipes should be checked to ensure that they are not blocked. The quality of biogas should be monitored regularly to ensure that it meets the required standards. The gas pipes should be checked for leaks, and the gas pressure should be checked.

The following are the steps that can be taken during emergency situations to manage solid waste effectively:

- The segregation of waste is done into different categories such as recyclable, non-recyclable, hazardous, and first-aid medical waste
- Disaster times, the first-aid medical waste are collected by medical waste management facilities that specialize in collection, treatment and disposal
- Toxic waste like batteries are collected by toxic waste management facilities that specialize in collection, treatment and disposal
- The bio degradable waste generated from kitchen at our site, is fed to the bio digestor and bio gas is generated for cooking fuel during disaster times.



PILE FOUNDATION

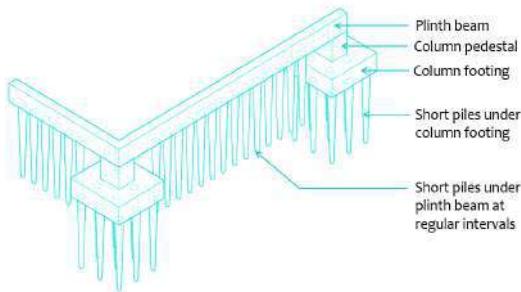


Fig xxvii. Pile foundation narrative

Precast concrete short pile foundation system was chosen for this project to combat with earthquakes. When compared to long piles that are subjected to plastic hinge effect during earthquakes, short piles are much more resilient with this regard. Short pile foundations are typically less expensive and faster to install than long pile foundations, making them a more cost-effective option. We have short piles under the plinth beam in addition to the footing short piles for additional stability. They also produce less waste during installation and can be easily removed and recycled at the end of their useful life, making them an environmentally

SOLAR PV PANELS WITH ENERGY-STORAGE SYSTEM ALONG WITH OTHER ENERGY

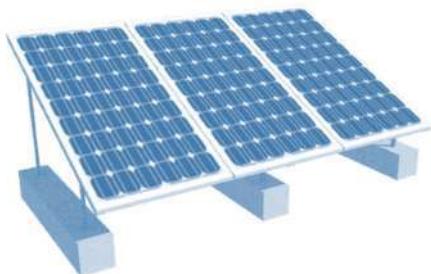


Fig xxviii. Solar PV panel narrative

1. It generates off-grid power using solar panels and lithium phosphate batteries for energy storage, enabling four days of autonomy. In addition, mechanical energy from gym equipment and the power of prayer - Buddhist prayer wheels with a gear system - are used to generate energy. Everything is executed manually, including operable windows with shading devices tailored to each facade and the installation of energy-efficient fans

WINDOW WALL RATIO, UNIFORMITY RATIO FOR LIGHTING AND VENTILATION

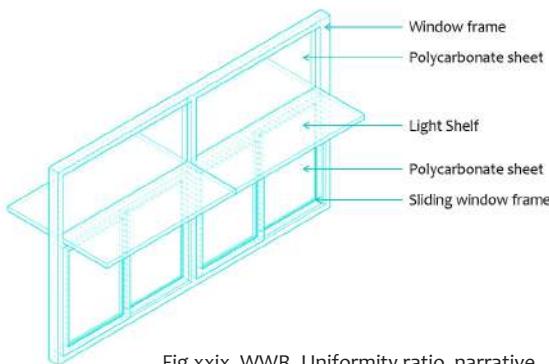


Fig xxix. WWR, Uniformity ratio narrative

The ventilation system comprises of an adaptable cooling system that is often utilised with variable diurnal temperatures and allows the building's occupants to choose the quantity of light and ventilation they desire to enter into the structure.

The manual procedures involved in window operation are as follows:

- a) Both casement and sliding windows are manually operated
 - b) BLDC fans in the building are a switch-operated systems and occupants have the option of speed regulation.
 - c) light switches are operated by manual control
- Instruction for routine inspection and maintenance is that the reflective coating must be cleaned. During the monsoon season we might have to repaint to maintain the efficiency of the light shelf.

The following are the steps that can be taken during emergency situations to manage energy systems effectively:

- a) in case of critical conditions, only the important loads are considered given the sunshine hours reduced, and only four days of battery backup is taken into considerations, so the building's critical functions, such as the SDMA office, will be maintained, as will emergency lights and adequate ventilation for the refugees.



9.12 INNOVATION

Power calculation for Prayer Wheels

We assume that the prayer wheel is rotated by 20 rpm(rotations per minute). To get a rotation of 720 rpm on the dynamo, we use gears that have 1440 and 40 teeth meshed together.

Calculations-

$$720/20=36 \text{ (final rpm/ initial rpm)}$$

Gear 2=40 teeth

$$\text{Gear 1}=40*36=1440 \text{ teeth}$$

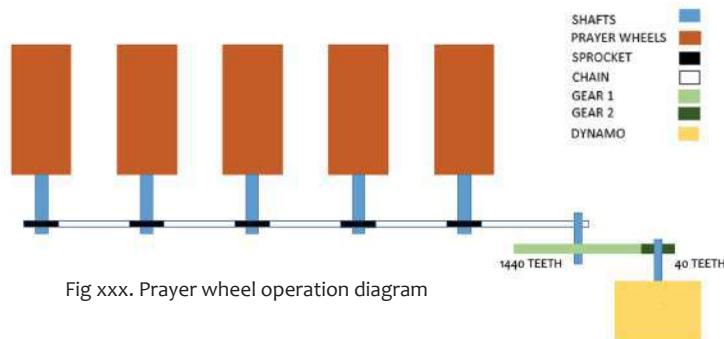


Fig xxx. Prayer wheel operation diagram

Costing for the prayer wheel

Number of prayer wheels purchased- 118

Cost of each Prayer wheel- 2000 rupees

Cost of each sprocket- 300 rupees

Cost of chain- 5000 rupees

Cost of gears- 12000 rupees

Cost of dynamo- 7000 rupees

Total cost of the setup = 295400 rupees

Hardware List

S No.	Innovation	Hardware	Brand	Dimensions	
1.	The Refuge Rest	180° Backrest Hinge	Global Furniture Components (GFC 030)	305mm * 36mm*6mm thk	
2.	The Serenity Chair	180° Self-Locking Hinge	Enenes	700mm*550m m*20mm thk	

Table 21 Hardware list



9.12 RESILIENCE

Food items (ingredients)	Average amount needed per person per day	Amount needed per person for 4 days	Amount needed to feed a population of 320 for 4 days
Maize, rice	400g	1600g	512kg
Legumes	60g	240g	76.8kg
Vit. A fortified oil	25g	100g	32kg
Fortified blended foods	50g	200g	64kg
Salt	15g	60g	19.2kg
Sugar	15g	60g	19.2kg

Nutritional value per person- Energy- 2100 calories, Protein- 58g, Fat- 43g

Table showing the amount of food needed to feed a population of 320 for 4 days

Food items (ingredients)	Average amount needed per person per day	Amount needed per person for 4 days	Amount needed to feed a population of 530 for 4 days
Maize, rice	400g	1600g	848kg
Legumes	60g	240g	127.2kg
Vit. A fortified oil	25g	100g	53kg
Fortified blended foods	50g	200g	106kg
Salt	15g	60g	31.8
Sugar	15g	60g	31.8

Nutritional value per person- Energy- 2100 calories, Protein- 58g, Fat- 43g

Table showing the amount of food needed to feed a population of 530 for 4 days



9.13 VALUE PROPOSITION

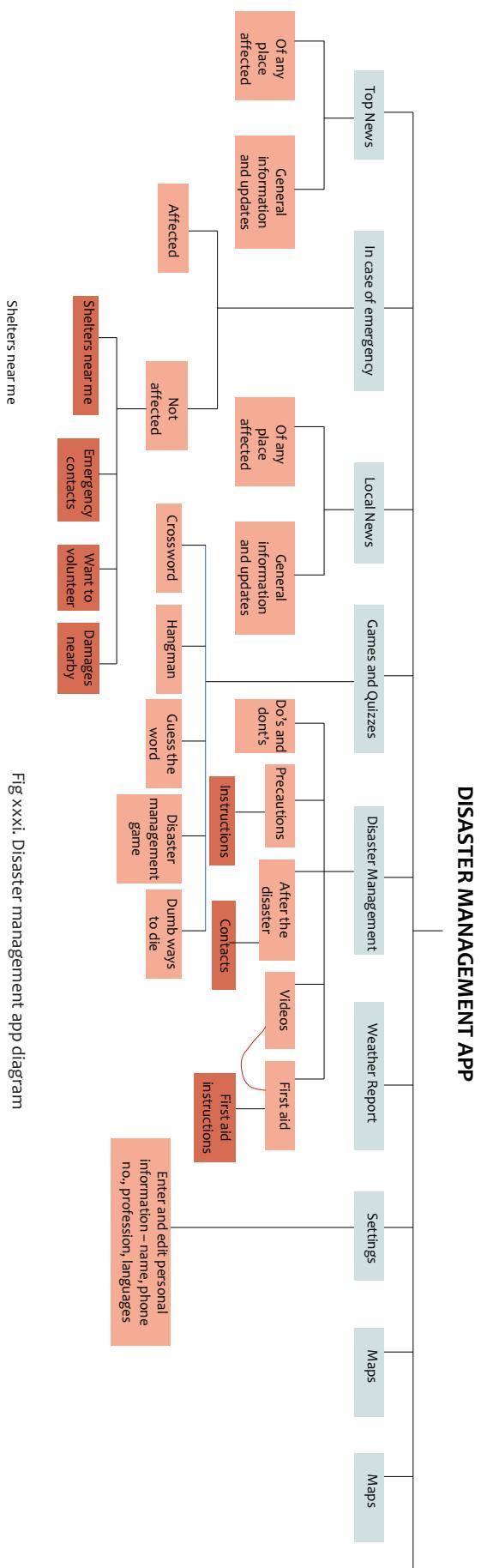


Fig xxxi. Disaster management app diagram



9.14. Letter of confirmation from project partner

GOVERNMENT OF ARUNACHAL PRADESH
OFFICE OF THE SENIOR ARCHITECT PWD AP
ITANAGAR
sapwdapi@gmail.com

NO. SA/E-1 (GEN) /2022-23/ 3029

DATED ITANAGAR AUGUST 30, 2022

To
The Director
Solar Decathlon India

Dear Sir

This is to inform you that our organisation, PWD AP has provided information about our community Resilience Shelter project to the participating team led by RV College of Architecture, so that their team 'EnCircle' may use this information for their Solar Decathlon India 2022-23 competition entry.

As a project partner to this team for Solar Decathlon India 2022-23 competition, we are interested in seeing the Net – Zero – Energy, Net – Zero – water, Resilient and Affordable solutions that this student team proposes and the innovations that result from this.

We have no issues with our organisation logo being displayed on the Solar Decathlon India contest, recognising us as one of the project partner for the 2022-23 competition

DAWA TSERING
DAWA TSERING
Senior Architect PWD AP
ITANAGAR
20/08/22



9.15. Letter of confirmation from industry partner



FIDUCIA AI (INDIA) PRIVATE LIMITED
Phone: +91-6302395390 Web: www.fiduciaai.com

Date: 18-Feb-2023

Industry Partner Confirmation Letter

To,

The Director,
Solar Decathlon India

Dear Sir,

This is to inform you that our organization, **Fiducia AI India Private Limited**, is collaborating with the participating team led by **R.V. College of Architecture** on a Community Resilience Shelter Building project for their Solar Decathlon India 2022-23 competition entry.

The nature of our collaboration was to provide technical assistance in software development as part of their project.

We would like to have a representative from our organization attend the Design Challenge Finals event in April/May, if this team is selected for the Finals.

We would like our organization's logo to be displayed on the Solar Decathlon India website, recognizing us as one of the Industry Partners for the 2022-23 competition.

With warm regards,

Nipun Goel
CTO & MD
Fiducia AI India Private Limited
nipun.goel@fiduciaai.com
+91-6302395390

Regd Off.: 104, Aliens Fastrack, Vittalrao Nagar, Madhapur, Hyderabad. Telangana – 500081

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Letter of Appreciation

07 August 2023

Dear **Dishita Goel**,

This letter is to convey our deep appreciation for your commendable contribution as a member of the team "**EnCircle**" that represented RV College of Architecture at Solar Decathlon India - 2023 competition.

The aim of this competition was to design and innovate a sustainable, Net-Zero energy building, and furthermore, substantiate and prove your claims to a jury panel consisting of nationally acclaimed experts in the field.

In the capacity of the leader of the **Value Proposition contest**, you performed your role with dedication. Exceeding your group's expectations, you also shouldered the role of a team-worker in the Resilience and Energy performance contests.

You were involved in making the app prototype and suggesting strategies to make the building more valuable. You also helped in getting the industry partner and co-ordinating with them. You also helped in creating engaging infographics for the reports. You facilitated the preparation of the jury presentation slides as well.

Your team would not have been judged the **Finalist** in Community resilience shelter division of this national level competition, if it were not for your superlative teamwork, support, and motivation.

RV College of Architecture acknowledges you for your invaluable contribution and wishes that many more successes come your way.

Dr. O.P. Bawane

Principal

RV College of Architecture

Certificate of Completion

This is to certify that

Dishita Goel

from

RV College of Architecture

has completed the Self-Learning Modules on
Net-zero Energy and Water Buildings



Aromar Revi



Ashok B Lall



Nandini Kannan



Prasad Vaidya



Satish Kumar



Certificate of Achievement



Awarded to **Dishita Goel**
from Team **EnCircle**
from **RV College of Architecture**
for competing as a finalist in the
Solar Decathlon India 2022-23 Challenge.

Aromar Revi

Ashok B Lall

Chaitali Bhattacharya

Prasad Vaidya

Satish Kumar



RV College of Architecture®

Affiliated to Visvesvaraya
Technological University ,
Belagavi.

Approved by Council
of Architecture
(COA), New Delhi.

RVCA Annual Magazine
KALPA
Volume 03

CERTIFICATE OF APPRECIATION

awarded to

Dishita Goel

USN: 1RW19AT035

For her tireless efforts and valuable contribution as a member of the student marketing team for "**KALPA - RVCA Annual Research Magazine, Issue 03, 2021-22**

Dean
Prof. Suresh K Murthy

Principal
Prof. Dr. Om Prakash Bawane

Ms. Ramya.K

Ms. Alisha Sinha

Ms. Hiranmayi.S

Members, Faculty Editorial Team

Go, change the world



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Belagavi.

Approved by Council
of Architecture
(COA), New Delhi.

CERTIFICATE OF COURSE COMPLETION

This is to certify

Dishita Goel

1RW19AT035

has successfully completed the value- addition certificate course

"Relevance of Vedic Vastushastra in Contemporary Architecture"

offered from 28/10/2022 to 23/11/2022.

Phani Ram Pingli
Chief Coordinator

Akanksha Singh
Coordinator

Om Prakash Bawane
Principal

Go, change the world