



Nālandā
UNIVERSITY

Vastu Shilpa Consultants
Nalanda University Library
Preliminary Architecture Report 2021

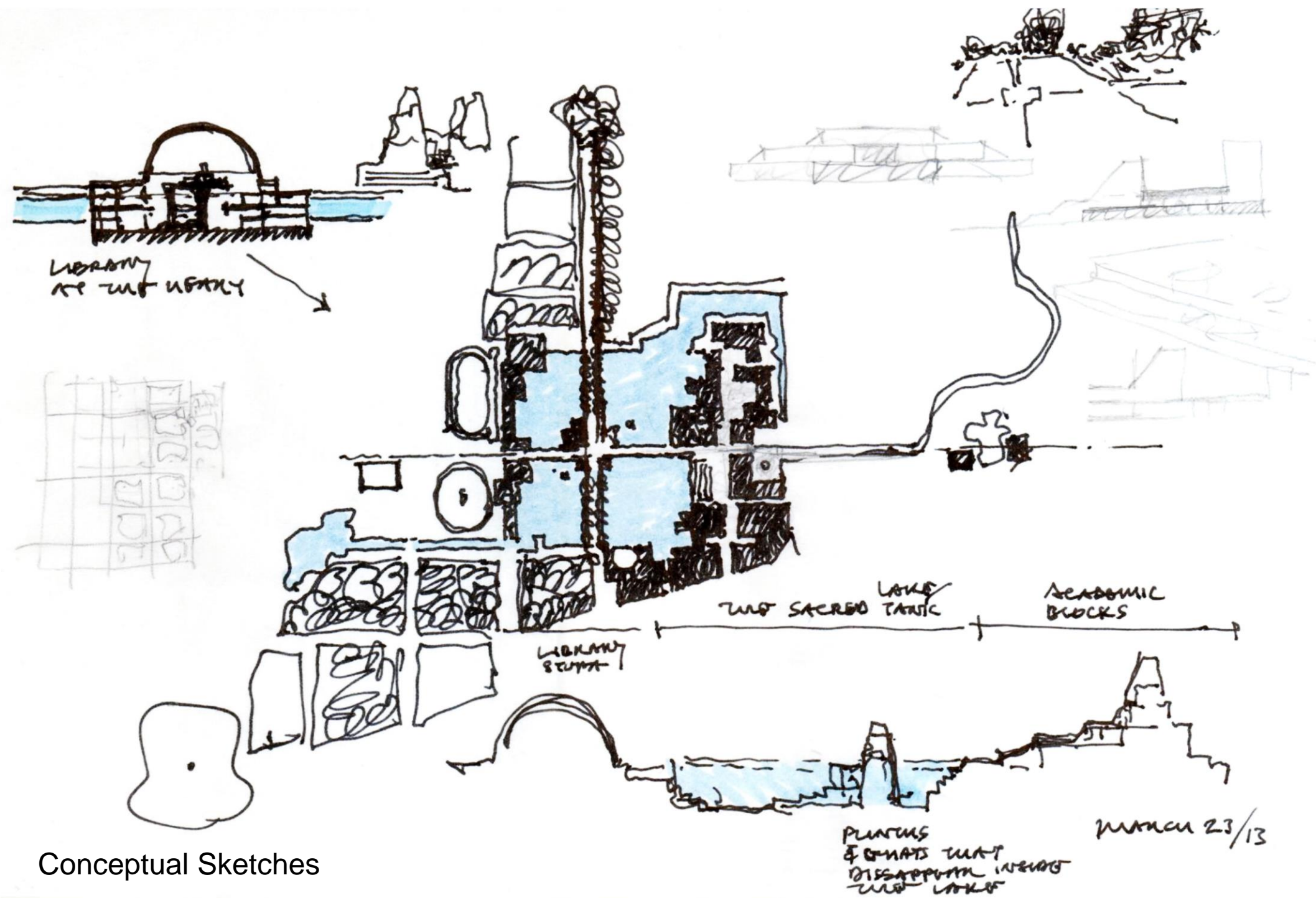




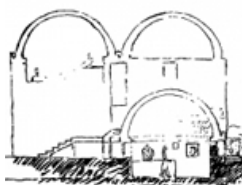
Nalanda Ruins

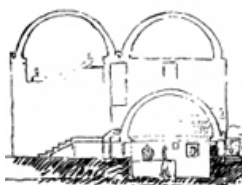
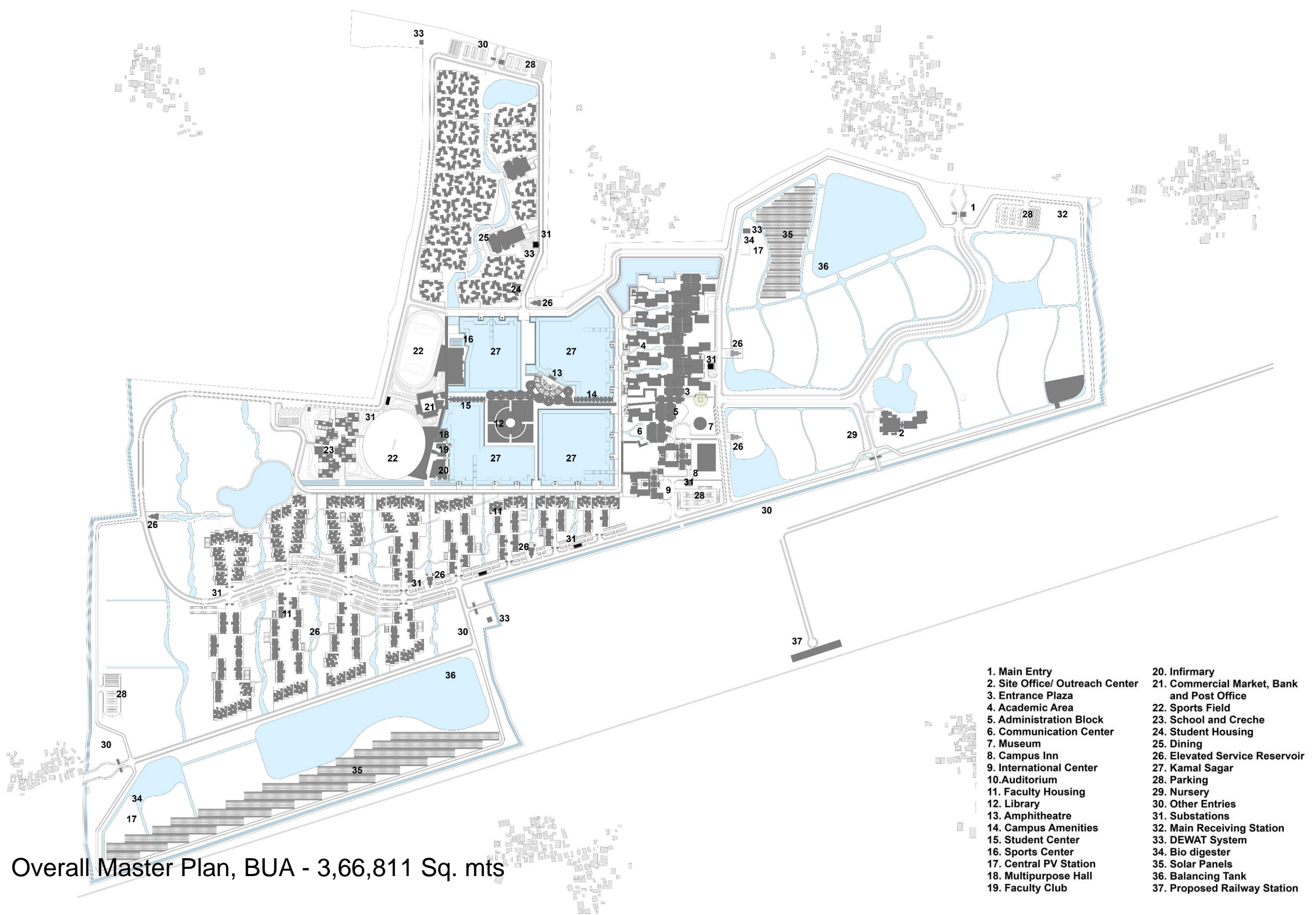


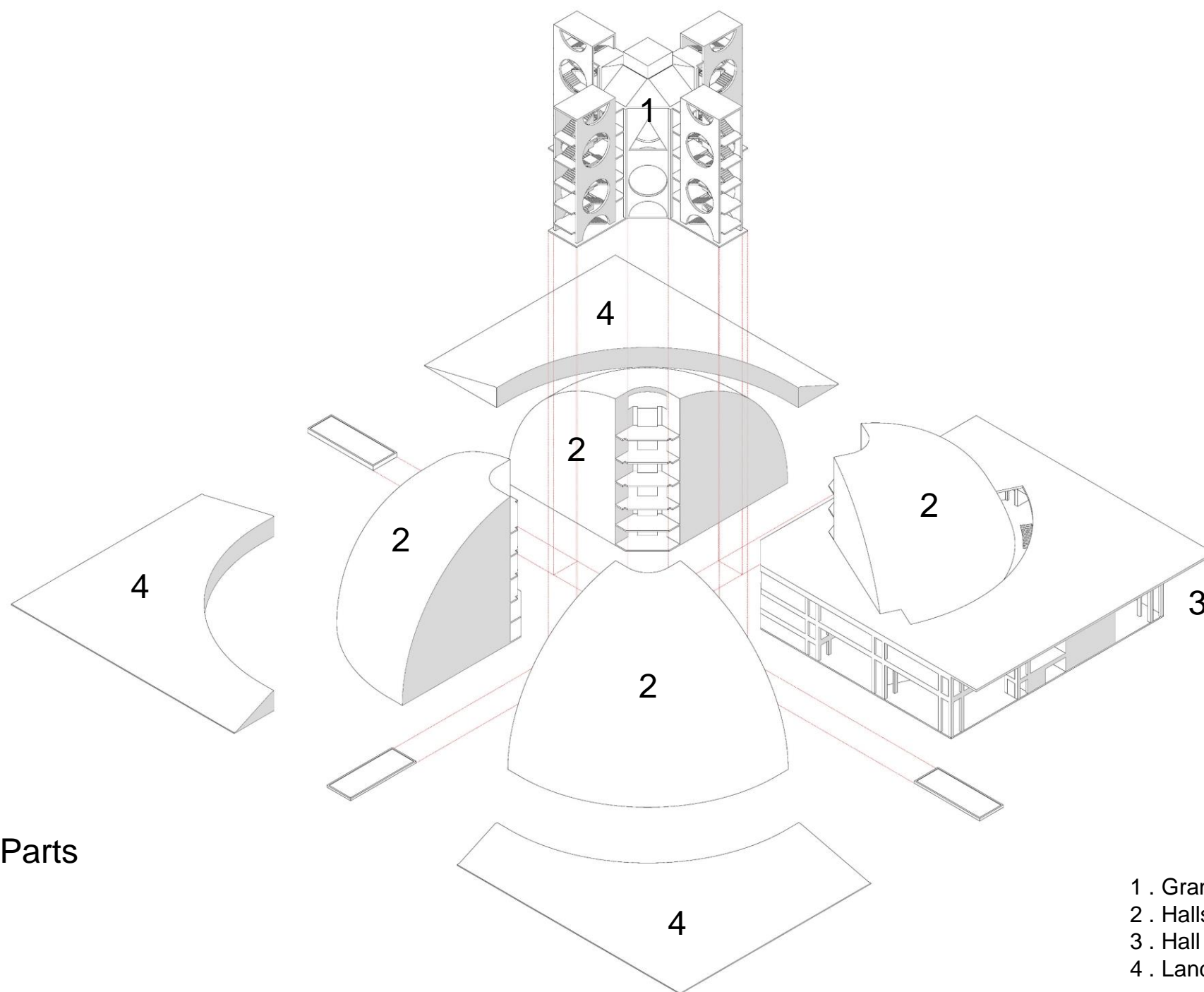
Nalanda Site



Conceptual Sketches







Area Program

BUILT UP AREA		
FLOOR PLATE	SQMT	WATER TANKS
BASEMENT FLOOR -5.10 LVL	3018	
GROUND FLOOR 0.00 LVL	4656	
FIRST FLOOR +4.20 LVL	2050	
SECOND FLOOR +8.40 LVL	3041	
THIRD FLOOR +12.60 LVL	2082.5	
FOURTH FLOOR +16.80 LVL	1717.5	
FIFTH FLOOR +21.00 LVL	980	
SIXTH FLOOR +24.30 LVL	-	38.7

TOTAL	17545	38.7
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USER CAPACITY			
FLOOR PLANS	STUDENTS	STAFF	OTHER
GROUND FLOOR 0.00 LVL	530	80	93
FIRST FLOOR +4.20 LVL	256	14	3
SECOND FLOOR +8.40 LVL	502	28	10
THIRD FLOOR +12.60 LVL	235	81	3
FOURTH FLOOR +16.80 LVL	128	220	11
FIFTH FLOOR +21.00 LVL	-	-	-
TOTAL	1651	423	120
GRAND TOTAL		2194	

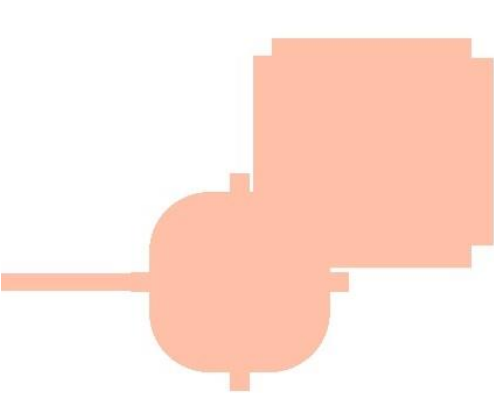
NUMBER OF VOLUME		
FLOOR PLANS	RACKS	BOOKS
GROUND FLOOR 0.00 LVL	705	88125
FIRST FLOOR +4.20 LVL	120	15000
SECOND FLOOR +8.40 LVL	330	41250
THIRD FLOOR +12.60 LVL	250	31250
FOURTH FLOOR +16.80 LVL	241	30125
FIFTH FLOOR +21.00 LVL	-	-
TOTAL	1646	205750

LIFT	QUANTITY	CAPACITY	LOAD (KG)	STOPS
PASSENGER LIFT	3	13	884	7
GOODS LIFT	1	-	3000	8

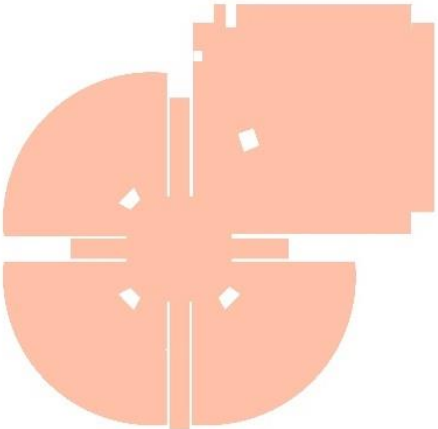
NUMBER OF FURNITURE				
FLOOR PLANS	TABLE	CHAIR / READING STOOL	SOFA	RACKS
GROUND FLOOR 0.00 LVL	164	406	124	705
FIRST FLOOR +4.20 LVL	110	252	40	120
SECOND FLOOR +8.40 LVL	242	408	40	330
THIRD FLOOR +12.60 LVL	65	220	60	250
FOURTH FLOOR +16.80 LVL	27	160	96	241
FIFTH FLOOR +21.00 LVL	-	-	-	-
TOTAL	608	1446	360	1646

SOURCE AS PER NBC 2016
For Detail Refer Annexure - I

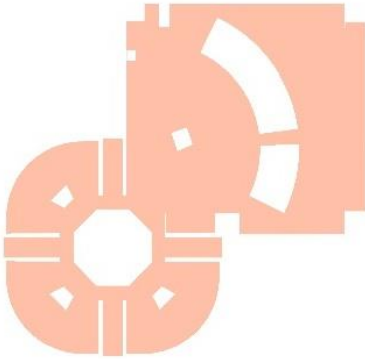
TOTAL BUA - 17545 sq.m



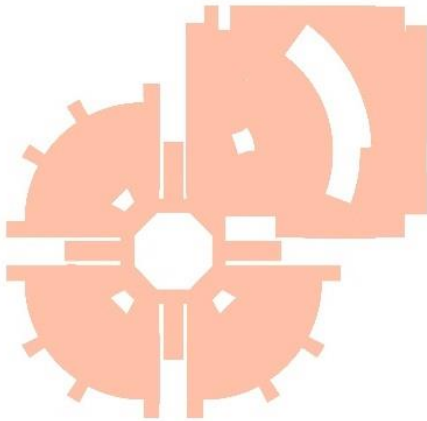
BASEMENT -5.1 LVL : 3018 SQMT



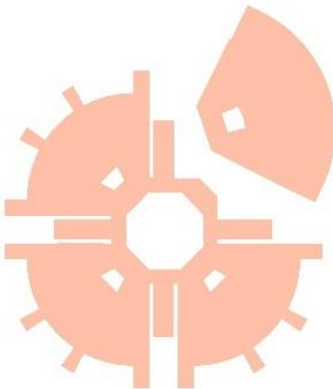
GROUND FLOOR +0 LVL : 4187 SQMT



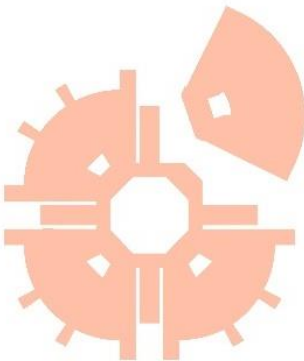
FIRST FLOOR +4.2 LVL : 2150 SQMT



SECOND FLOOR +8.4 LVL : 3041 SQMT



THIRD FLOOR +12.6 LVL : 2082.5 SQMT

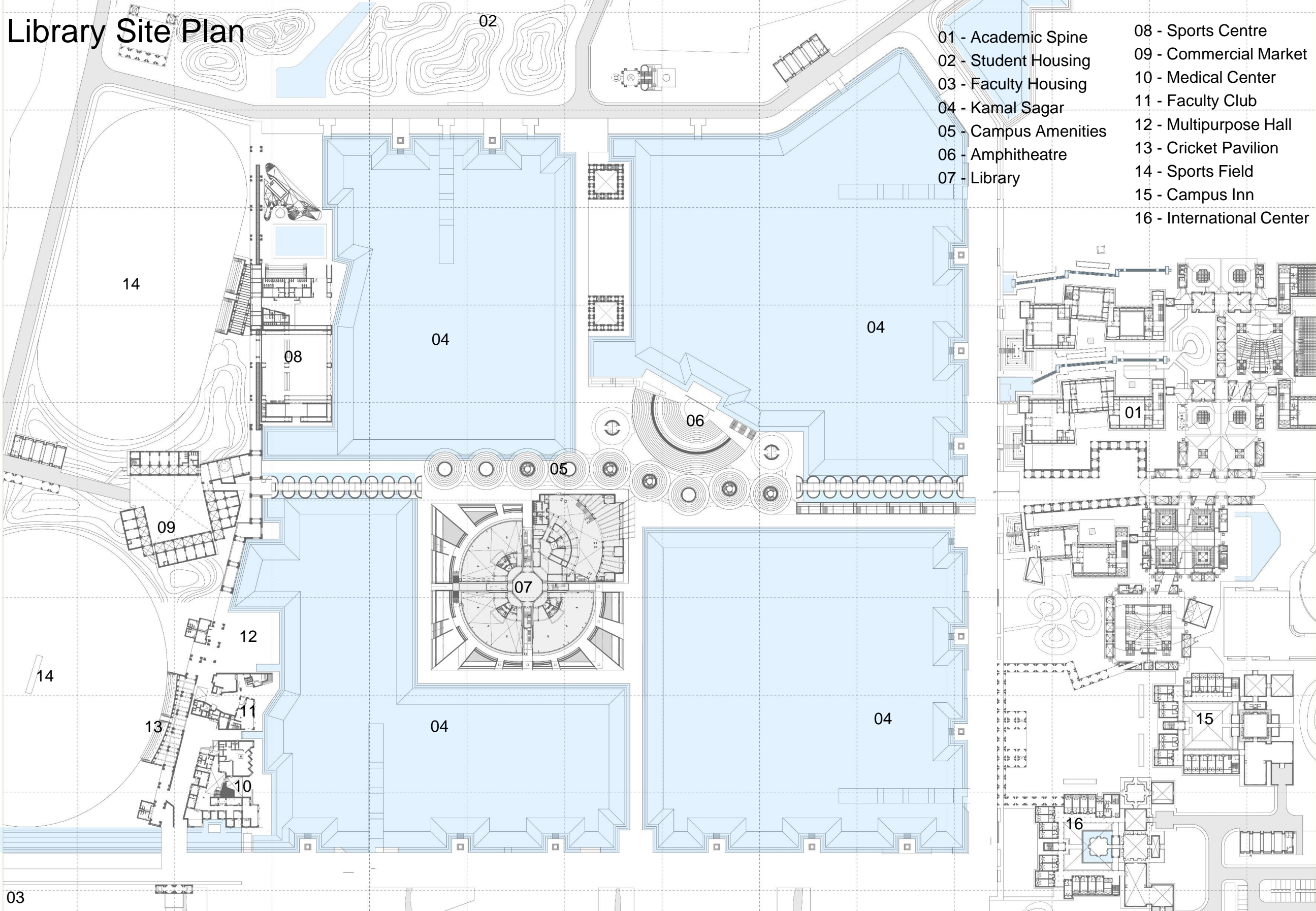


FOURTH FLOOR +16.8 LVL : 1717.5 SQMT

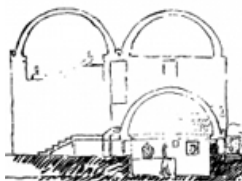
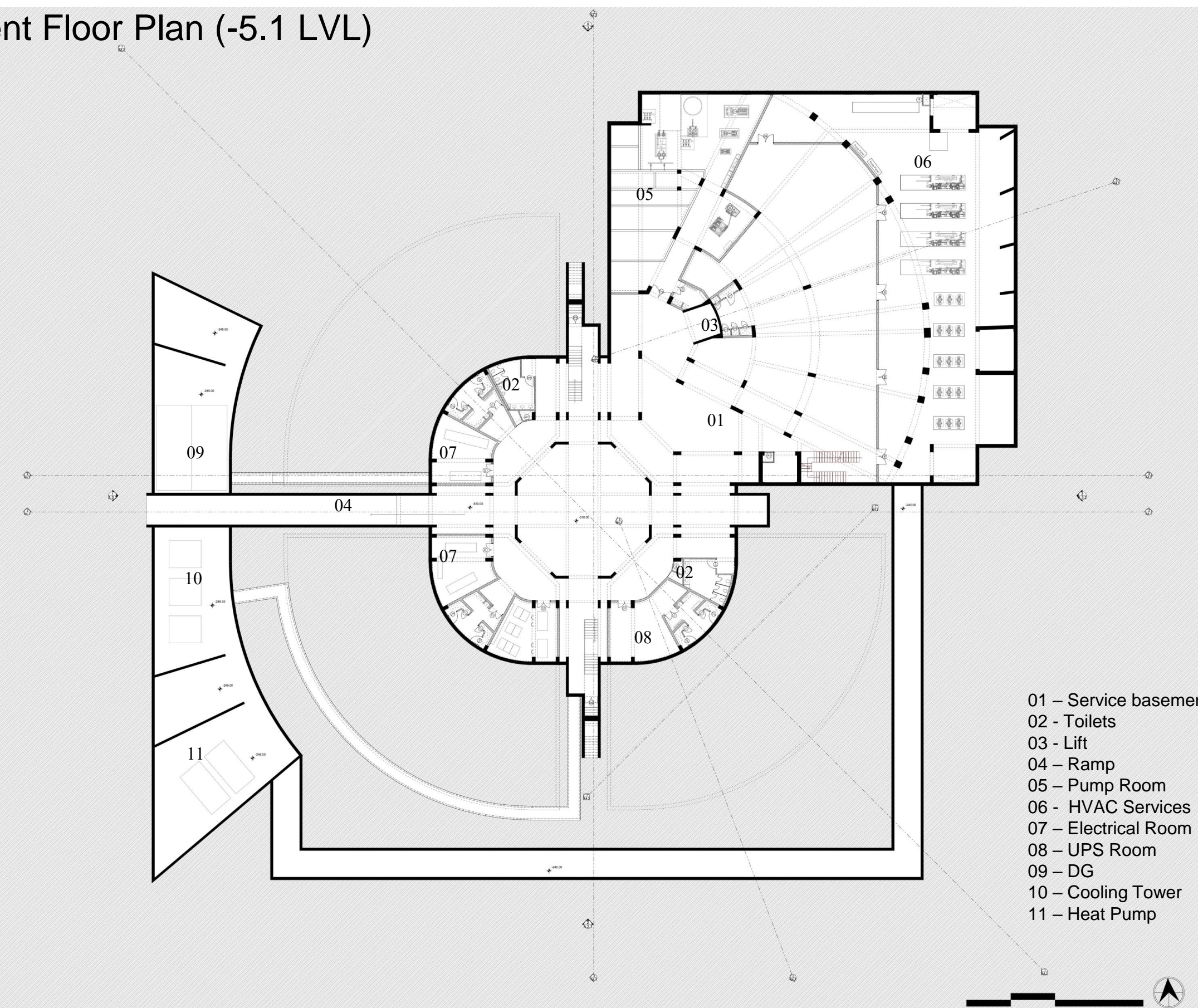


FIFTH FLOOR +21.0 LVL : 980 SQMT

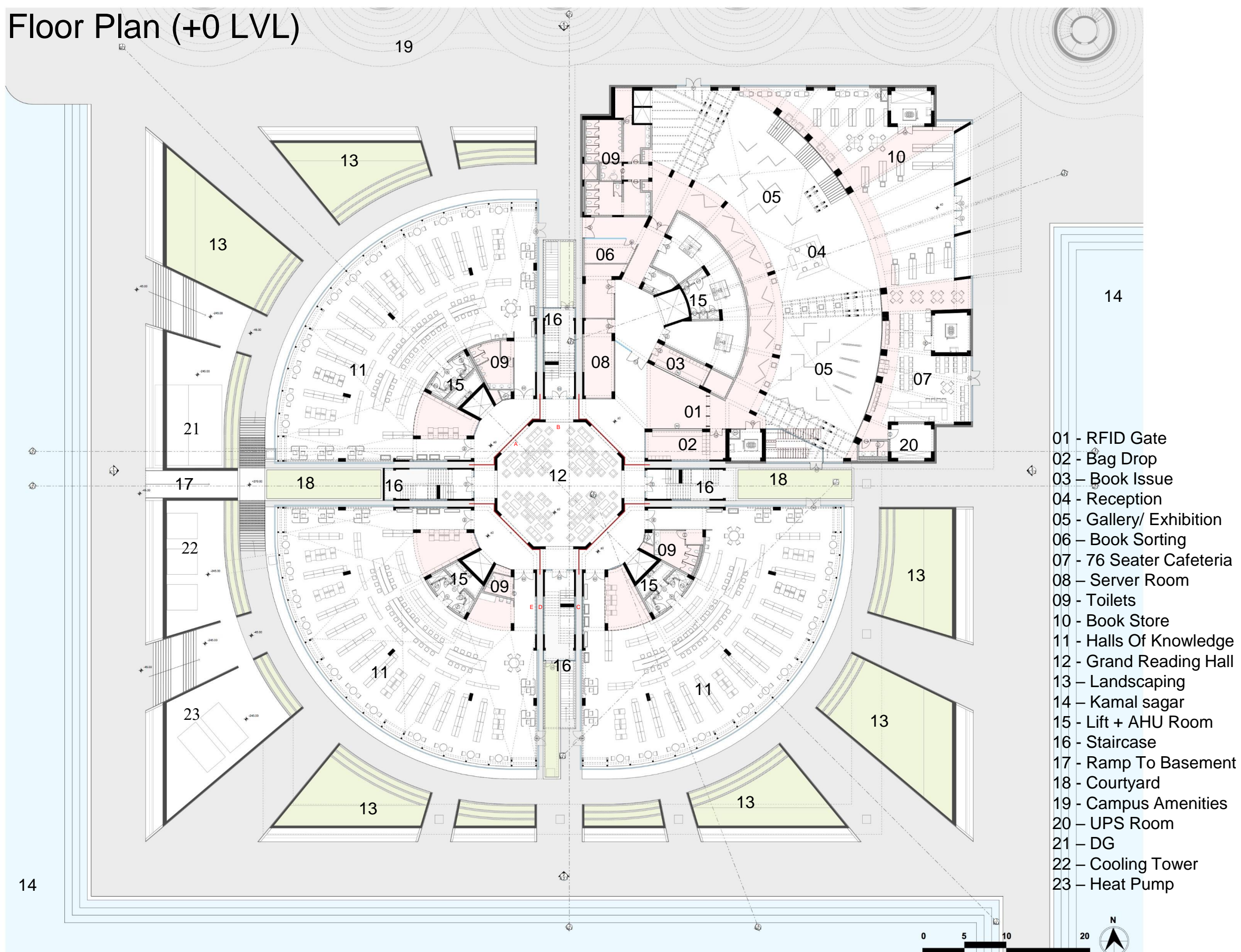
Library Site Plan



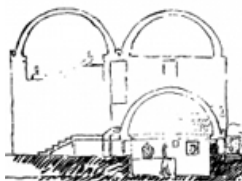
Basement Floor Plan (-5.1 LVL)



Ground Floor Plan (+0 LVL)

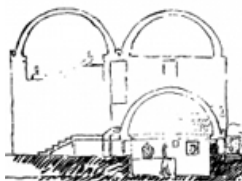
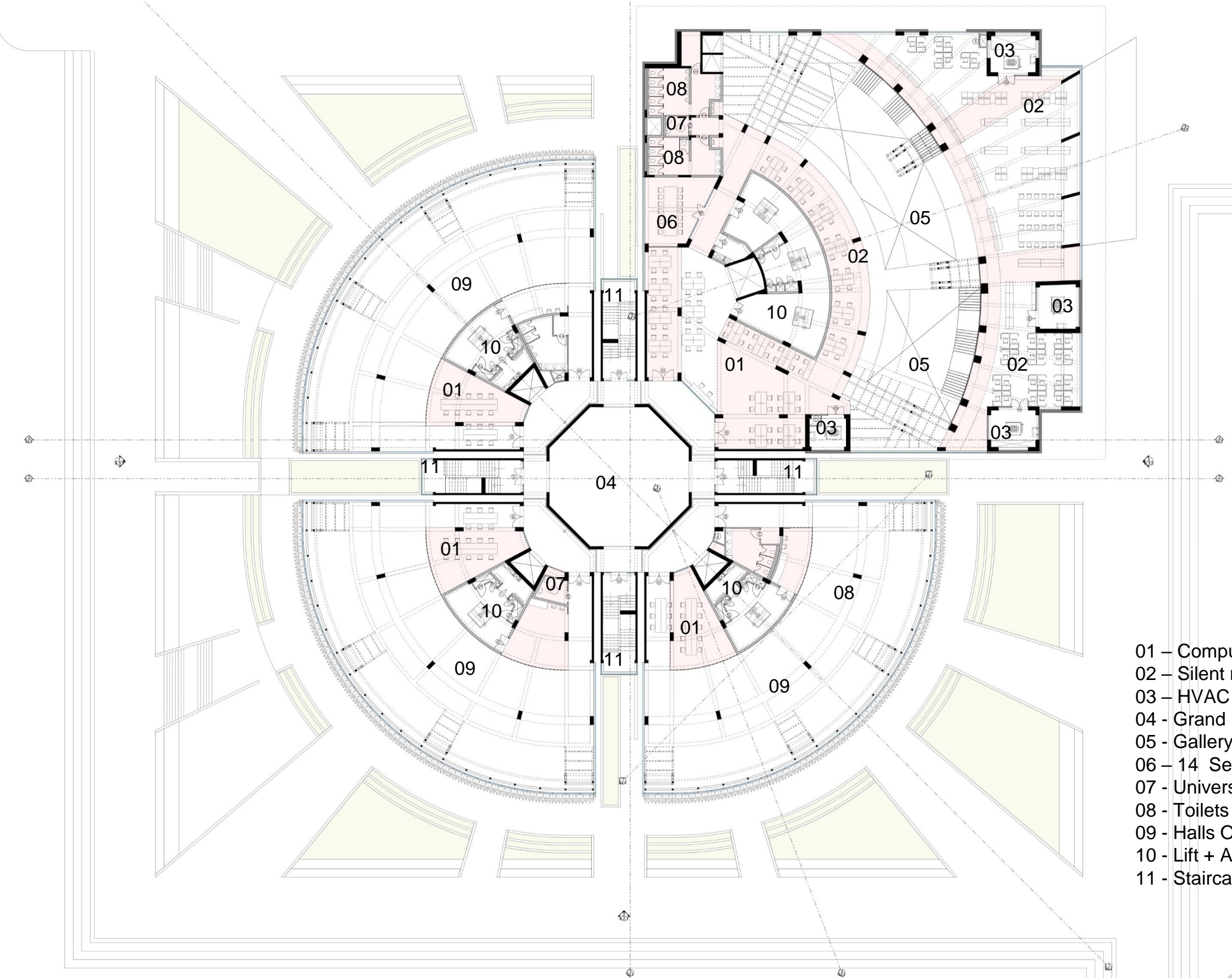


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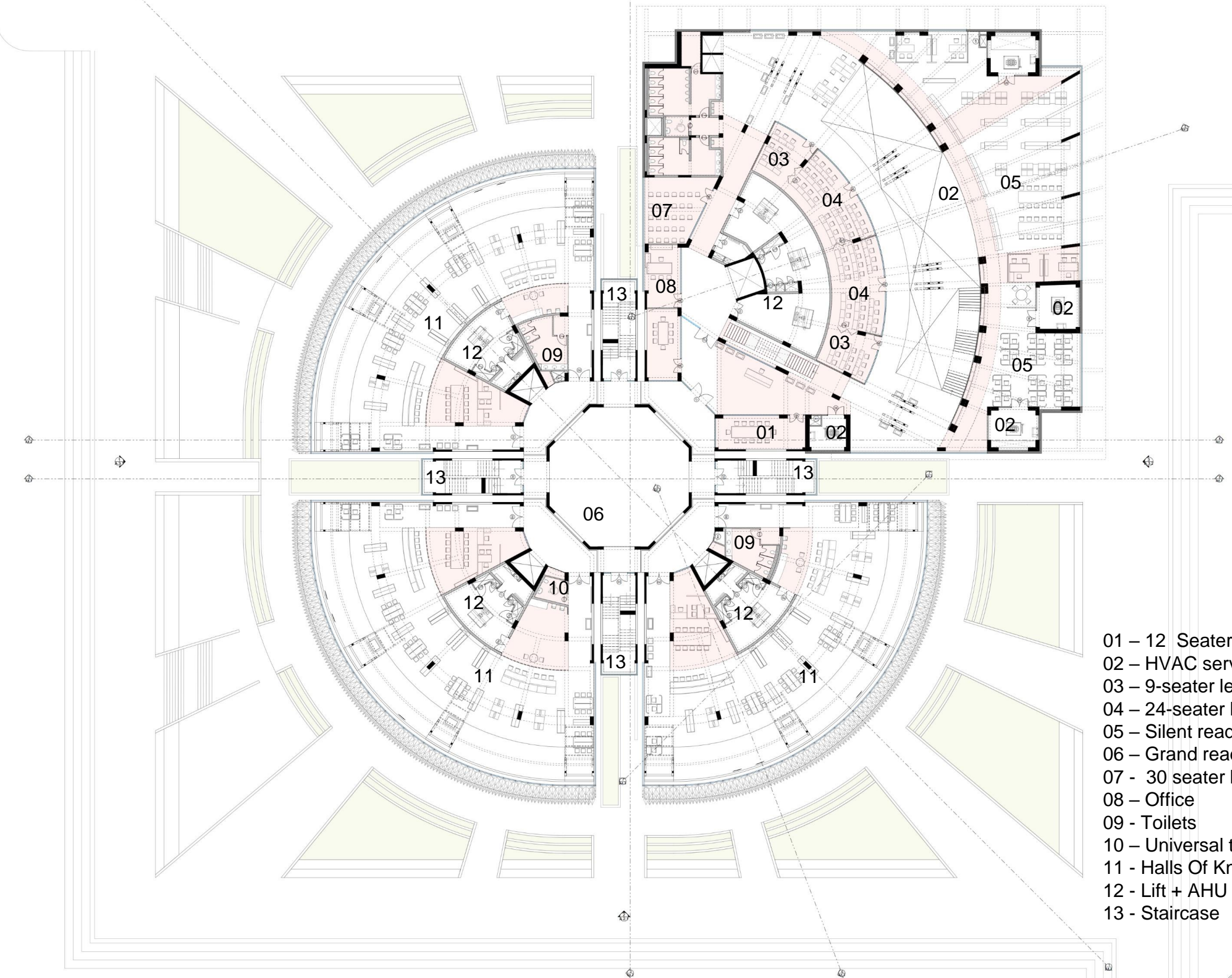


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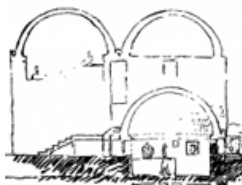
First Floor Plan (+4.2 LVL)



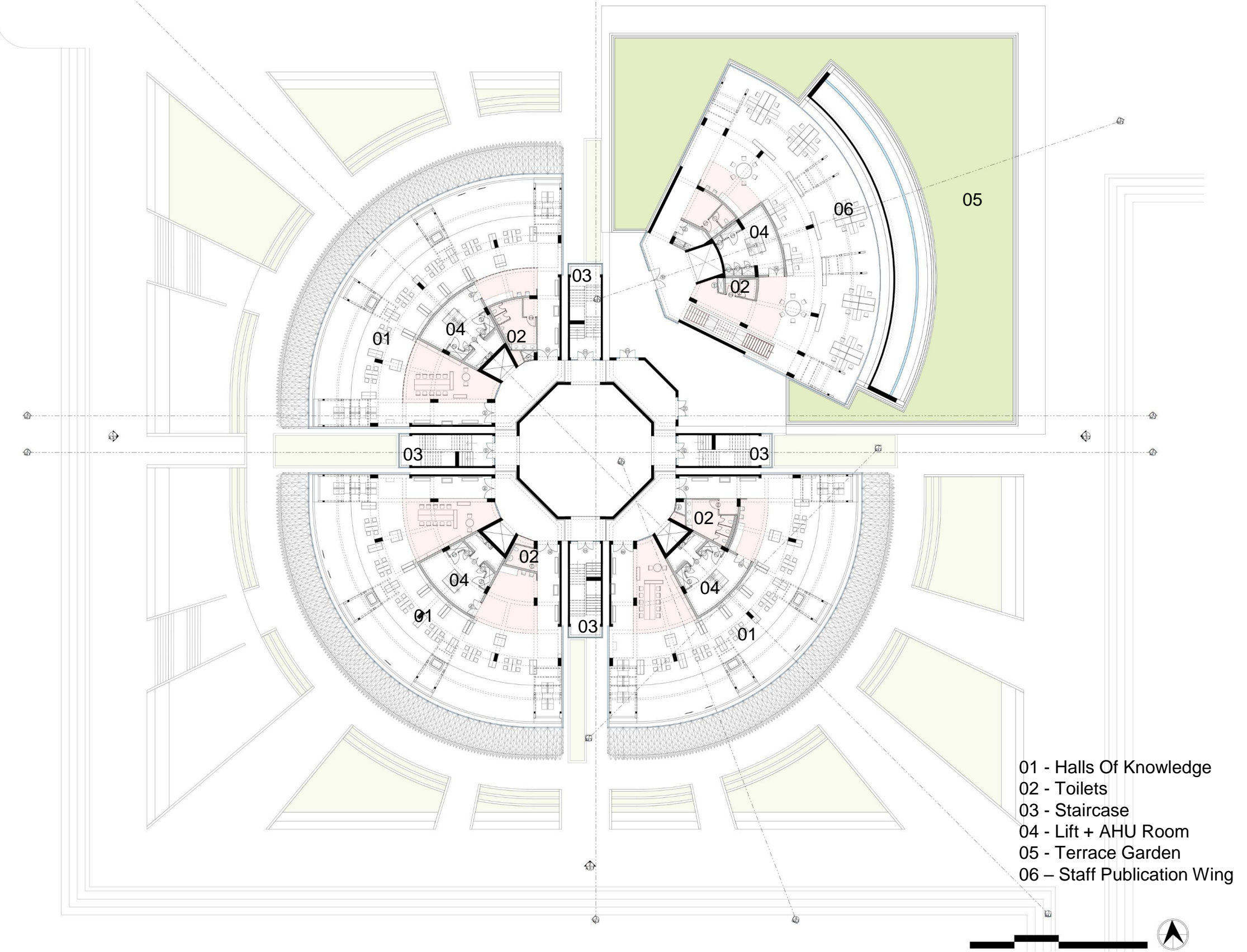
Second Floor Plan (+8.4 LVL)



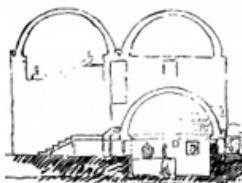
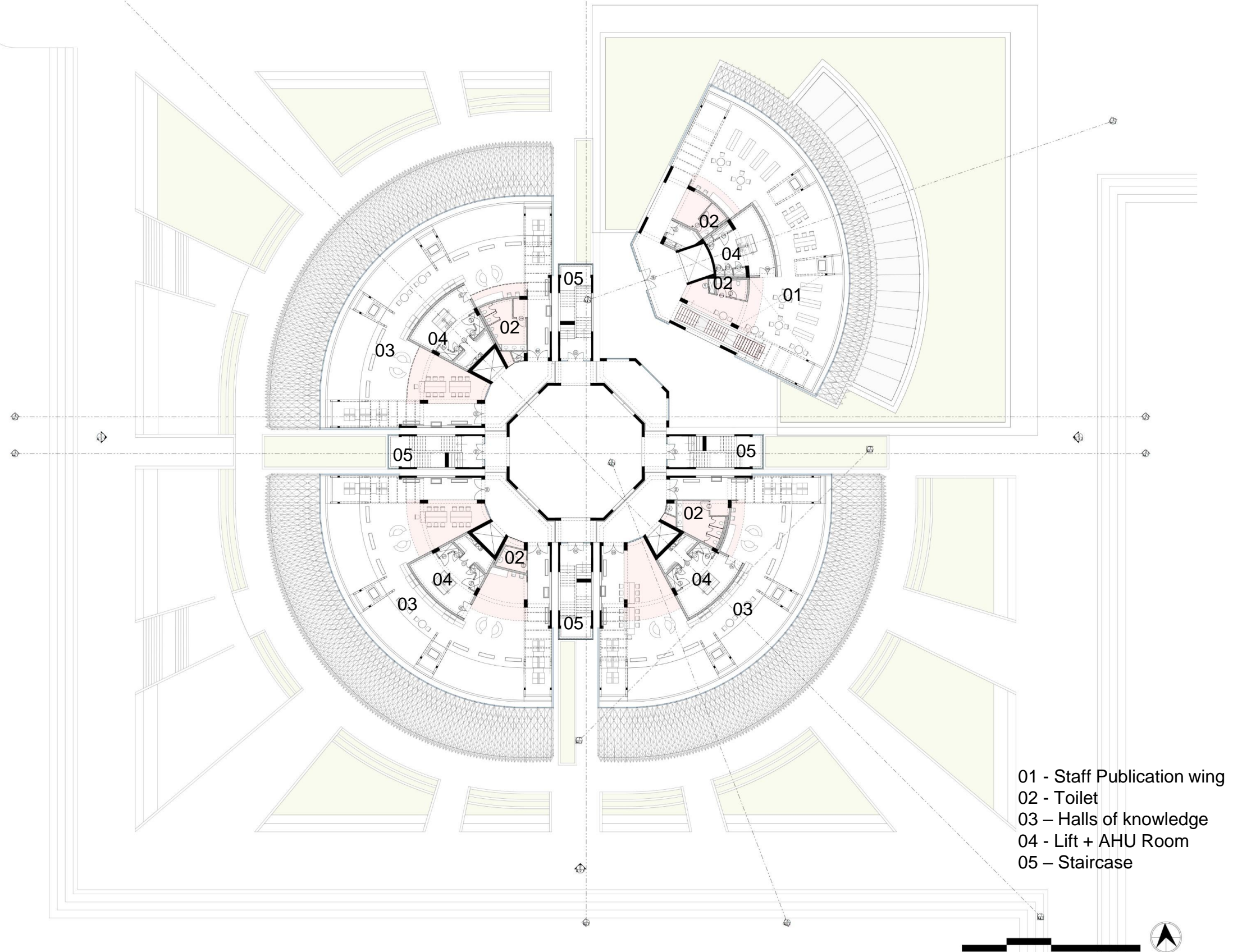
- 01 – 12 Seater discussion room
- 02 – HVAC services
- 03 – 9-seater lecture halls (x2)
- 04 – 24-seater lecture halls (x2)
- 05 – Silent reading
- 06 – Grand reading hall
- 07 - 30 seater lecture room
- 08 – Office
- 09 - Toilets
- 10 – Universal toilet
- 11 - Halls Of Knowledge
- 12 - Lift + AHU Room
- 13 - Staircase



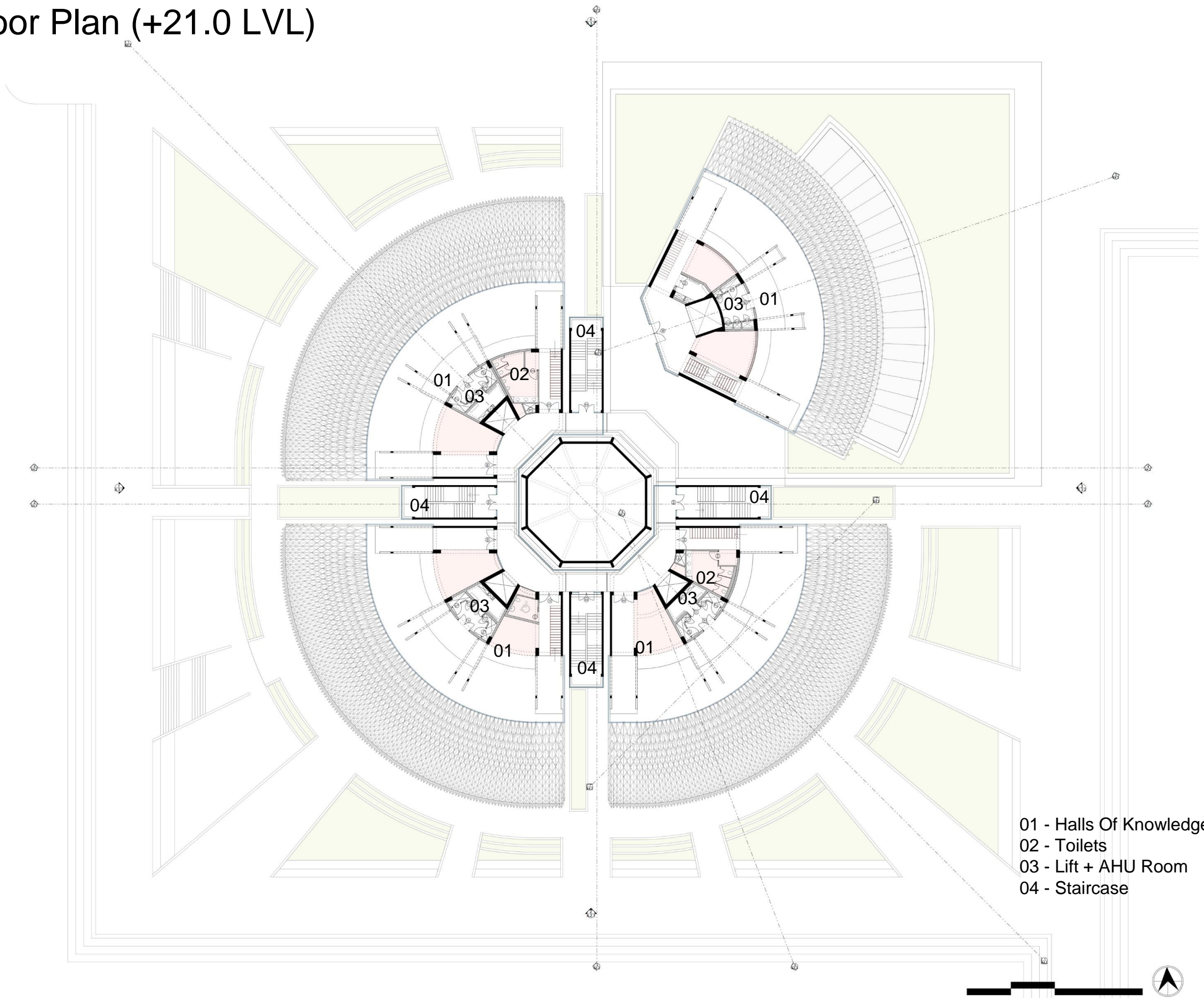
Third Floor Plan (+12.6 LVL)



Fourth Floor Plan (+16.8 LVL)

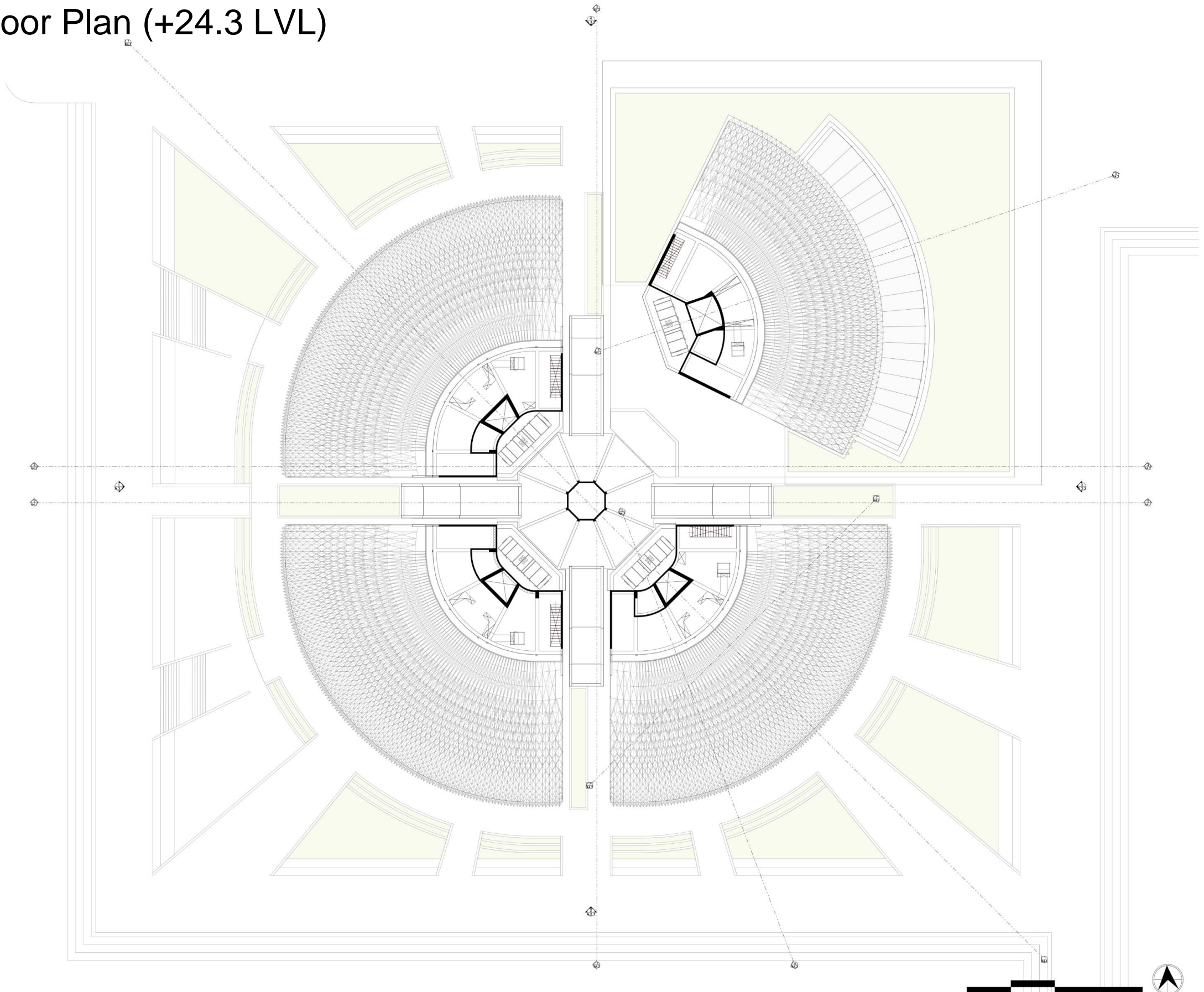


Fifth Floor Plan (+21.0 LVL)

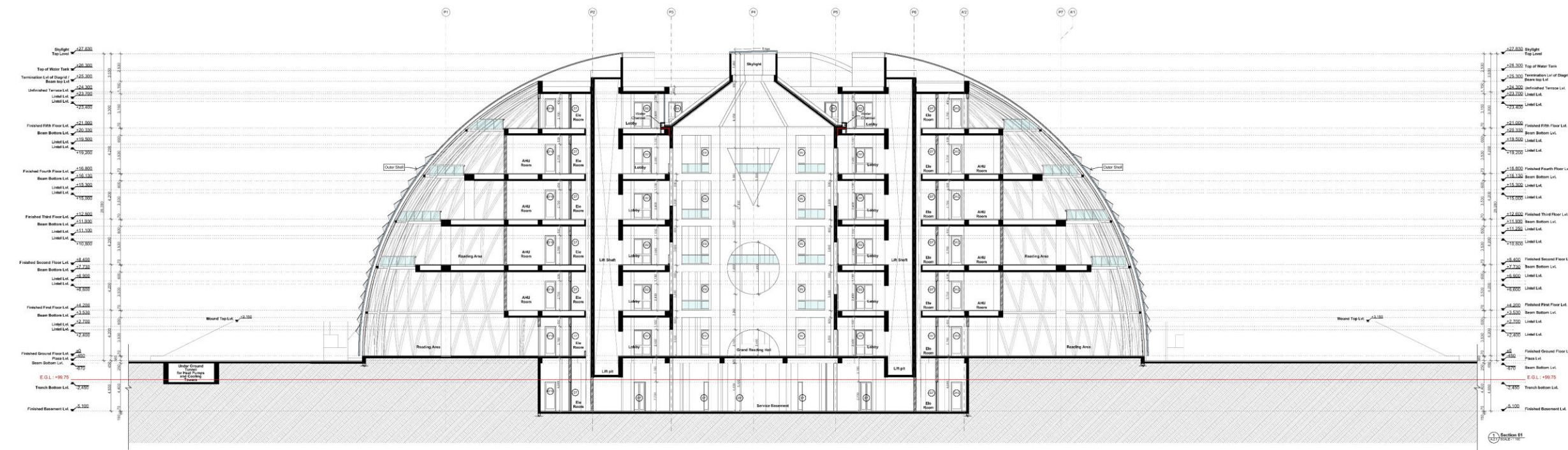


- 01 - Halls Of Knowledge
- 02 - Toilets
- 03 - Lift + AHU Room
- 04 - Staircase

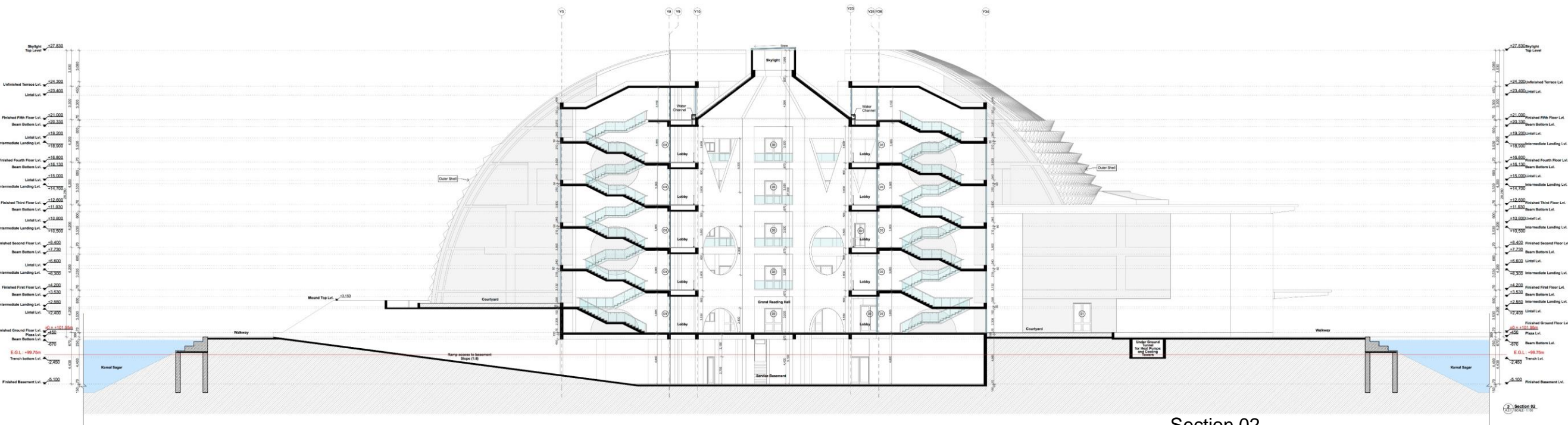
Sixth Floor Plan (+24.3 LVL)



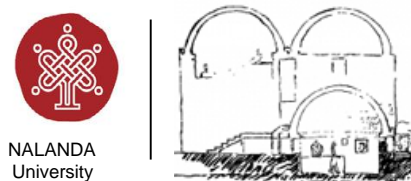
Sections



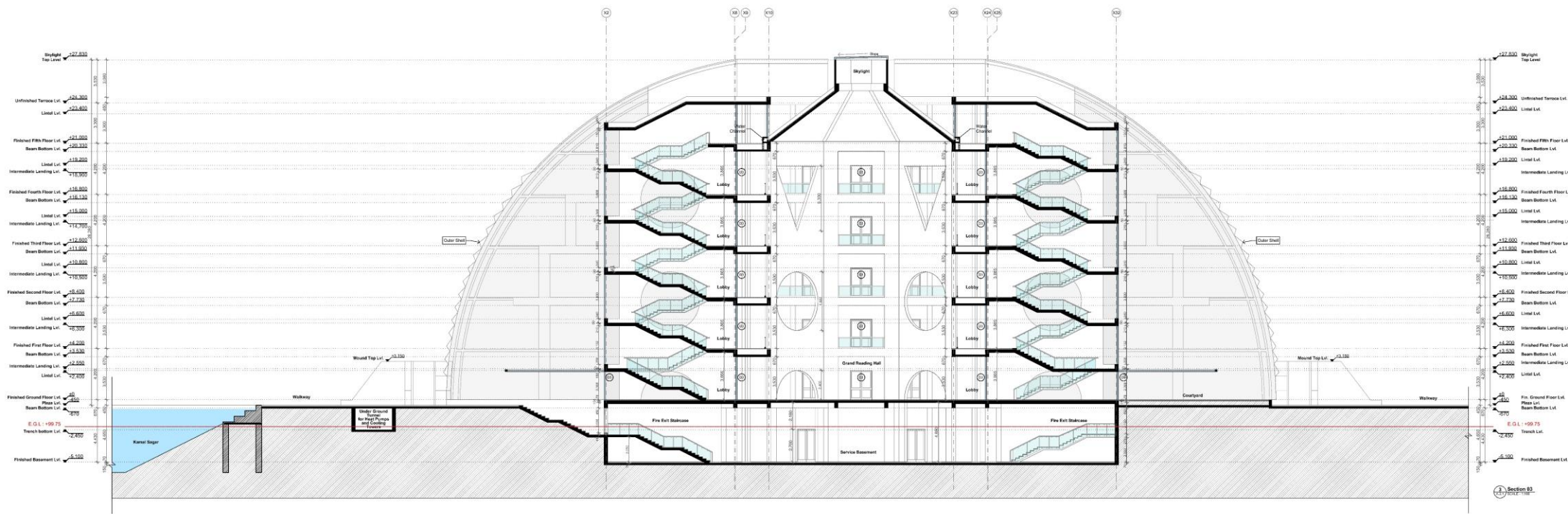
Section 01



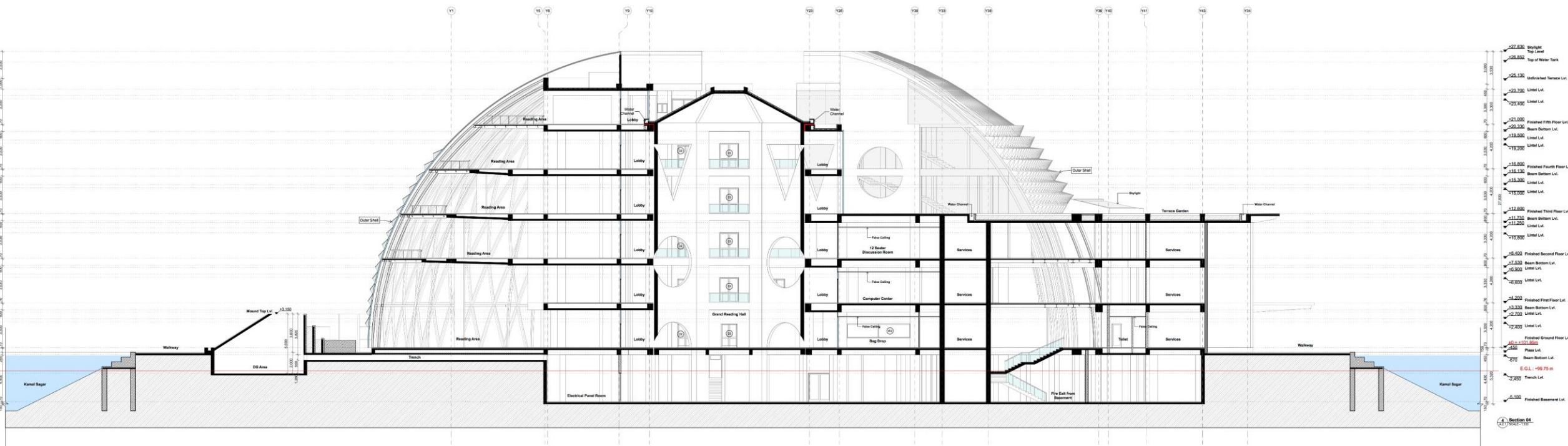
Section 02



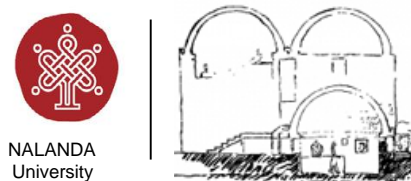
Sections



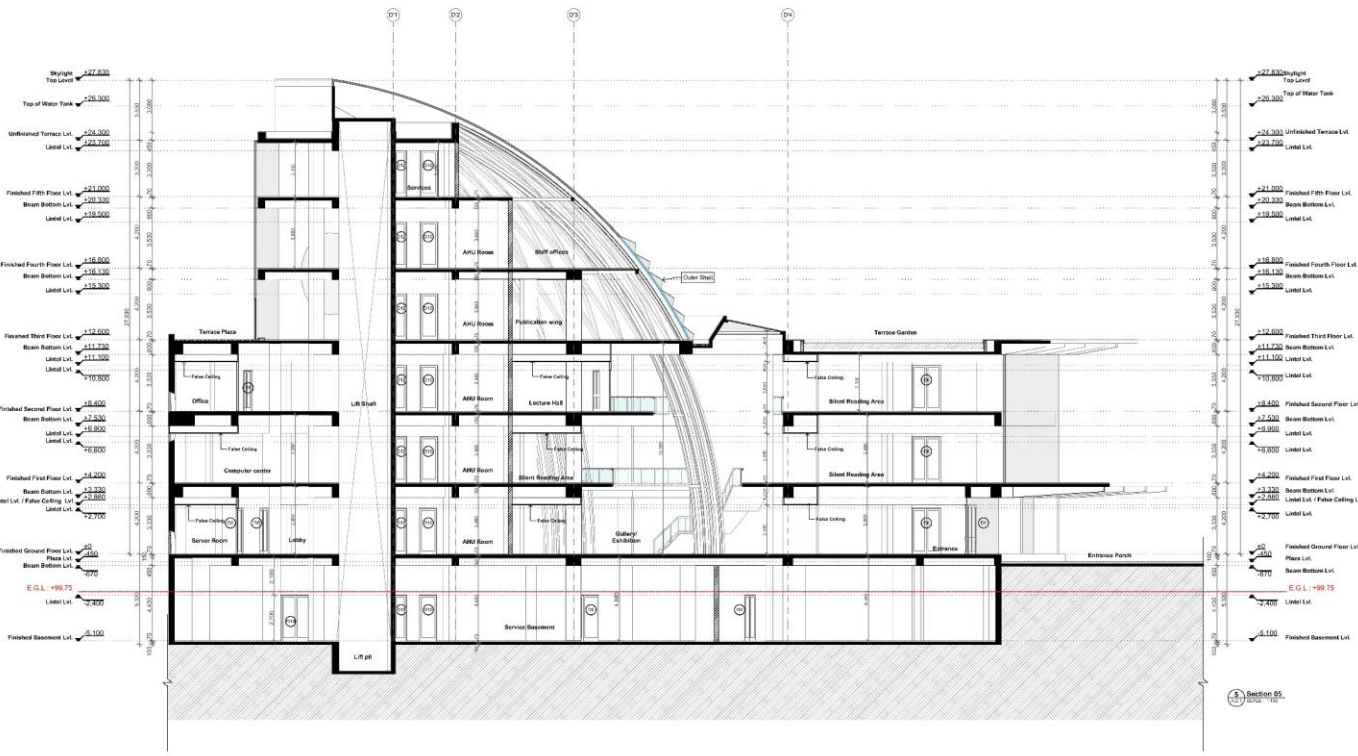
Section 03



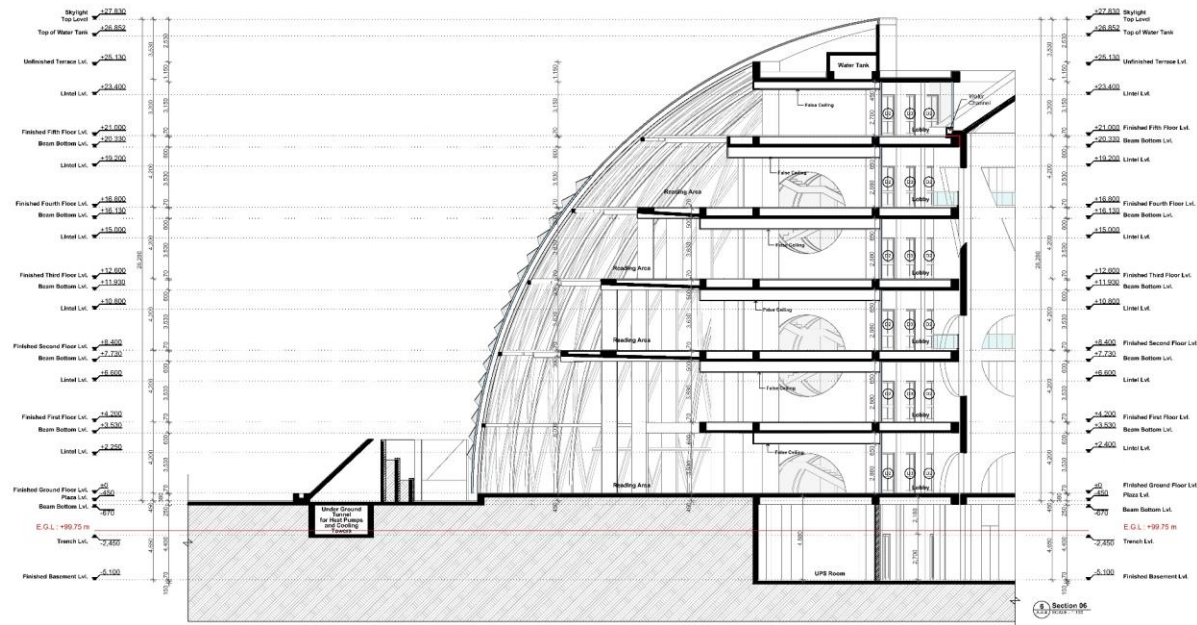
Section 04



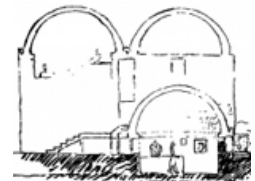
Sections



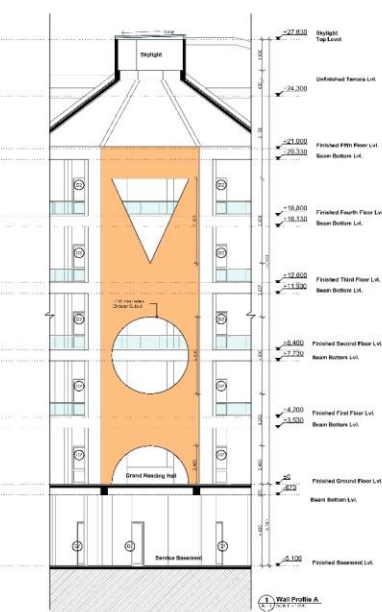
Section 05



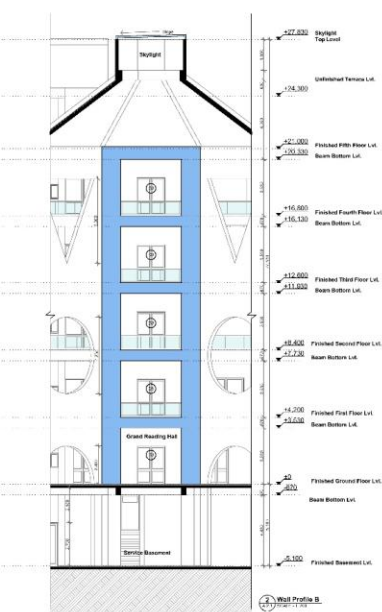
Section 06



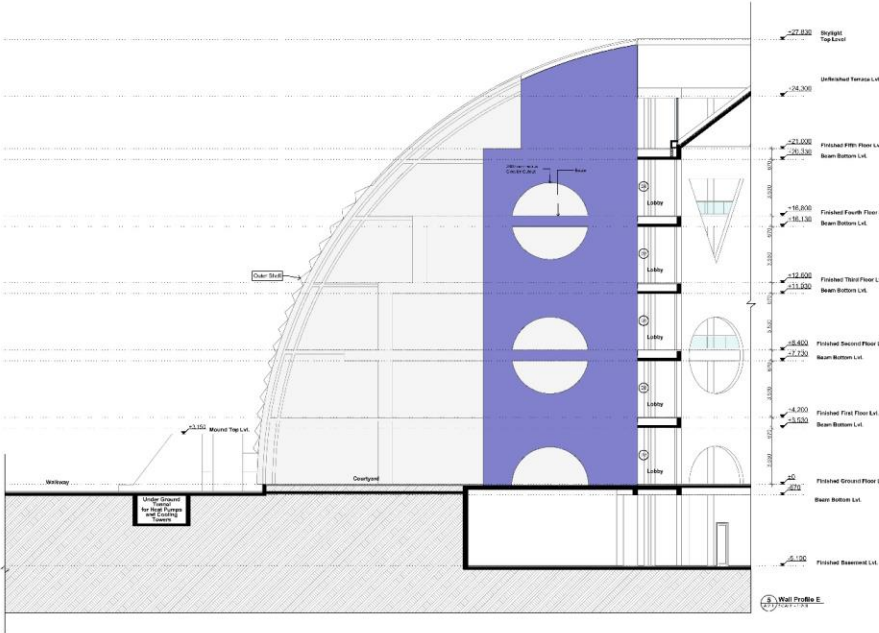
Shear Wall Profiles



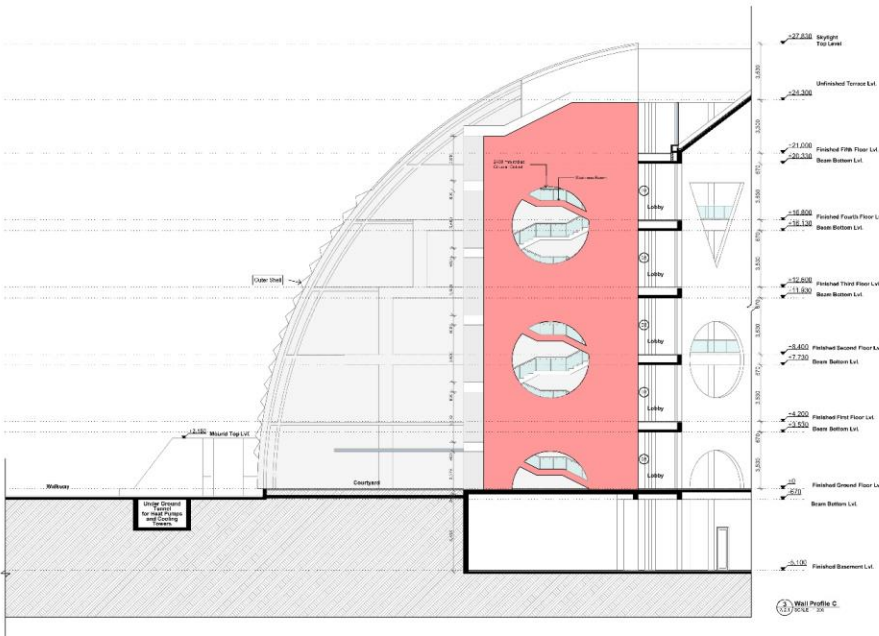
Wall Profile A



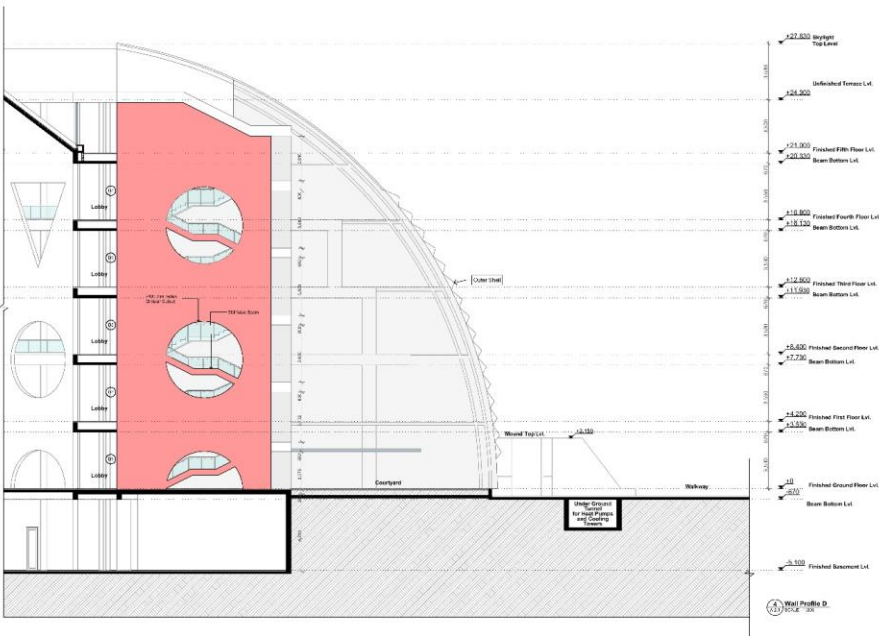
Wall Profile B



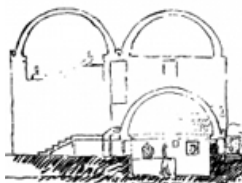
Wall Profile E



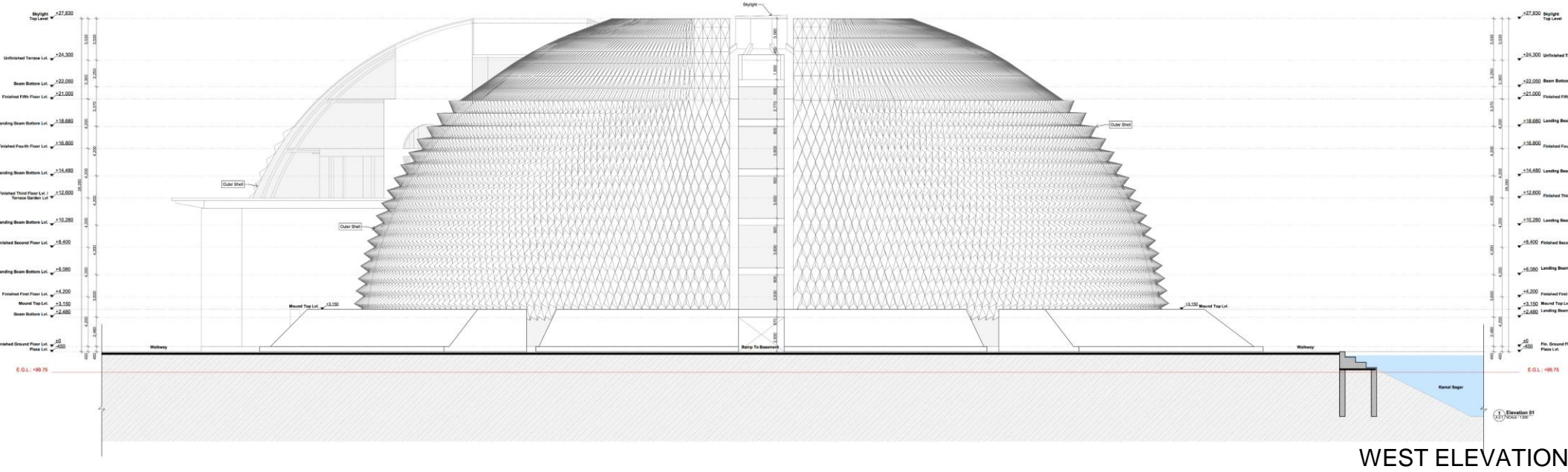
Wall Profile C



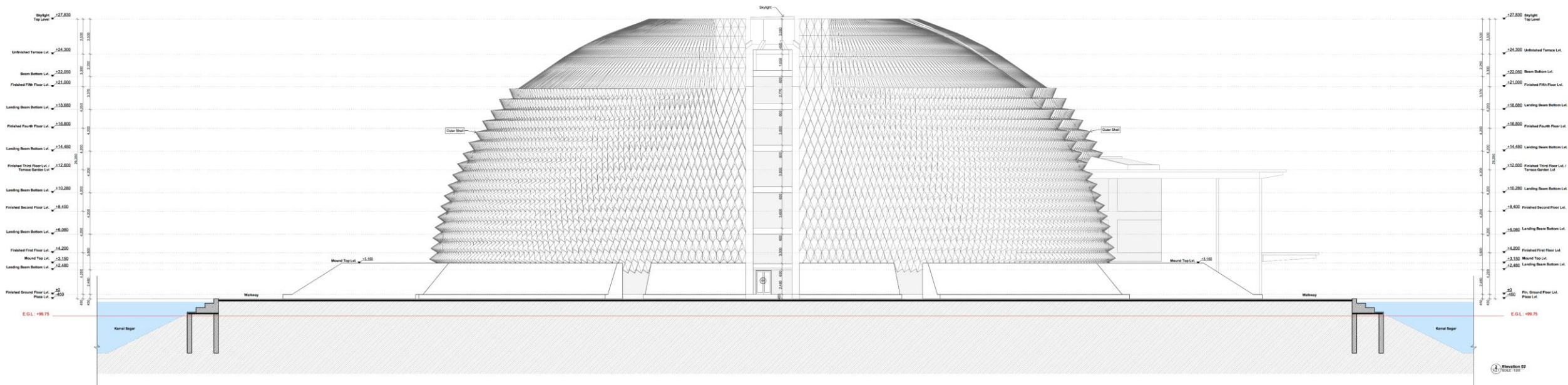
Wall Profile D



Elevations

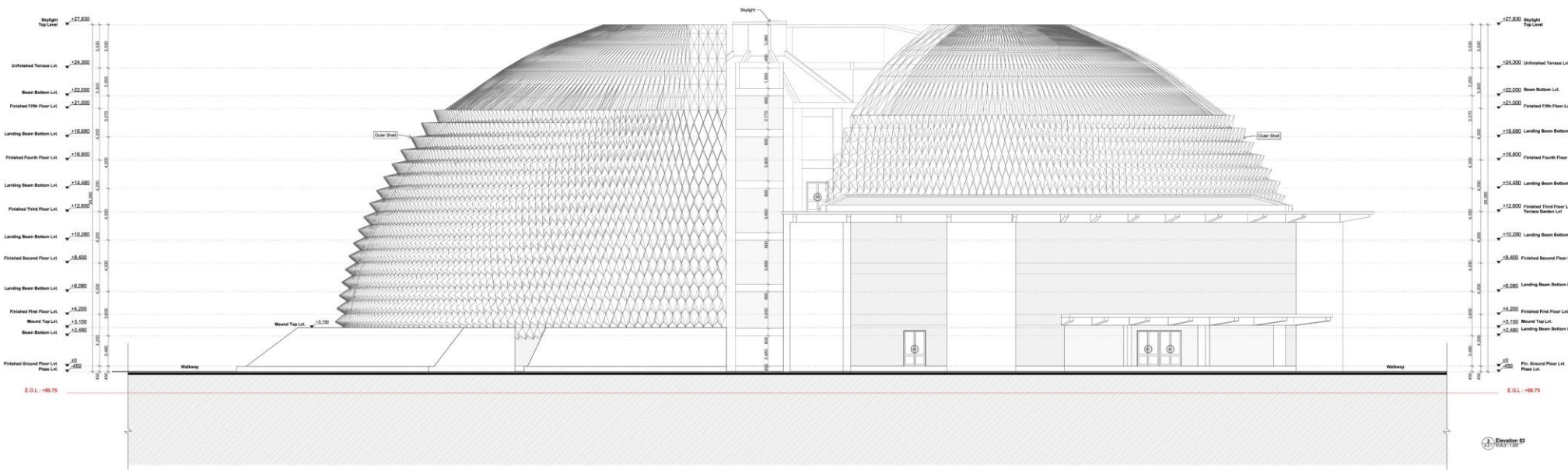


WEST ELEVATION

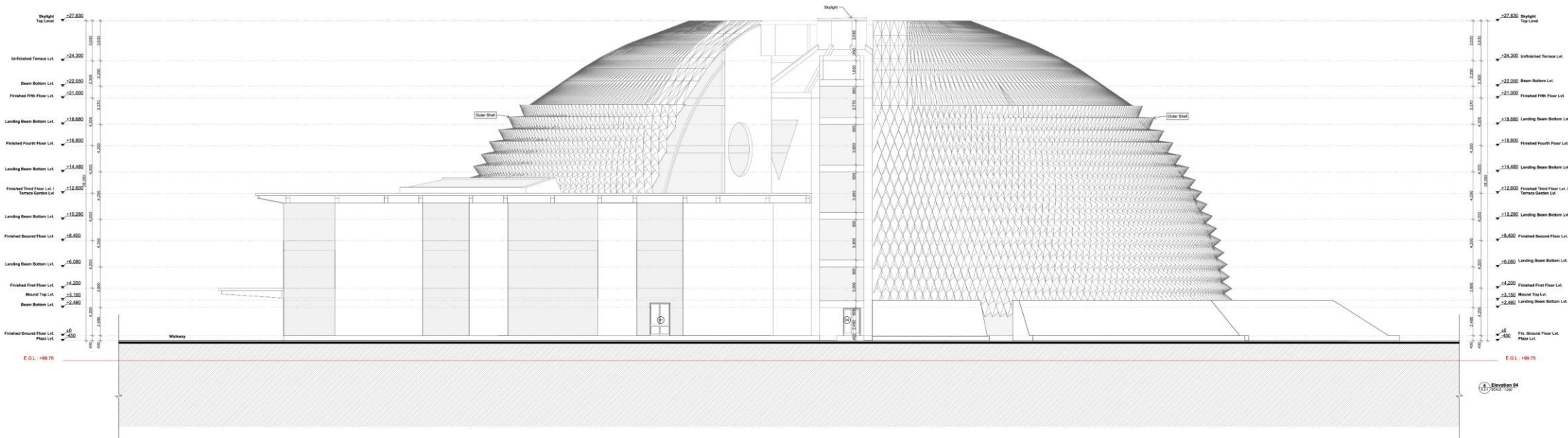


SOUTH ELEVATION

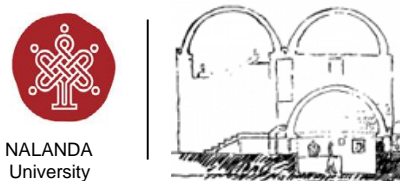
Elevations



EAST ELEVATION



NORTH ELEVATION





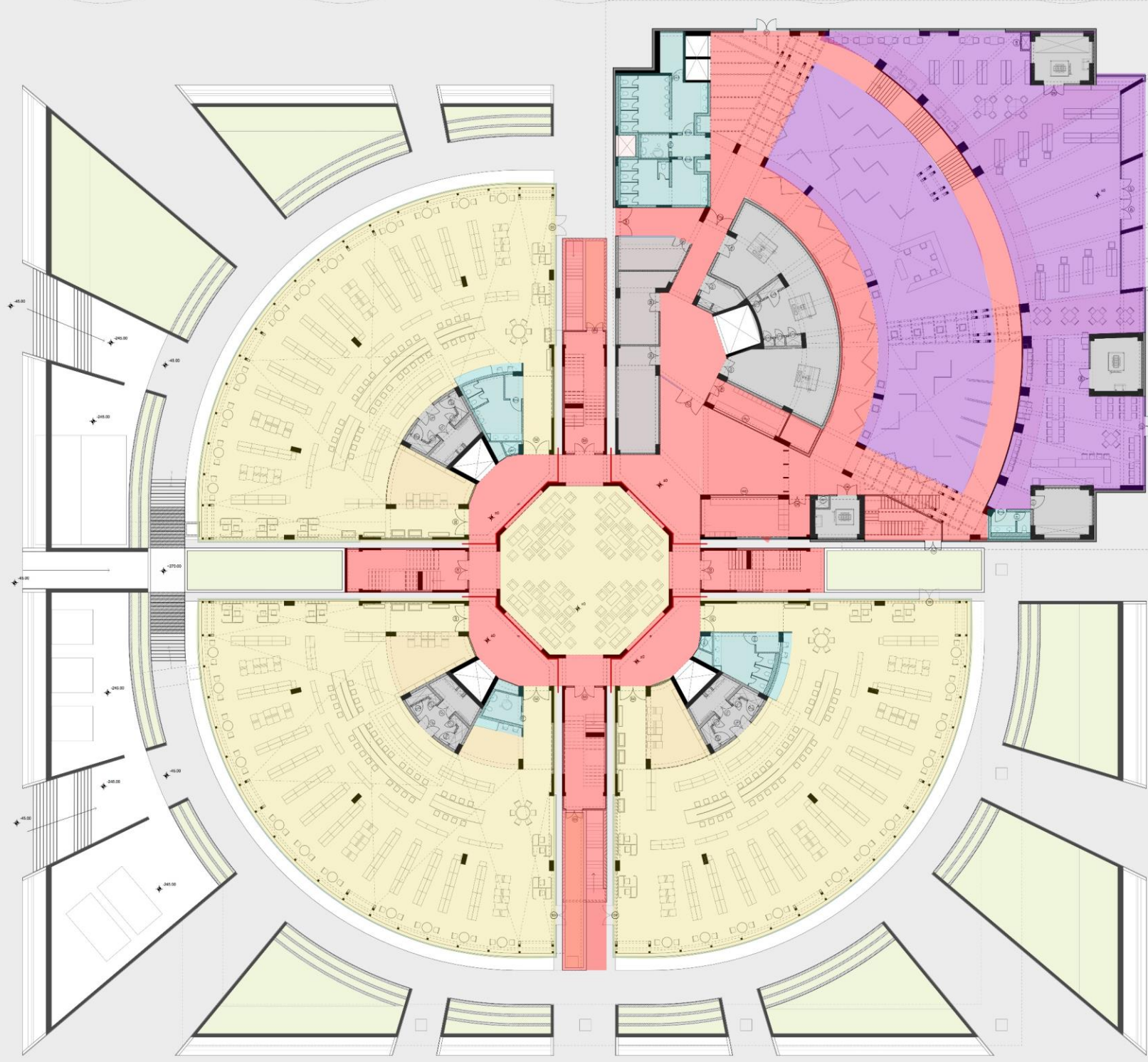
Aerial View



View From Campus Amenities

Area Zoning

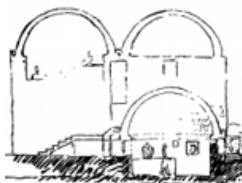
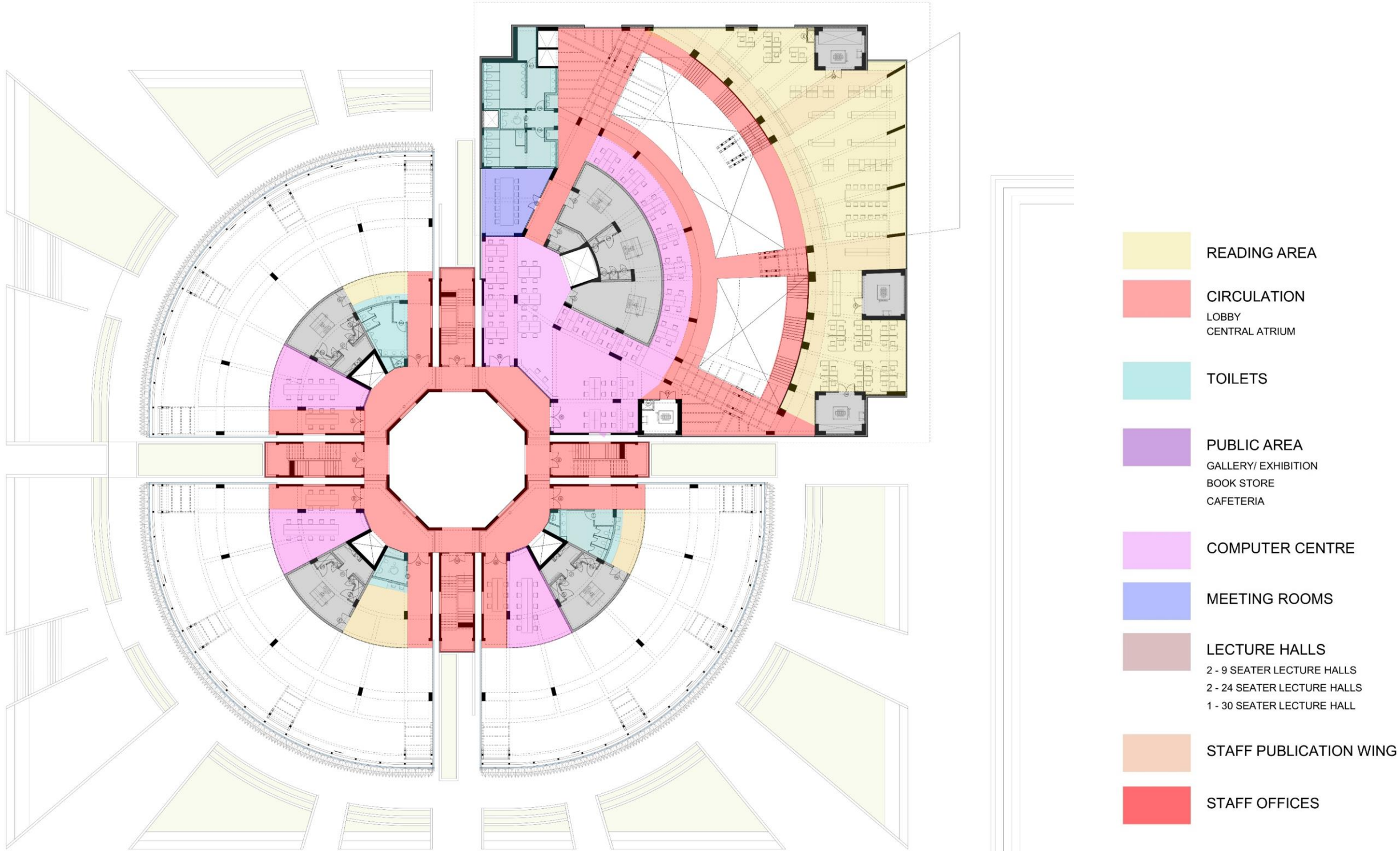
Ground Floor Plan +0 LVL



- READING AREA
- CIRCULATION
LOBBY
CENTRAL ATRIUM
- TOILETS
- PUBLIC AREA
GALLERY/ EXHIBITION
BOOK STORE
CAFETERIA
- COMPUTER CENTRE
- MEETING ROOMS
- LECTURE HALLS
2 - 9 SEATER LECTURE HALLS
2 - 24 SEATER LECTURE HALLS
1 - 30 SEATER LECTURE HALL
- STAFF PUBLICATION WING
- STAFF OFFICES

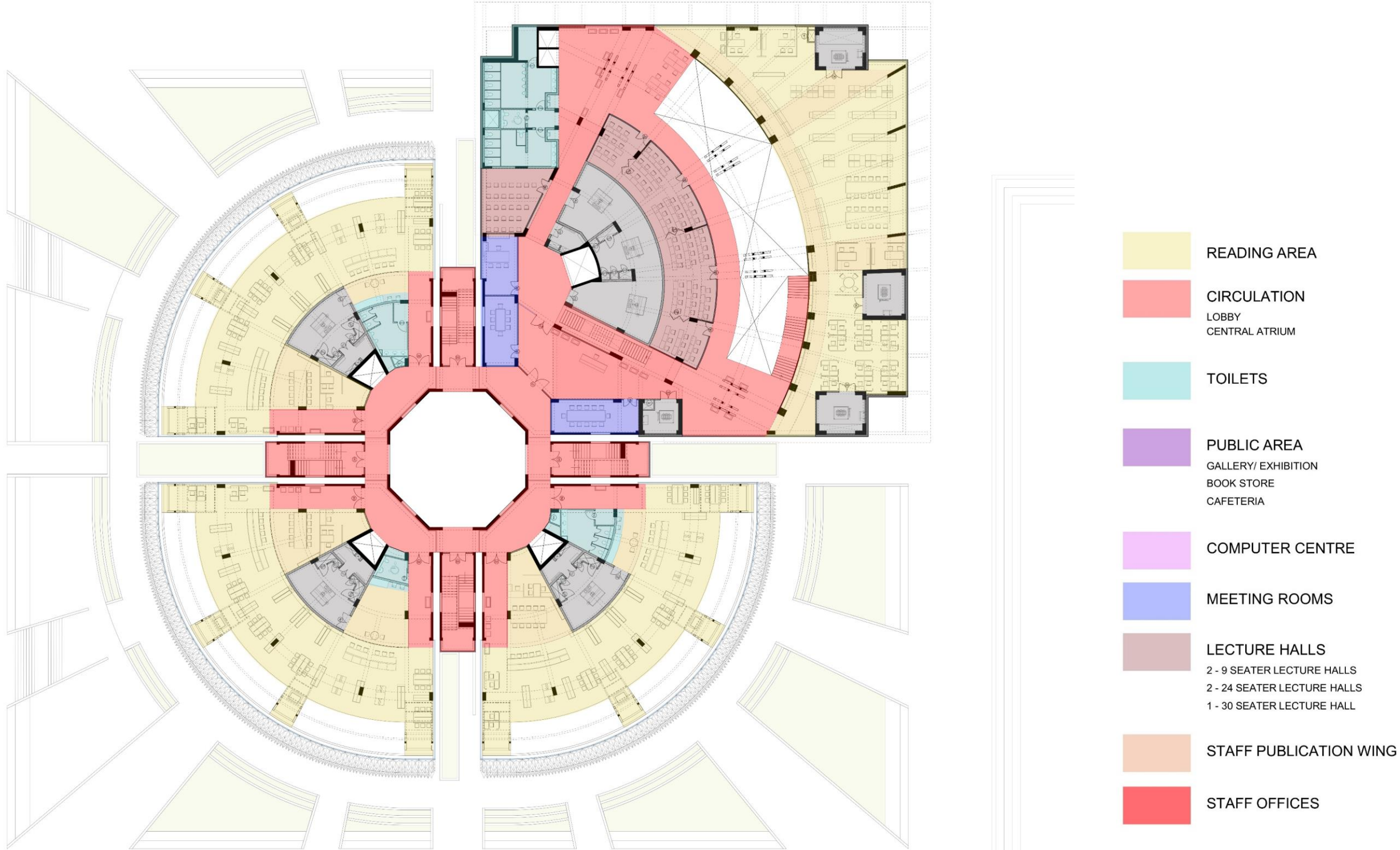
Area Zoning

First Floor Plan +4.2 LVL



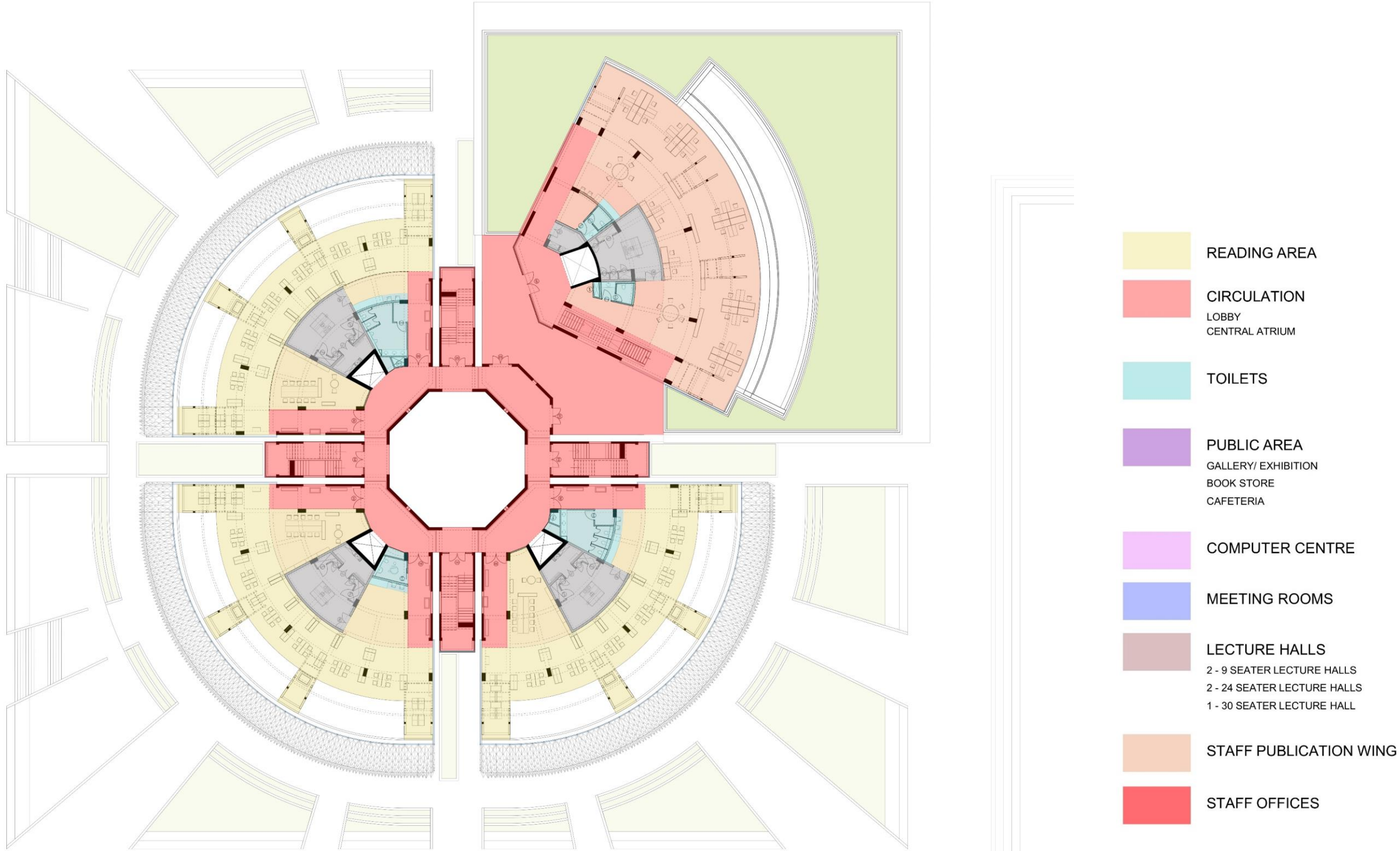
Area Zoning

Second Floor Plan +8.4 LVL



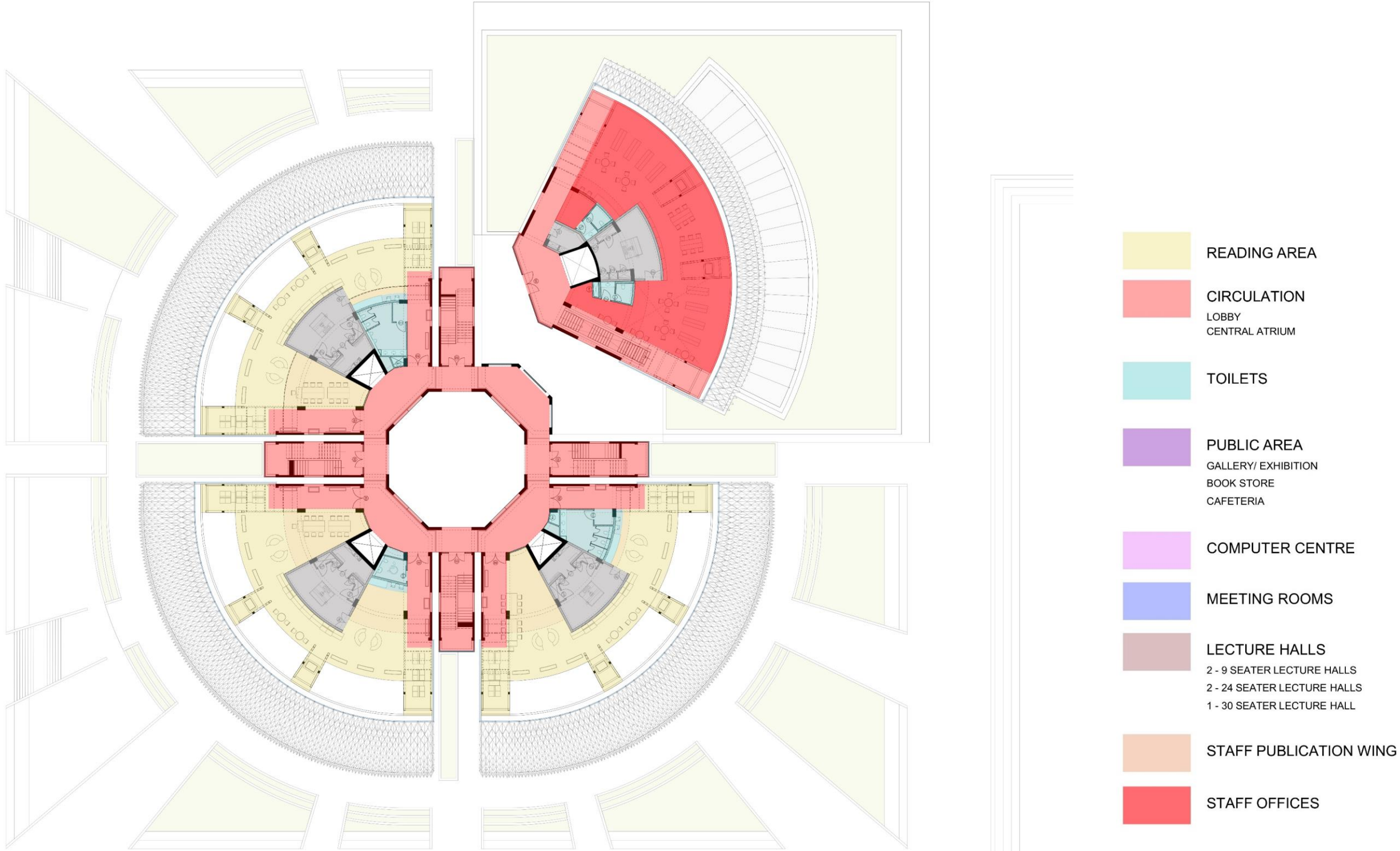
Area Zoning

Third Floor Plan +12.6 LVL



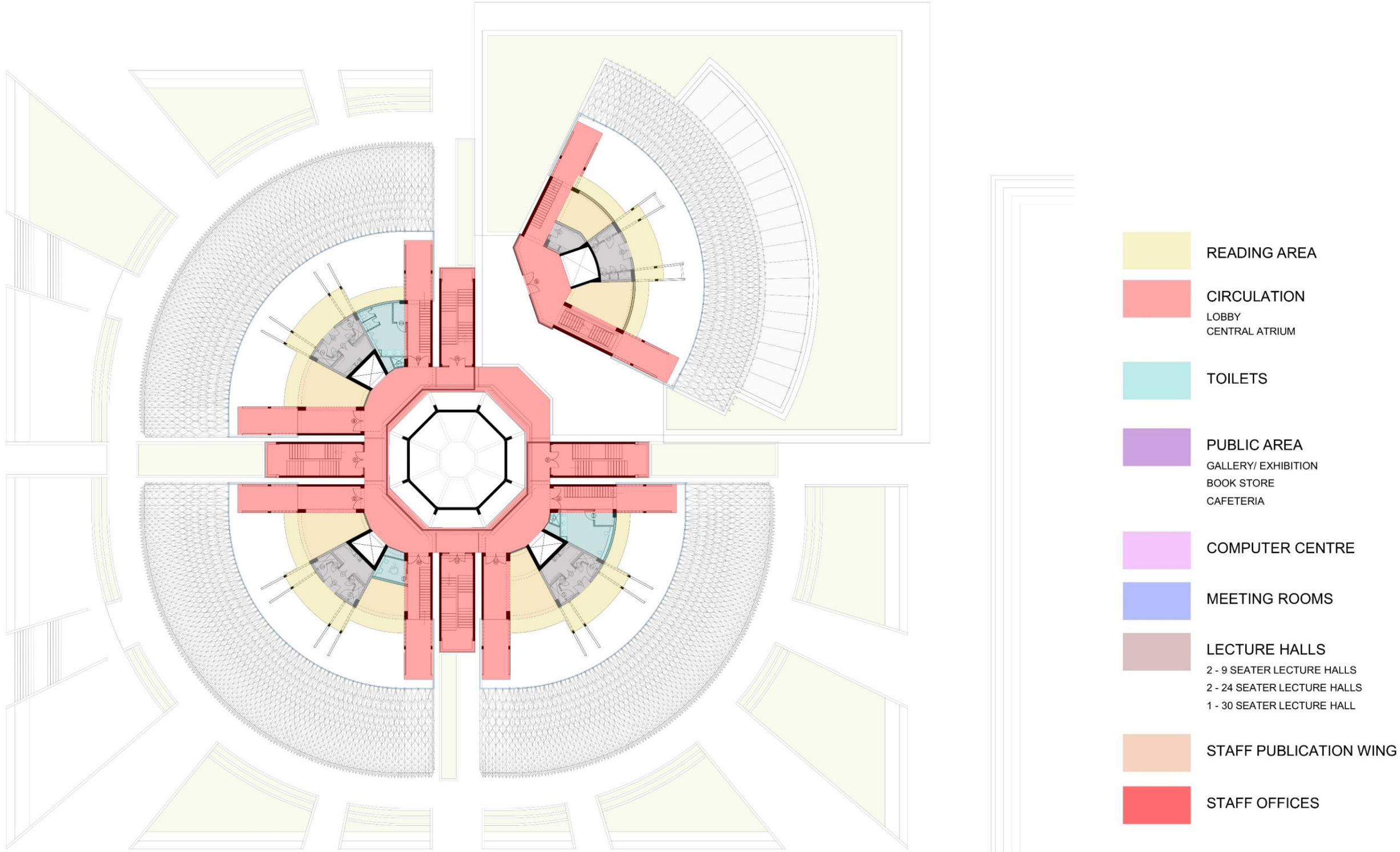
Area Zoning

Fourth Floor Plan +16.8 LVL



Area Zoning

Fifth Floor Plan +21.0 LVL

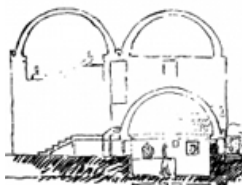
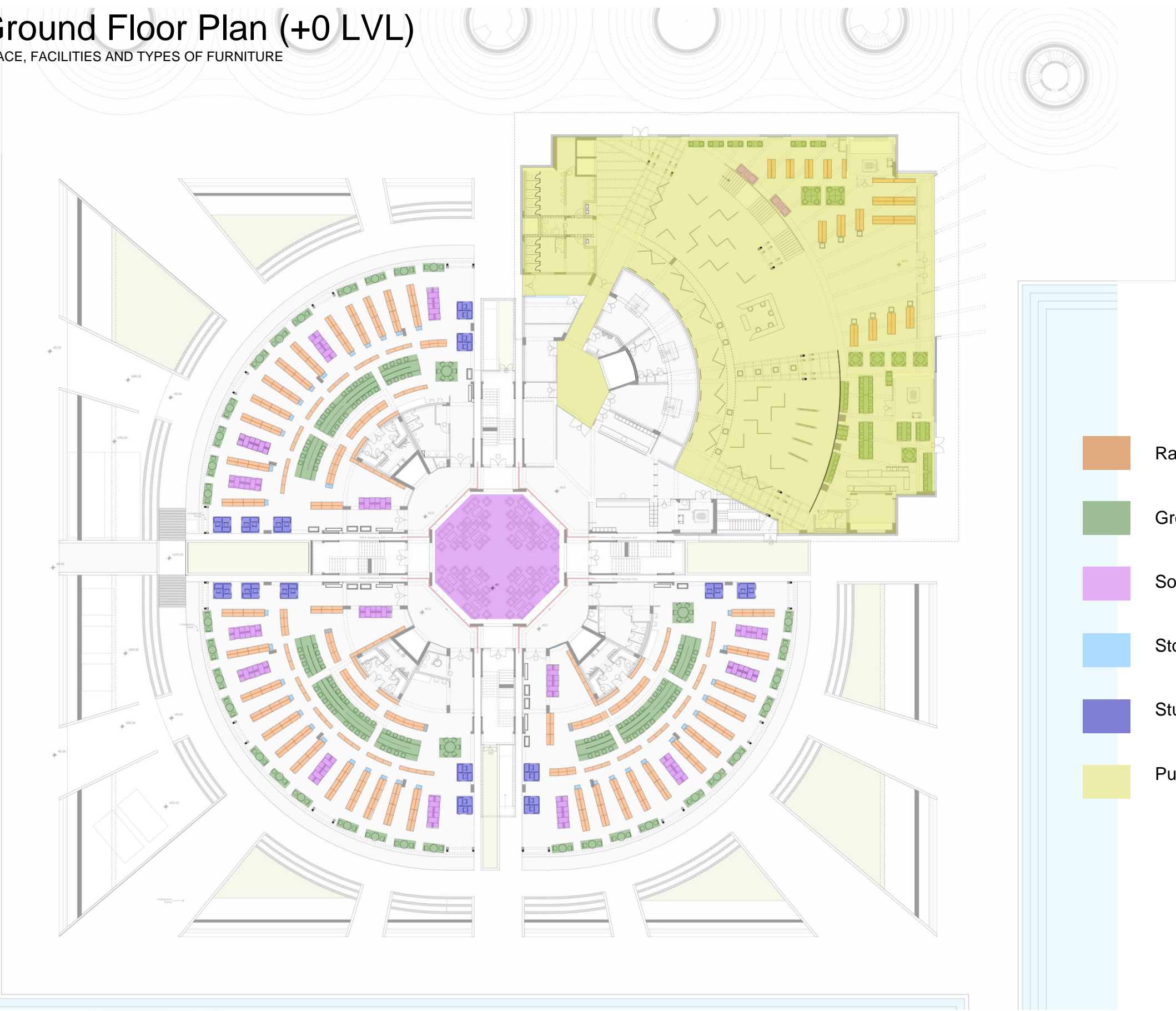




Grand Reading Hall

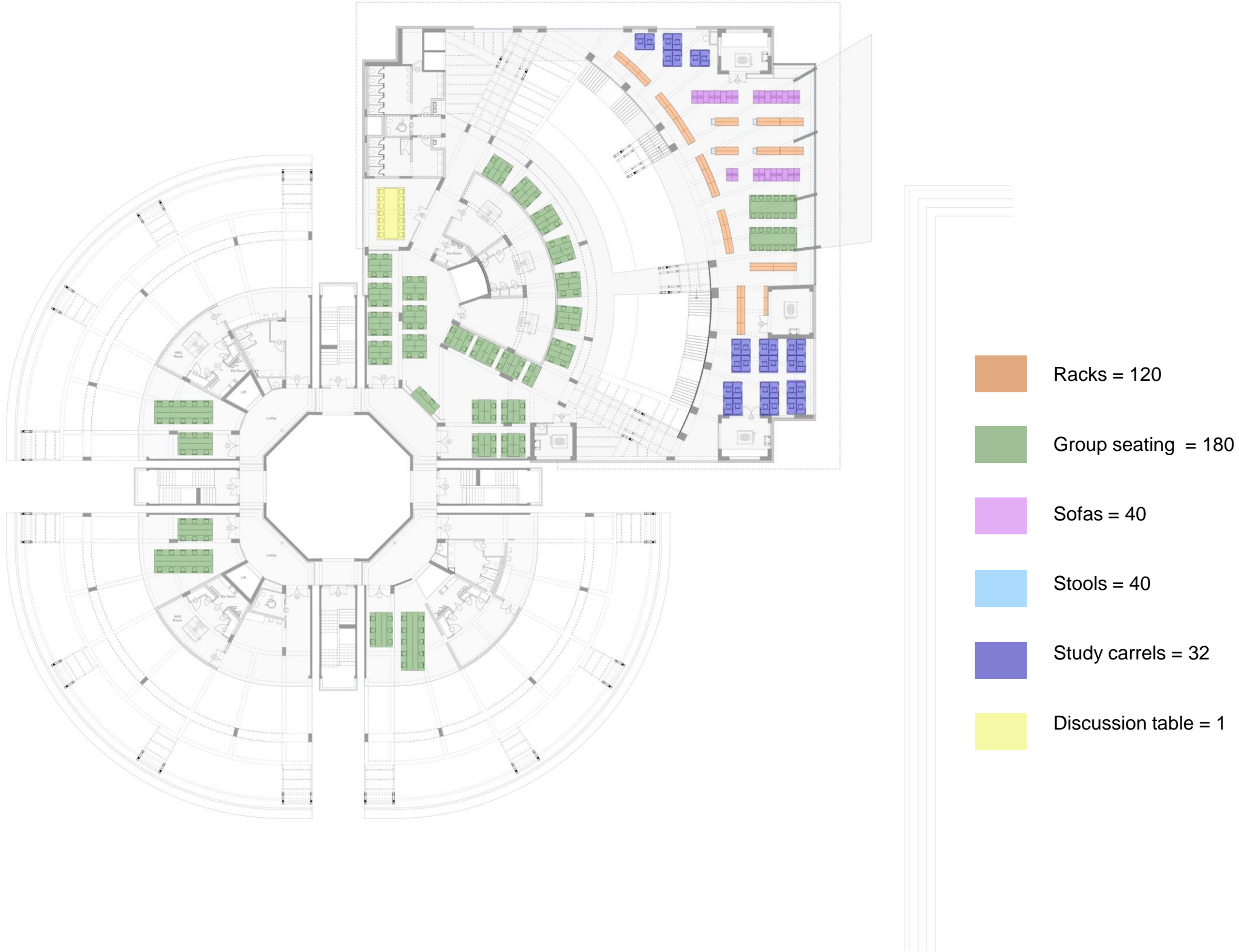
Ground Floor Plan (+0 LVL)

SPACE, FACILITIES AND TYPES OF FURNITURE



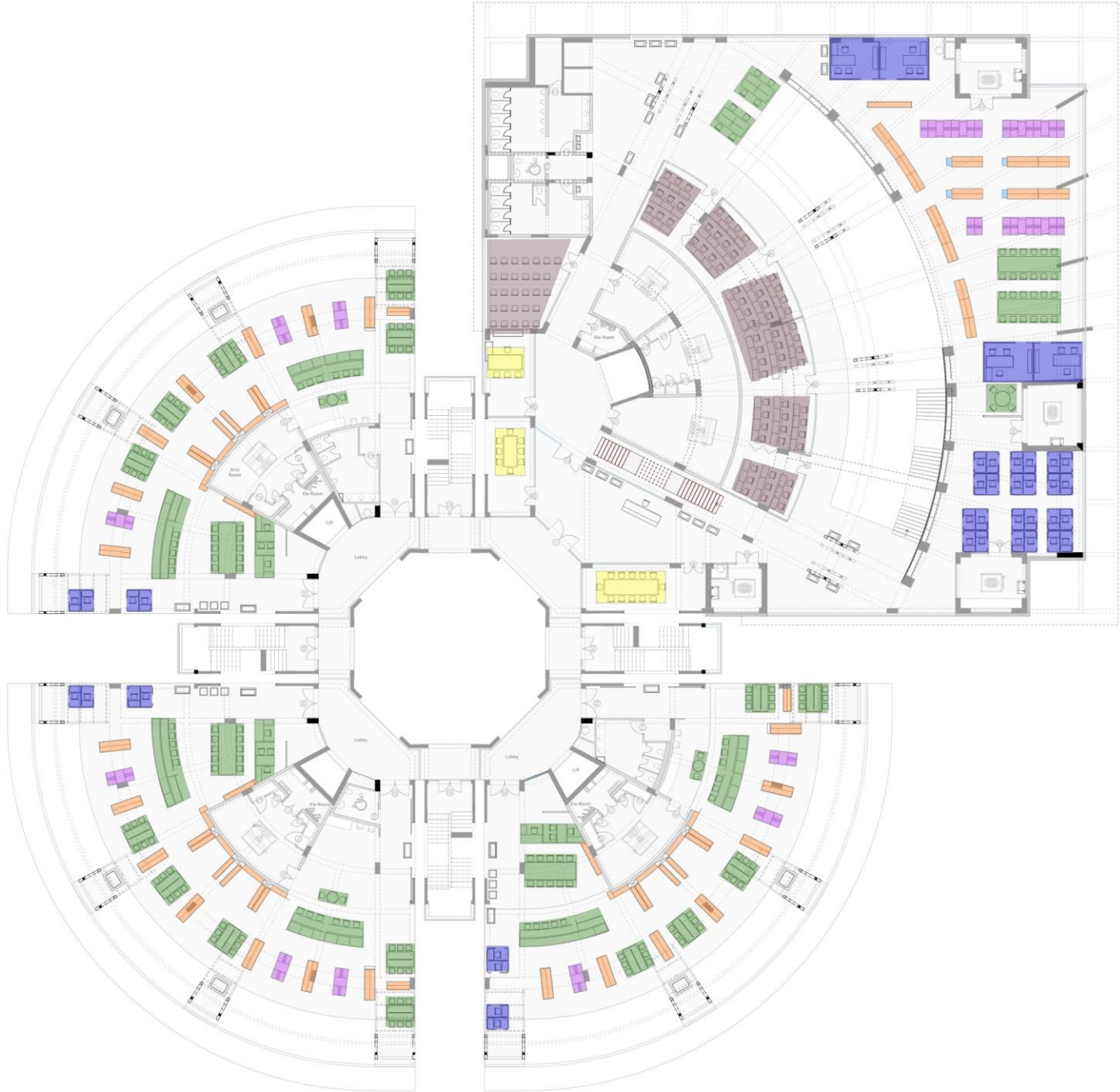
First Floor Plan (+4.2 LVL)

SPACE, FACILITIES AND TYPES OF FURNITURE

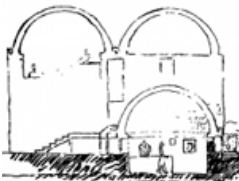


Second Floor Plan (+8.4 LVL)

SPACE, FACILITIES AND TYPES OF FURNITURE



- Racks = 330
- Group seating = 264
- Sofas = 40
- Stools = 12
- Study carrels = 36
- Lecture hall seats = 96
- Discussion tables - 3



Third Floor Plan (+12.6 LVL)

SPACE, FACILITIES AND TYPES OF FURNITURE



Racks = 250



Group Seating= 200



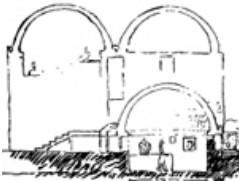
Sofas = 60



Office Seating = 24



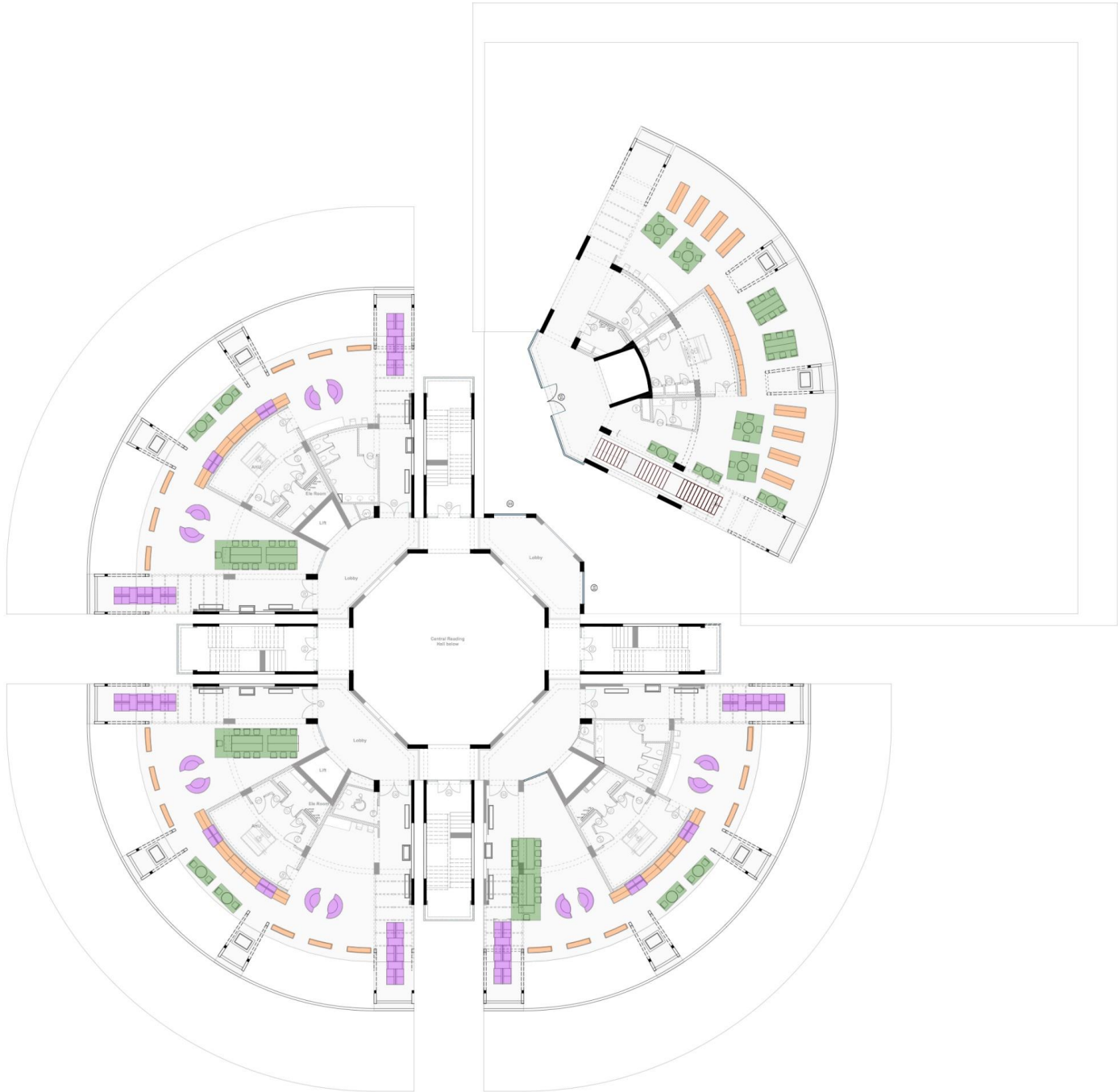
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


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Fourth Floor Plan (+16.8 LVL)

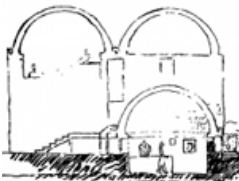
SPACE, FACILITIES AND TYPES OF FURNITURE



-  Racks = 241
-  Group sitting = 90
-  Sofas = 96
-  Chairs/ Stools = 70



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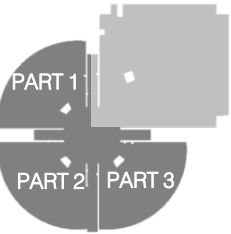
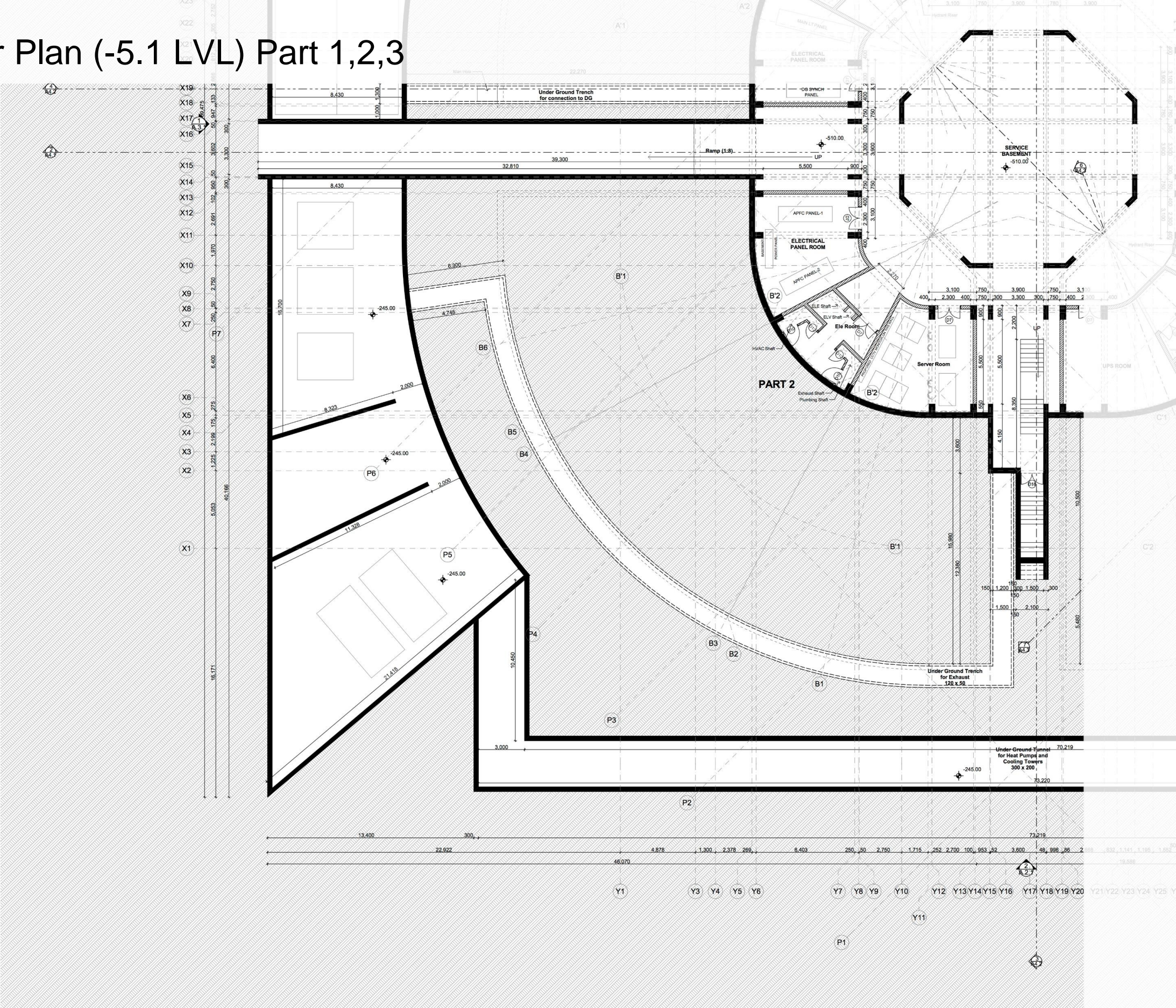


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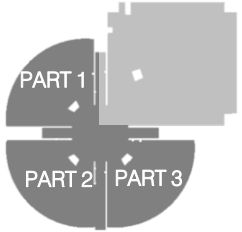
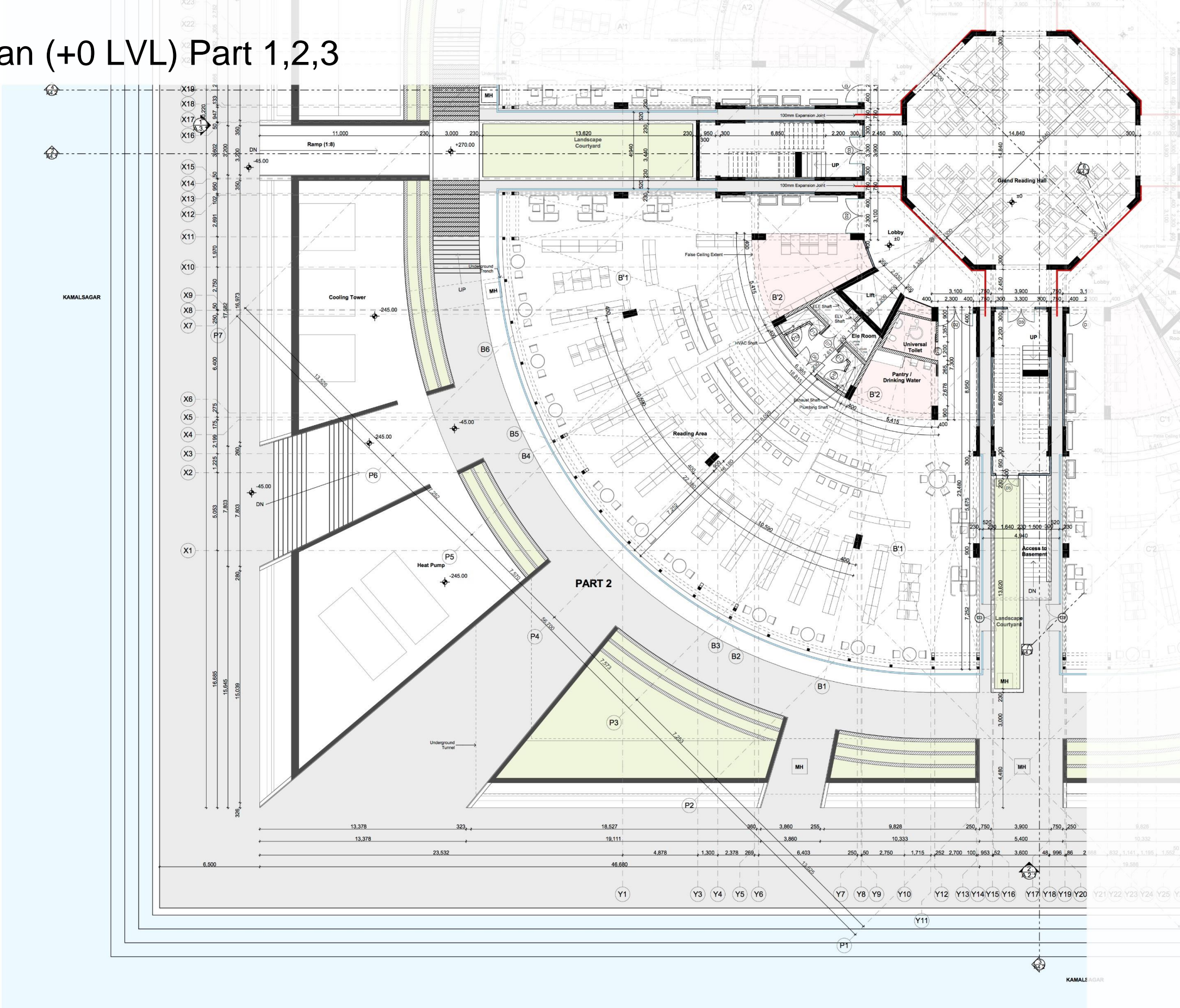
Hall Of Knowledge

Basement Floor Plan (-5.1 LVL) Part 1,2,3



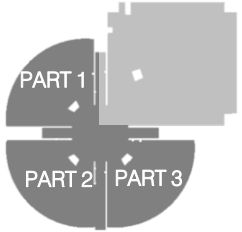
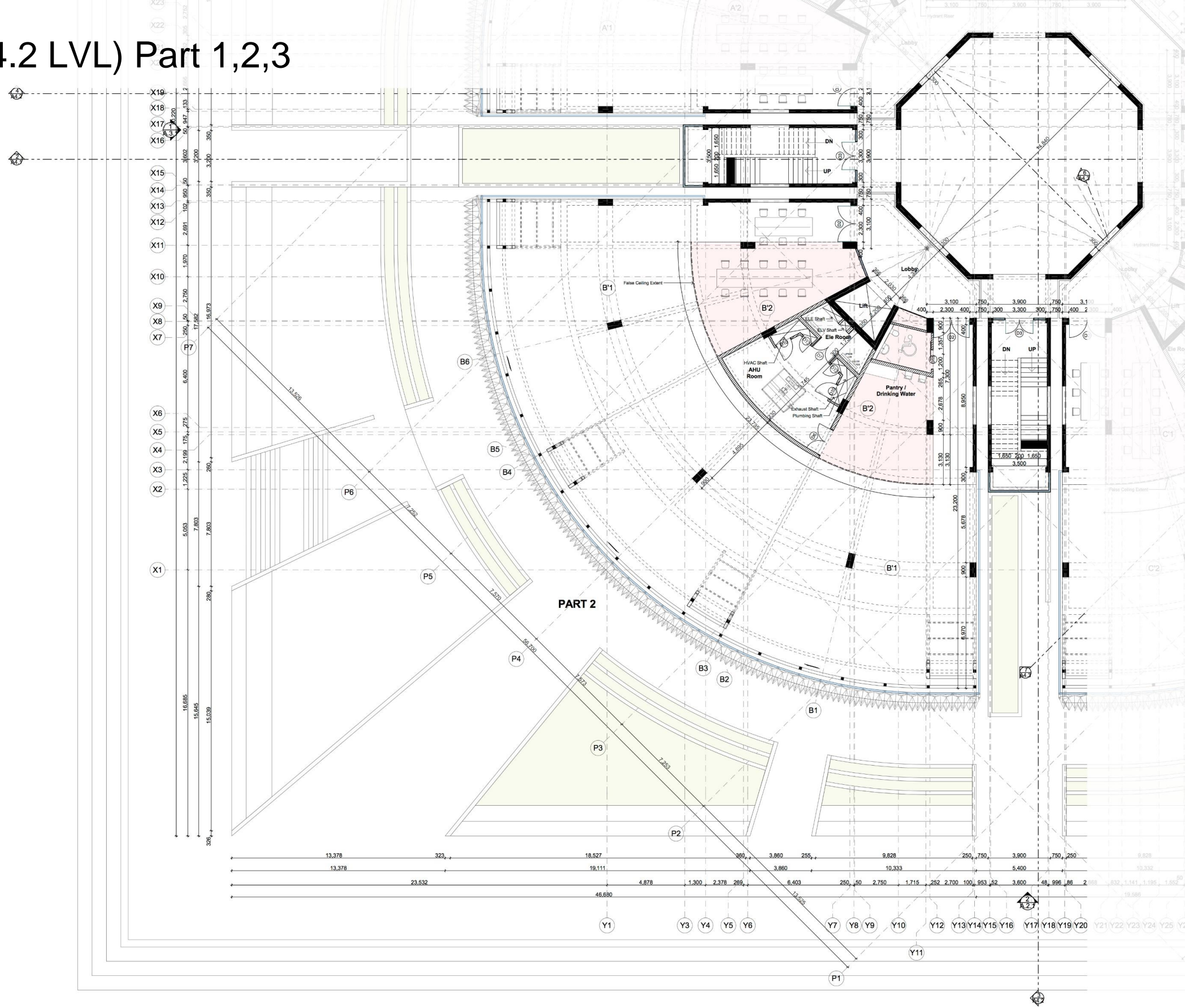
KEY PLAN

Ground Floor Plan (+0 LVL) Part 1,2,3



KEY PLAN

First Floor Plan (+4.2 LVL) Part 1,2,3



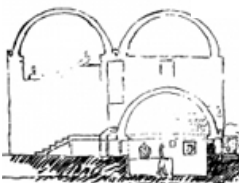
KEY PLAN

(+8.4 LVL) Part 1,2,3

The architectural floor plan shows a complex building layout with a curved, semi-circular main section. The plan is divided into several functional areas:

- Reading Area:** A large, open space with curved walls and a curved wall.
- Lobby:** A central area with a curved wall and a curved wall.
- Pantry/Drinking Water:** A small, rectangular area with a curved wall.
- Restrooms:** Multiple restrooms labeled B1, B2, B3, B4, B5, and B6, distributed throughout the plan.
- Elevators and Stairs:** Several elevators and stairs are shown, including a large set of stairs labeled "UP" and "DN" on the right side.
- Other Rooms:** Various smaller rooms, including a "False Ceiling Extant" area and a "Reading Area".

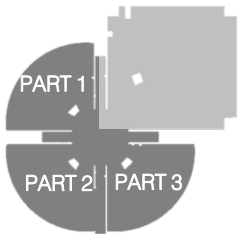
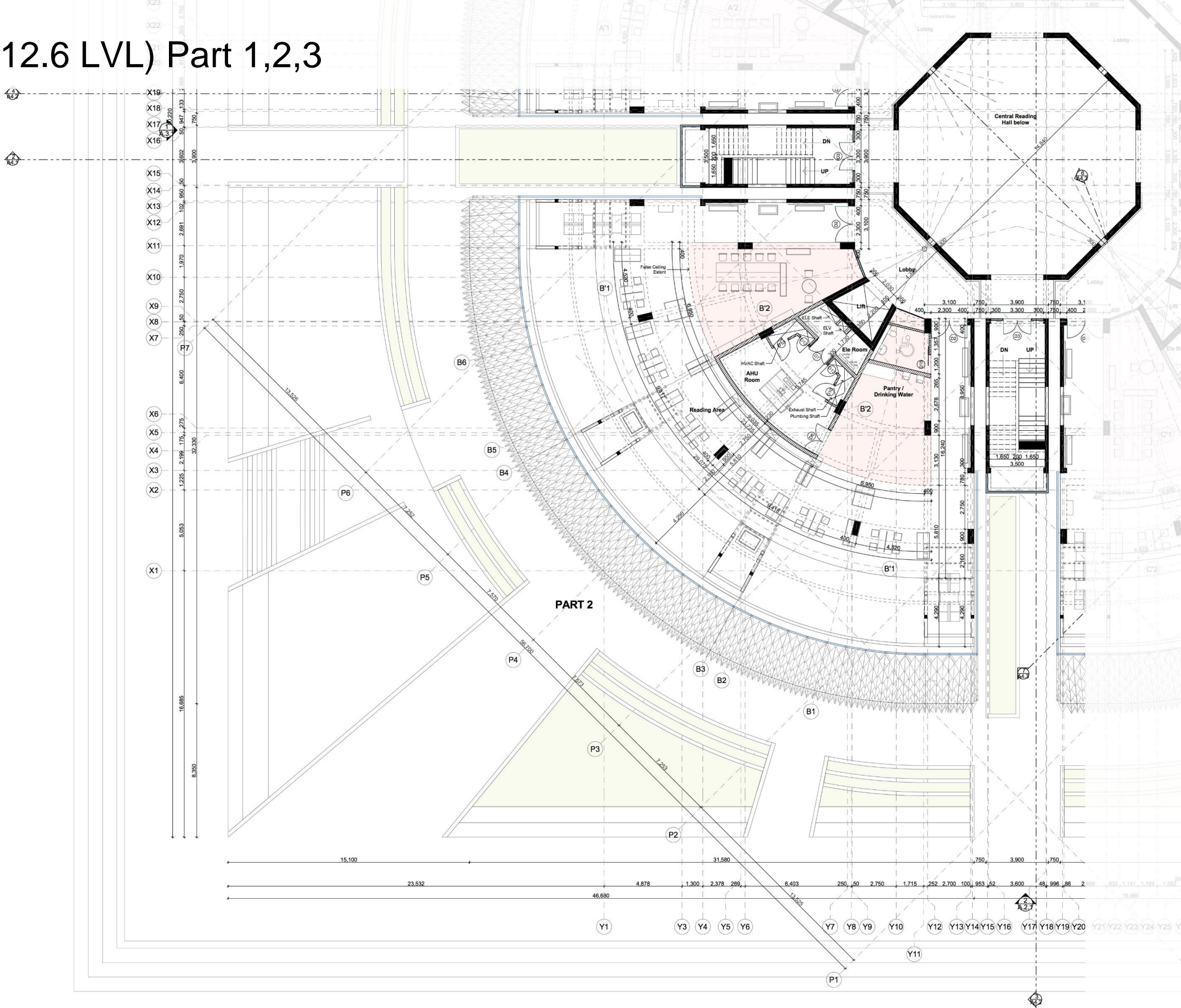
The plan is divided into sections by grid lines X1 to X19 and Y1 to Y25. Dimensions are provided for various sections and overall building dimensions. The plan is labeled "PART 2" in the center.



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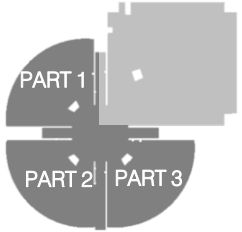
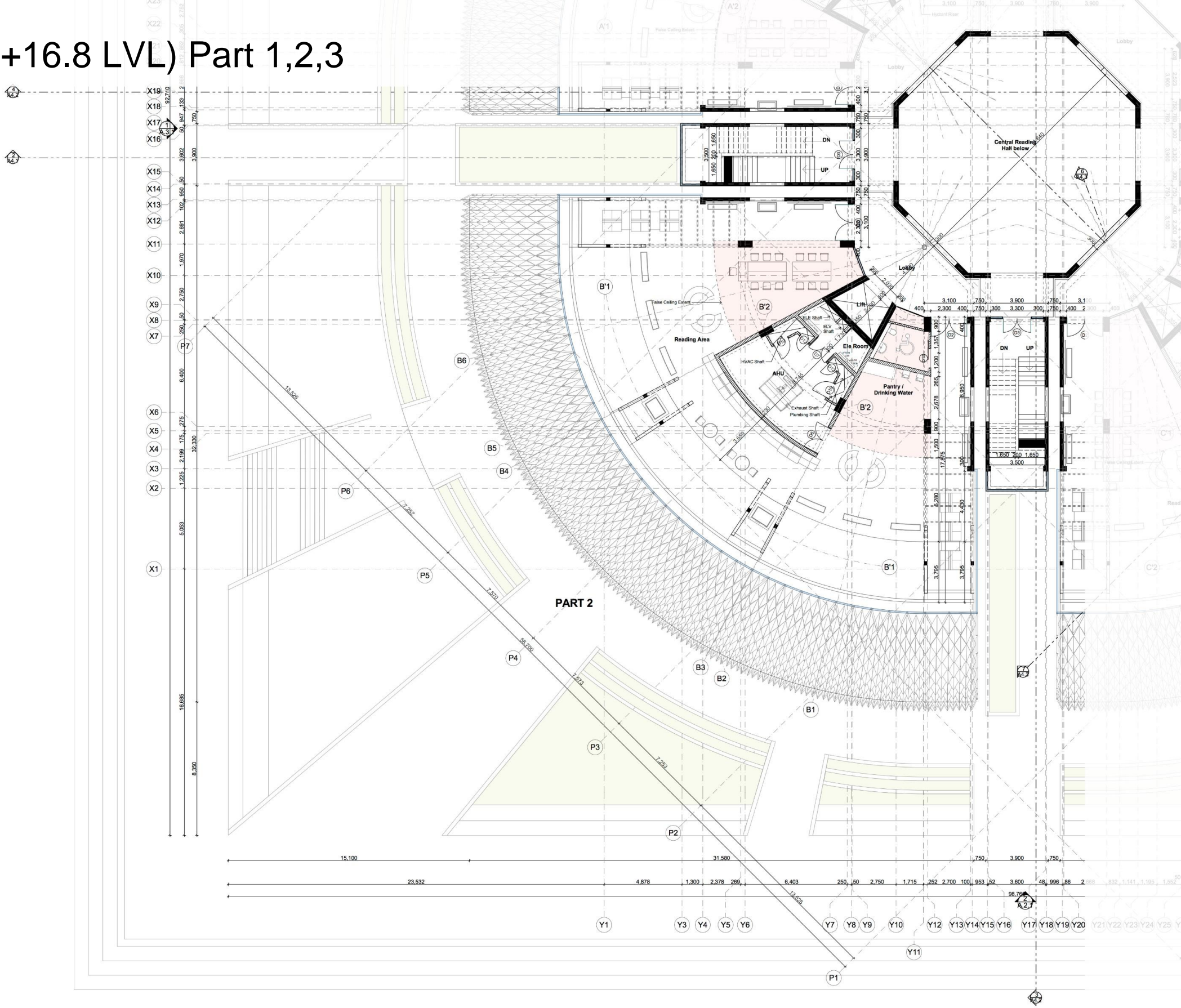


Third Floor Plan (+12.6 LVL) Part 1,2,3



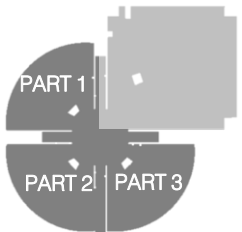
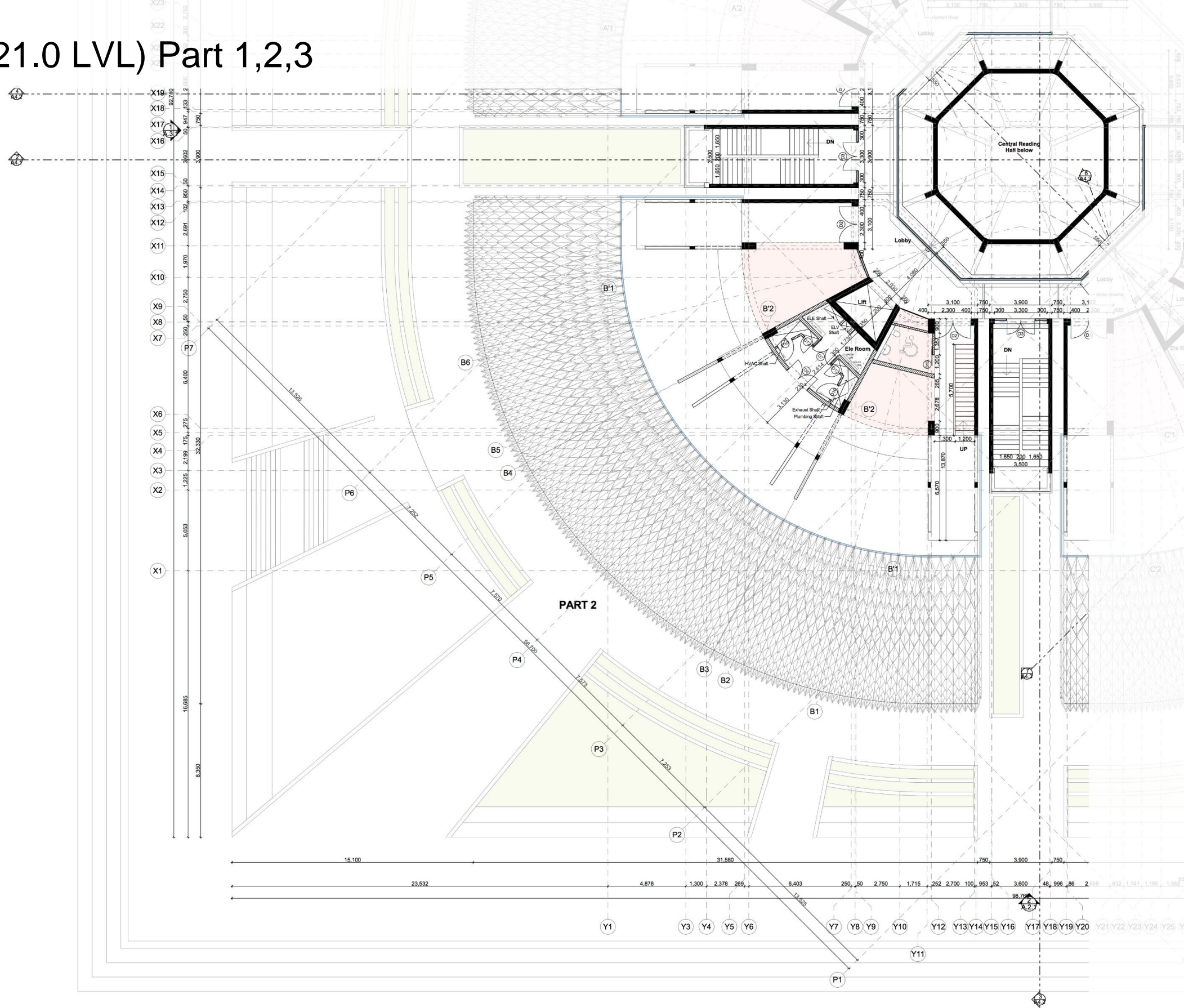
KEY PLAN

Fourth Floor Plan (+16.8 LVL) Part 1,2,3



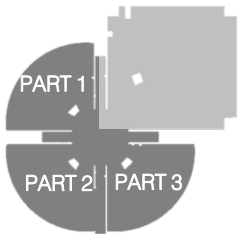
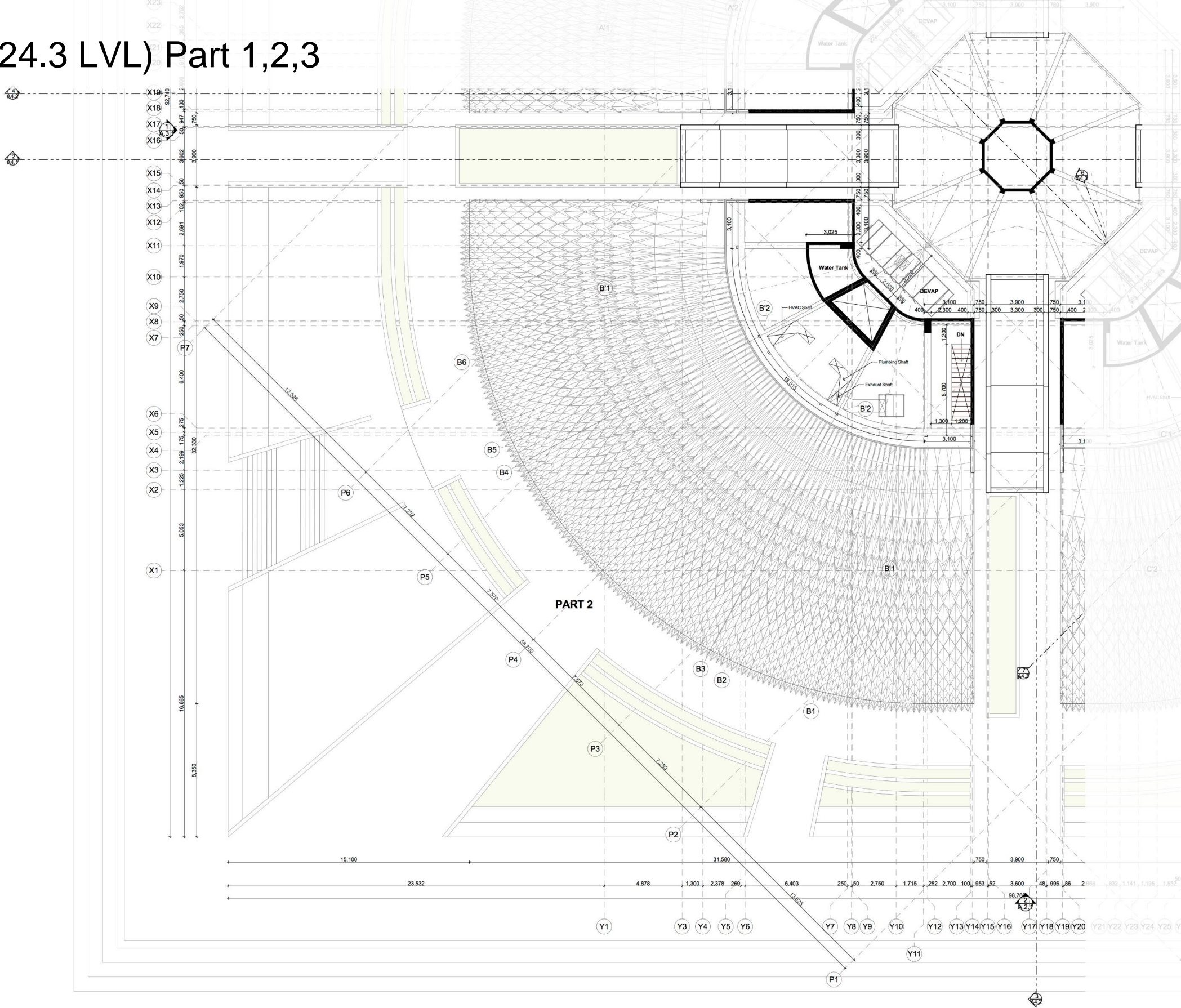
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Fifth Floor Plan (+21.0 LVL) Part 1,2,3




KEY PLAN

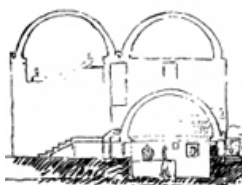
Sixth Floor Plan (+24.3 LVL) Part 1,2,3



KEY PLAN

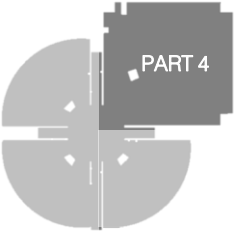
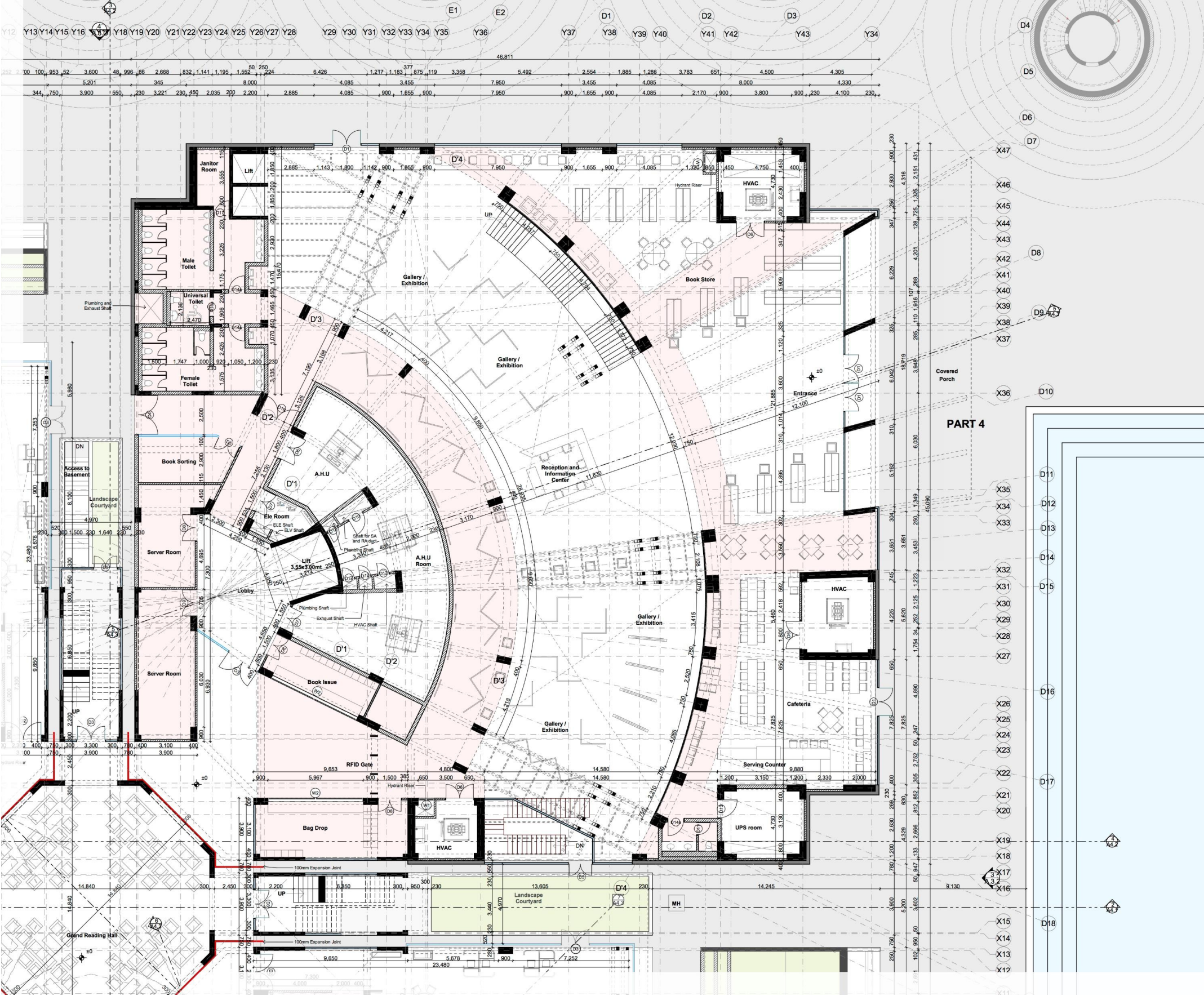
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PART 4



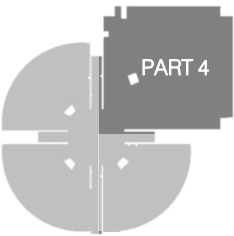
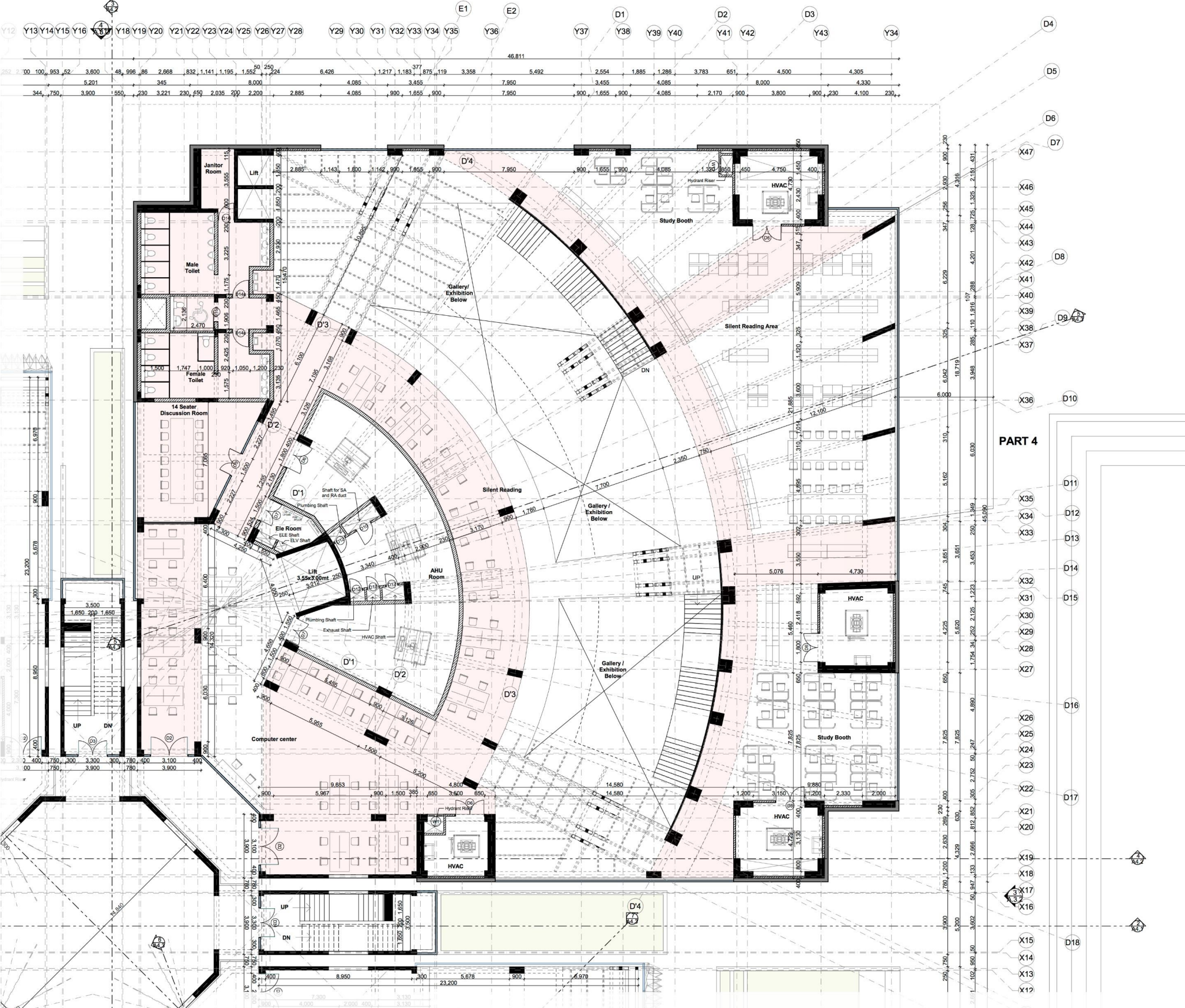
Library Preliminary Architecture Report
Nalanda University , Rajgir

Ground Floor Plan (+0 LVL) Part 4



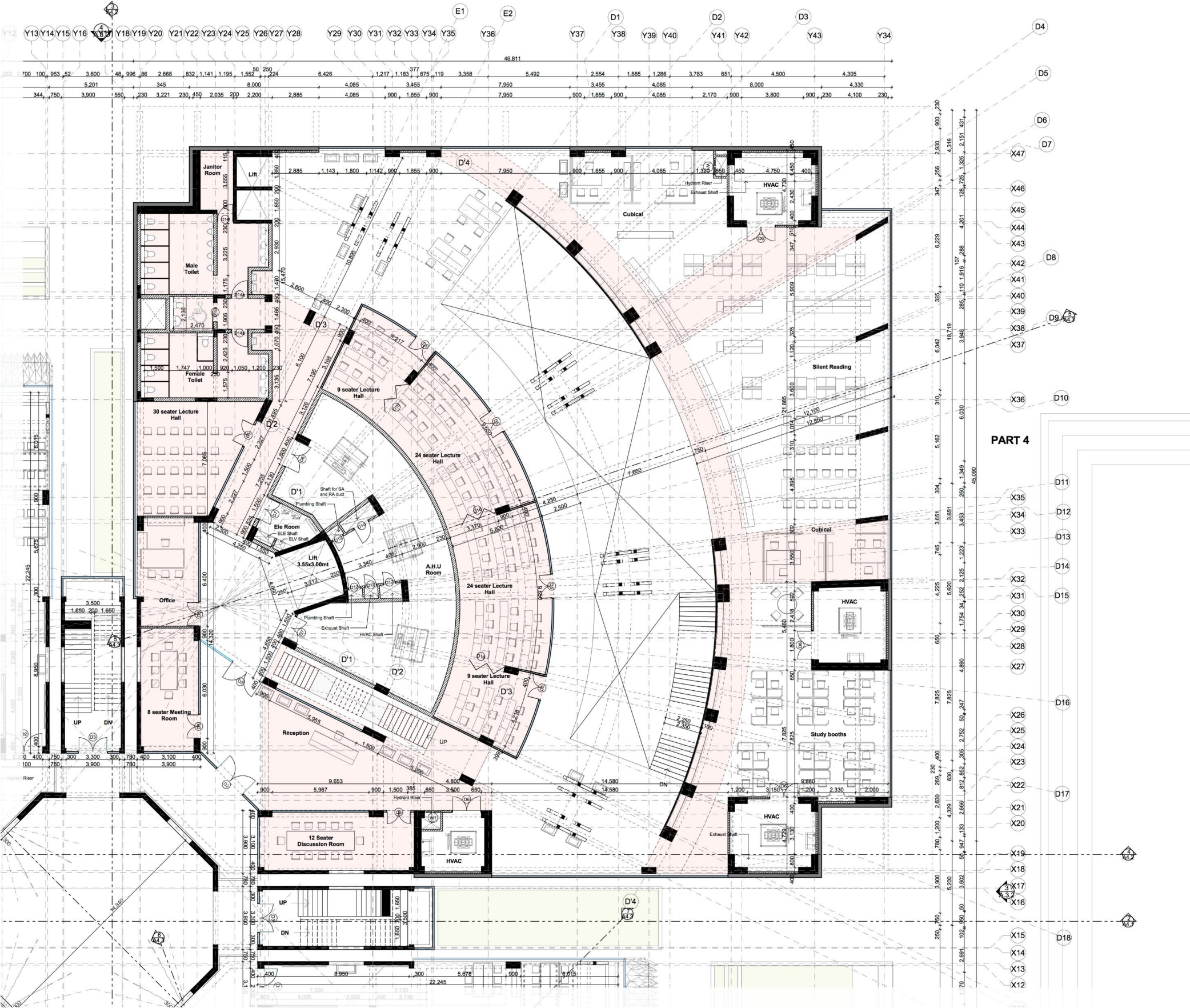
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First Floor Plan (+4.2 LVL) Part 4



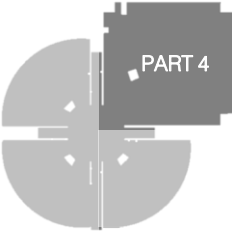
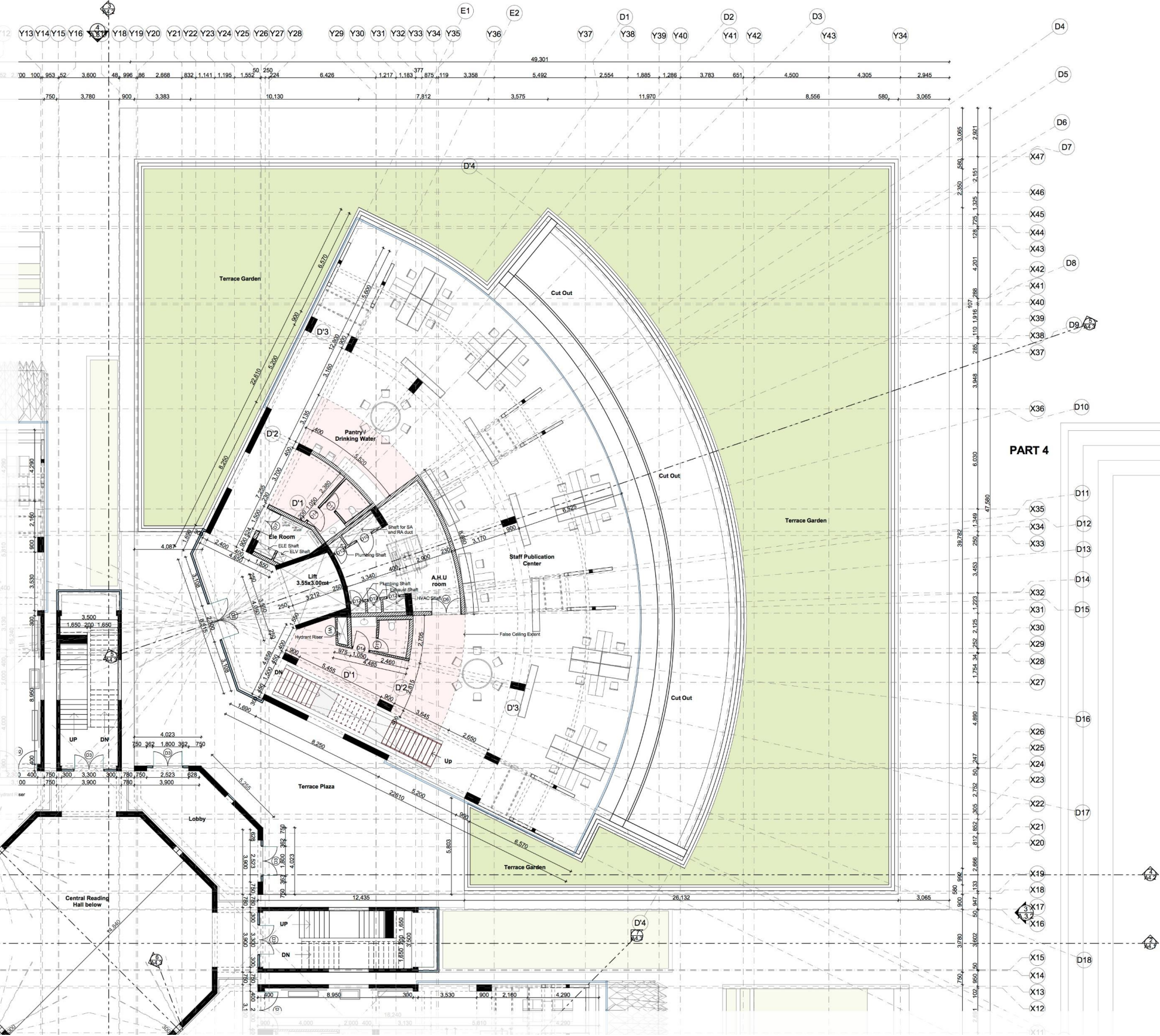
KEY PLAN

Second Floor Plan (+8.4 LVL) Part 4



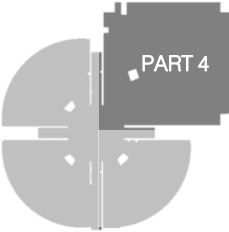
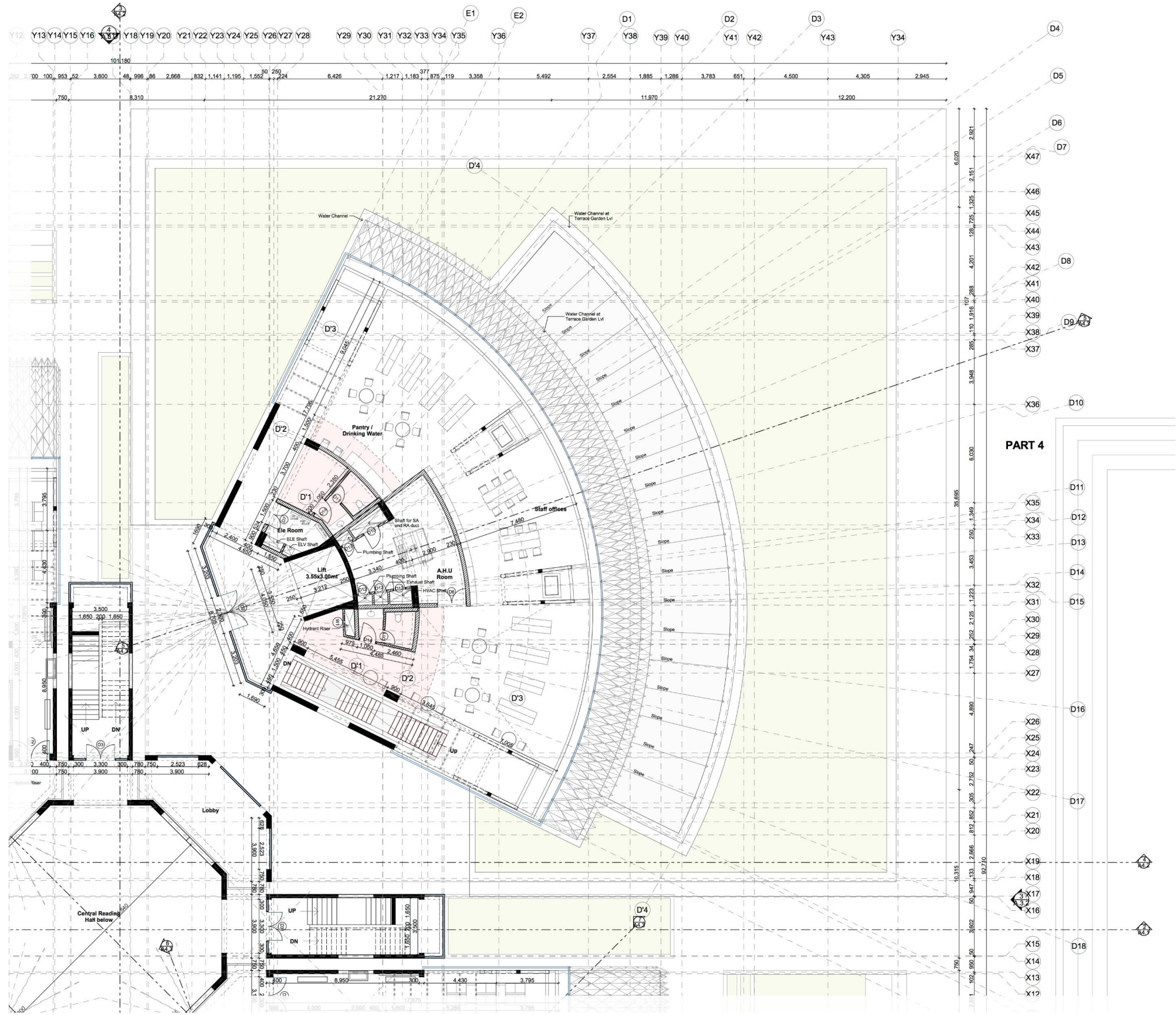
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Third Floor Plan (+12.6 LVL) Part 4



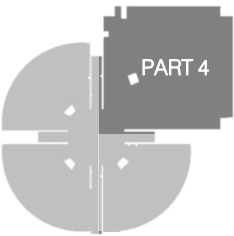
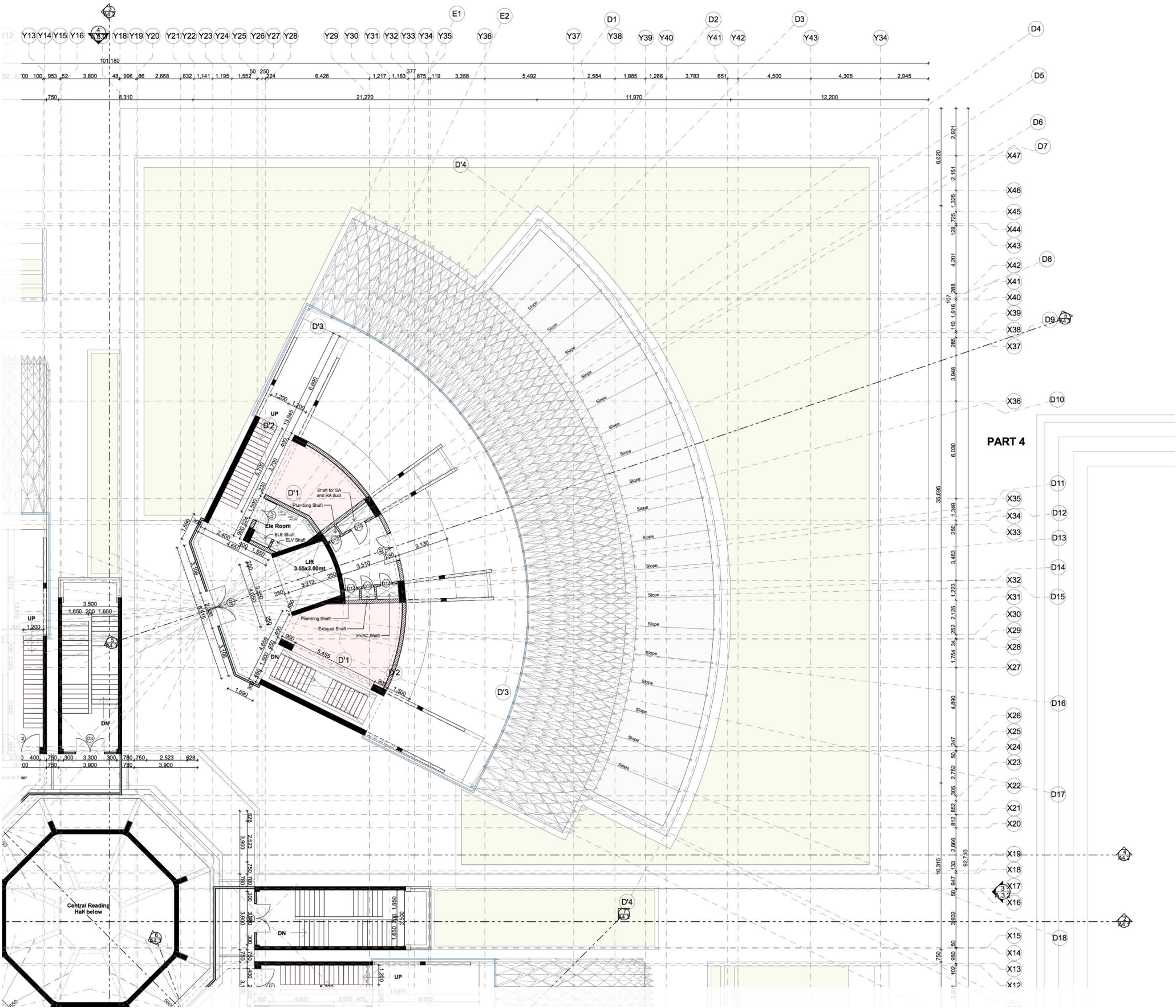
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Fourth Floor Plan (+16.8 LVL) Part 4



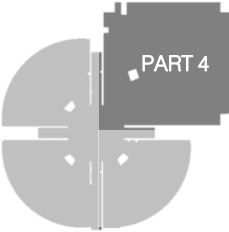
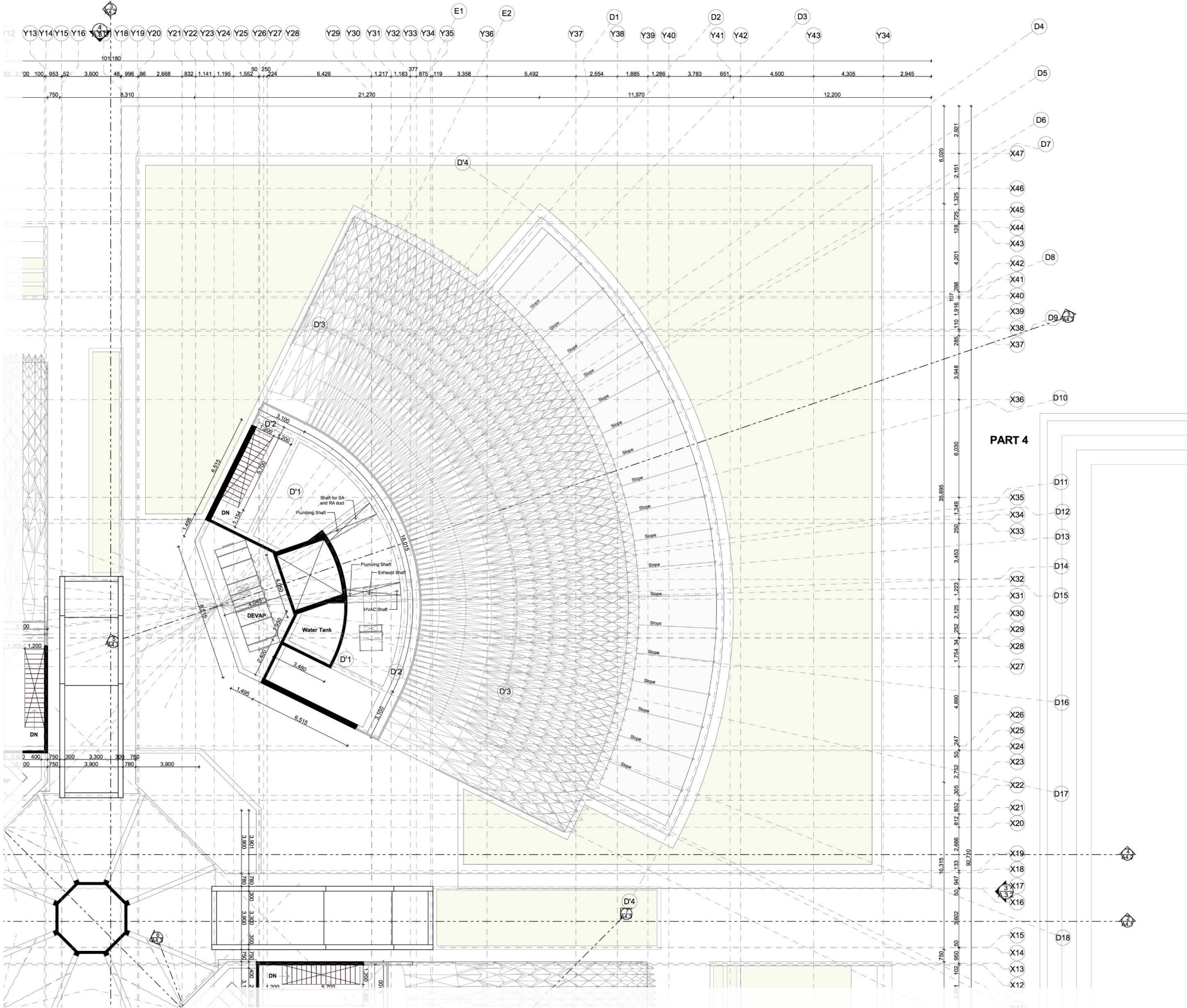
KEY PLAN

Fifth Floor Plan (+21.0 LVL) Part 4



KEY PLAN

Sixth Floor Plan (+24.3 LVL) Part 4



KEY PLAN

Annexure – 1

Area Program

BASEMENT PLATE – 5.10 LVL : 3018 SQMT	
SPACE NAME	BUA (IN SQMT)
SERVICE AREA	2310.2
WATER TANKS	107.8
TOTAL	3018

GROUND FLOOR PLATE 0.00 LVL :4656 SQMT														
SPACE NAME			BUA (IN SQMT)	CPA (IN SQMT)	FURNITURE					USER				HEIGHT (CM)
					TABLE	CHAIR / READING STOOL	SOFA	STUDY CUBICLES	RACKS	STUDENT	STAFF	OTHERS	TOTAL	
PART 1, 3	LOBBY		76.9	64									353	
	READING AREA		631.2	610.8	35	90	40	10	208	140	-	-	140	353
	SERVICES		30	16.7	-	-	-	-	-	-	-	-	-	288
	PASSENGER LIFT		7.1		-	-	-	-	-	-	-	-	-	
	CENTRAL ATRIUM		197.4	192.4	-	-	-	-	-	-	-	-	-	353
	TOILETS		27	17.8	-	-	-	-	-	-	-	-	-	288
PART 2	LOBBY		76.9	64									353	
	READING AREA		640.7	626.4	35	90	40	10	200	140	-	-	140	353
	SERVICES		30	16.7	-	-	-	-	-	-	-	-	-	288
	PASSENGER LIFT		7.1	-	-	-	-	-	-	-	-	-	-	
	TOILETS		9.5	7.3	-	-	-	-	-	-	-	-	-	288
PART 4	RFID GATE		47.2	45.4	-	-	-	-	-	-	-	-	-	-
	CIRCULATION		511	436	-	-	-	-	-	-	-	-	-	-
	RECEPTION				-	-	-	-	-	-	-	-	-	-
	BAG STORAGE				-	-	-	-	-	-	-	-	-	-
	BOOK ISSUE		28.7	24.7	-	-	-	-	-	-	-	-	-	-
	SERVICES		226.6	185.6	-	-	-	-	-	-	-	-	-	-
	BOOK STORE		320	265	10	20	4	-	89	24	-	15	39	-
	EXHIBITION AREA		380	354	19	86	-	-	-	-	-	-	86	-
	CAFE TERRA	SEATING AREA INDOOR	205.1	174	-	-	-	-	-	-	-	-	-	-
		SERVING COUNTER			-	-	-	-	86	-	-	-	-	-
		TOILET		10	5	-	-	-	-	-	-	-	-	-
	UPS BATTERIES		44.5	32.5	-	-	-	-	-	-	-	-	-	-
	SERVER ROOMS (2 NO)		65.6	58	-	-	-	-	-	-	-	2	2	-
	GOOD LIFT		12	-	-	-	-	-	-	-	-	-	-	-
	MALE TOILET		42	31.7	-	-	-	-	-	-	-	-	-	-
	FEMALE TOILET		33.5	27	-	-	-	-	-	-	-	-	-	-
	UNIVERSAL TOILET		9.4	5.4	-	-	-	-	-	-	-	-	-	-
	DRINKING WATER AREA			-	-	-	-	-	-	-	-	-	-	-
JANITOR ROOM		13	8.3	-	-	-	-	-	-	-	-	-	-	
TOTAL							30	705						
TOTAL			4656 SQMT	4187 SQMT	TOTAL SEATING CAPACITY ON GROUND FLOOR									485
FOR STUDENTS													530	
FOR STAFF													-	
OTHER (CAFETERIA, MEETING ROOM, LECTURE ROOM, ETC)					16	76	-	-	-	-	-	-	80	
TOTAL													610	

TOTAL NUMBER OF VOLUME ON GF = 705 (RACKS) X 125 (BOOKS) = 88125

Annexure – 1

Area Program

FIRST FLOOR PLATE +4.20 LVL : 2049 SQMT													
SPACE NAME		BUA (IN SQMT)	CPA (IN SQMT)	FURNITURE					USER				HEIGHT (CM)
				TABLE	CHAIR / READING STOOL	SOFA	STUDY CARRELS	RACKS	STUDENT	STAFF	OTHERS	TOTAL	
PART 1, 3	READING AREA	73	67	3	30	-	-	-	30	-	-	30	353
	TOILET	27	17.1	-	-	-	-	-	-	-	-	-	288
	SERVICES	52.7	41	-	-	-	-	-	-	-	-	-	353
	CIRCULATION	93	64	-	-	-	-	-	-	-	-	-	353
	TOTAL												
PART 2	READING AREA	88	84.8	3	30	-	-	-	30	-	-	30	353
	TOILET	9.5	7.3	-	-	-	-	-	-	-	-	-	288
	SERVICES	52.7	41	-	-	-	-	-	-	-	-	-	353
	CIRCULATION	93	64	-	-	-	-	-	-	-	-	-	353
	TOTAL												
PART 4	SILENT READING	648	507.5	47	56	40	32	120	96	-	-	96	353
	COMPUTER CENTRE	339.2	329.6	15	60	-	-	-	60	-	2	62	353
	SERVICES	247	200.5	-	-	-	-	-	-	-	-	-	353
	GOOD LIFT												
	MALE TOILET	42	31.7	-	-	-	-	-	-	-	-	-	288
	FEMALE TOILET	33.5	27	-	-	-	-	-	-	-	-	-	288
	UNIVERSAL TOILET	9.4	5.4	-	-	-	-	-	-	-	-	-	288
	DRINKING WATER AREA	-	-	-	-	-	-	-	-	-	-	-	353
	JANITOR ROOM	13	8.3	-	-	-	-	-	-	-	-	-	288
	MEETING ROOM	45	42.7	1	14	-	-	-	-	14	-	14	353
	CIRCULATION	337.2	209	-	-	-	-	-	-	-	-	-	353
TOTAL				220	40	32	120						
TOTAL		2049 SQMT	1806 SQMT	TOTAL SEATING CAPACITY ON FIRST FLOOR									172
FOR STUDENTS												246	
FOR STAFF												14	
OTHER												2	
TOTAL												262	
TOTAL NUMBER OF VOLUME ON FF = 120 (RACKS) X 125 (BOOKS) = 15000													

Annexure – 1

Area Program

SECOND FLOOR PLATE +8.40 LVL : 3480 SQMT														
SPACE NAME			BUA (IN SQMT)	CPA (IN SQMT)	FURNITURE					USER				HEIGHT
					TABLE	CHAIR / READING STOOL	SOFA	STUDY CARRELS	RACKS	STUDENT	STAFF	OTHERS	TOTAL	
PART 1, 3	READING		416	400.2	21	60	25	4	90	82	-	-	82	353
	SERVICES		57.2	41	-	-	-	-	-	-	-	-	-	353
	TOILET		27	17.8	-	-	-	-	-	-	-	-	-	288
	LOBBY AREA		82	64	-	-	-	-	-	-	-	-	-	353
PART 2	READING		416	415.6	21	60	25	4	90	82	-	-	82	353
	SERVICES		52.7	41	-	-	-	-	-	-	-	-	-	353
	TOILET		7.3	7.3	-	-	-	-	-	-	-	-	-	288
	LOBBY AREA		82	64	-	-	-	-	-	-	-	-	-	353
PART 4	MEETING ROOM		30.6	26.1	1	8	-	-	-	2	8	-	10	353
	OFFICE		26.7	23.4	1	4	-	-	-	-	1	3	4	353
	12 SEATER DISCUSSION ROOM		38.5	33.2	1	12	-	-	-	12	12	-	24	288
	9 SEATER LECTURE HALL (2)		54	50	18	18	-	-	-	18	2	-	20	288
	24 SEATER LECTURE HALL (2)		110	108	48	48	-	-	-	48	2	-	50	288
	30 SEATER LECTURE HALL		50	42.7	30	30	-	-	-	30	1	-	31	288
	SILENT READING		603	508	44	72	40	24	60	136	2	-	138	353
	A.H.U. ROOM		247	200	-	-	-	-	-	-	-	-	-	288
	MALE TOILET		42	31.7	-	-	-	-	-	-	-	-	-	288
	FEMALE TOILET		33.5	27	-	-	-	-	-	-	-	-	-	288
	UNIVERSAL TOILET		9.4	5.4	-	-	-	-	-	-	-	-	-	288
	DRINKING WATER AREA		-	-	-	-	-	-	-	-	-	-	-	353
	JANITOR ROOM		13	8.3	-	-	-	-	-	-	-	-	-	288
	TOTAL					372	115	36	330					
TOTAL			3480 SQMT	2638 SQMT	TOTAL SEATING CAPACITY ON SECOND FLOOR									780
FOR STUDENTS														502
FOR STAFF														28
OTHER														10
TOTAL														540
TOTAL NUMBER OF VOLUME ON SF = 330 (RACKS) X 125 (BOOKS) = 41,250														

Annexure – 1

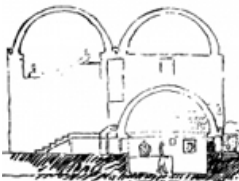
Area Program

THIRD FLOOR PLATE +12.60 LVL : 2082 SQMT														
SPACE NAME			BUA (IN SQMT)	CPA (IN SQMT)	FURNITURE					USER			HEIGHT	
					TABLE	CHAIR / READING STOOL	SOFA / CHAIR	STUDY CARRELS	RACKS	STUDENT	STAFF	OTHERS		TOTAL
PART 1, 3	READING AREA		317	310.7	12	58	20	-	75	78	20	-	98	353
	TOILET		27	17.8	-	-	-	-	-	-	-	-	-	288
	SERVICES		57.2	41	-	-	-	-	-	-	-	-	-	353
	LOBBY		82	64	-	-	-	-	-	-	-	-	-	353
PART 2	READING AREA		416	326.2	12	58	20	-	75	78	5	-	83	353
	TOILET		7.3	7.3	-	-	-	-	-	-	-	-	-	288
	SERVICES		52.7	41	-	-	-	-	-	-	-	-	-	353
	LOBBY		82	64	-	-	-	-	-	-	-	-	-	353
PART 4	PUBLICATION WING		450	440	26	40	-	-	25	-	36	2	38	353
	SERVICES		57.8	43.3	-	-	-	-	-	-	-	-	-	353
	TOILETS			11.6	-	-	-	-	-	-	-	-	-	288
	CIRCULATION		108	81.1	-	-	-	-	-	-	-	-	-	353
	TOTAL					214	60		250					
TOTAL			2082 SQMT	1881.5 SQMT	TOTAL SEATING CAPACITY ON THIRD FLOOR								317	
FOR STUDENTS													234	
FOR STAFF													81	
OTHER													2	
TOTAL													317	
TOTAL NUMBER OF VOLUME ON SF = 250 (RACKS) X 125 (BOOKS) = 31250														

Annexure – 1

Area Program

FOURTH FLOOR PLATE +16.80 LVL : 1717.5 SQMT													HEIGHT (CM)	
SPACE NAME		BUA (IN SQMT)	CPA (IN SQMT)	FURNITURE					USER					
				TABLE	CHAIR / READING STOOL	SOFA / CHAIR	STUDY CARRELS	RACKS	STUDENT	STAFF	OTHERS	TOTAL		
PART 1, 3	READING AREA		225	224.4	6	40	32	-	65	60	58	-	58	353
	TOILET		17.1	17.8	-	-	-	-	-	-	-	-	-	288
	SERVICES		57.2	41	-	-	-	-	-	-	-	-	-	353
	LOBBY		68	64	-	-	-	-	-	-	-	-	-	353
PART 2	READING AREA		240	238	6	40	32	-	65	-	58	-	58	353
	TOILET		7.3	7.3	-	-	-	-	-	-	-	-	-	288
	SERVICES		52.7	41	-	-	-	-	-	-	-	-	-	353
	LOBBY		80	64	-	-	-	-	-	-	-	-	-	353
PART 4	STAFF SEATING		288	284.4	9	40	-	-	46	8	40	4	52	353
	TOILETS		20.2	11.6	-	-	-	-	-	-	-	-	-	288
	SERVICES		57.8	43.3	-	-	-	-	-	-	-	-	-	353
	GOOD LIFT				-	-	-	-	-	-	-	-	-	
	CIRCULATION		141	112	-	-	-	-	-	-	-	-	-	353
	TOTAL				160		96	241						
TOTAL			1717.5 SQMT	1213 SQMT	TOTAL SEATING CAPACITY ON FOURTH FLOOR									227
FOR STUDENTS													128	
FOR STAFF													214	
OTHER													4	
TOTAL													346	
TOTAL NUMBER OF VOLUME ON FF = 181 (RACKS) X 125 (BOOKS) = 22625														



Annexure – 1

Area Program

FIFTH FLOOR PLATE +21.00 LVL : 981 SQMT										
SPACE NAME		BUA (IN SQMT)	CPA (IN SQMT)	FURNITURE					TOTAL PERSON	HEIGHT (CM)
				TABLE	CHAIR / READING STOOL	SOFA / CHAIR	STUDY CARRELS	RACKS		
PART 1, 3	READING AREA	100	96.2	-	-	-	-	-	-	315
	TOILET	27	17.8	-	-	-	-	-	-	288
	SERVICE ROOM	30	16.7	-	-	-	-	-	-	315
	LOBBY	121.08	64	-	-	-	-	-	-	315
PART 2	READING AREA	115	111.2	-	-	-	-	-	-	315
	UNIVERSAL TOILET	9.4	7.3	-	-	-	-	-	-	288
	SERVICE ROOM	30	16.7	-	-	-	-	-	-	315
	LOBBY	77	64	-	-	-	-	-	-	315
PART 4	READING AREA	92	87.7	-	-	-	-	-	-	315
	SERVICE AREA	32	20.1	-	-	-	-	-	-	315
	GOOD LIFT	-		-	-	-	-	-	-	
	CIRCULATION	120.3	85	-	-	-	-	-	-	315
TOTAL		981 SQMT	781.5 SQMT	TOTAL SEATING CAPACITY ON FIFTH FLOOR					-	
FOR STUDENTS									-	
FOR STAFF									-	
OTHER									-	
TOTAL									-	
TOTAL NUMBER OF VOLUME ON FF = 0 (RACKS) X 125 (BOOKS) = 0										

SPACE NAME		BUA (IN SQMT)
PART 1, 2, 3	OVERHEAD WATER TANKS- 3 NO.	26
PART 4	OVERHEAD WATER TANKS- 1 NO.	11
TOTAL		37

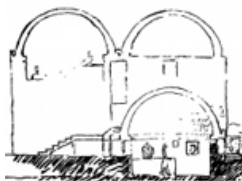
TOTAL	37 SQMT
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Schematic Interior for Library Block at Nalanda University

Mood Board

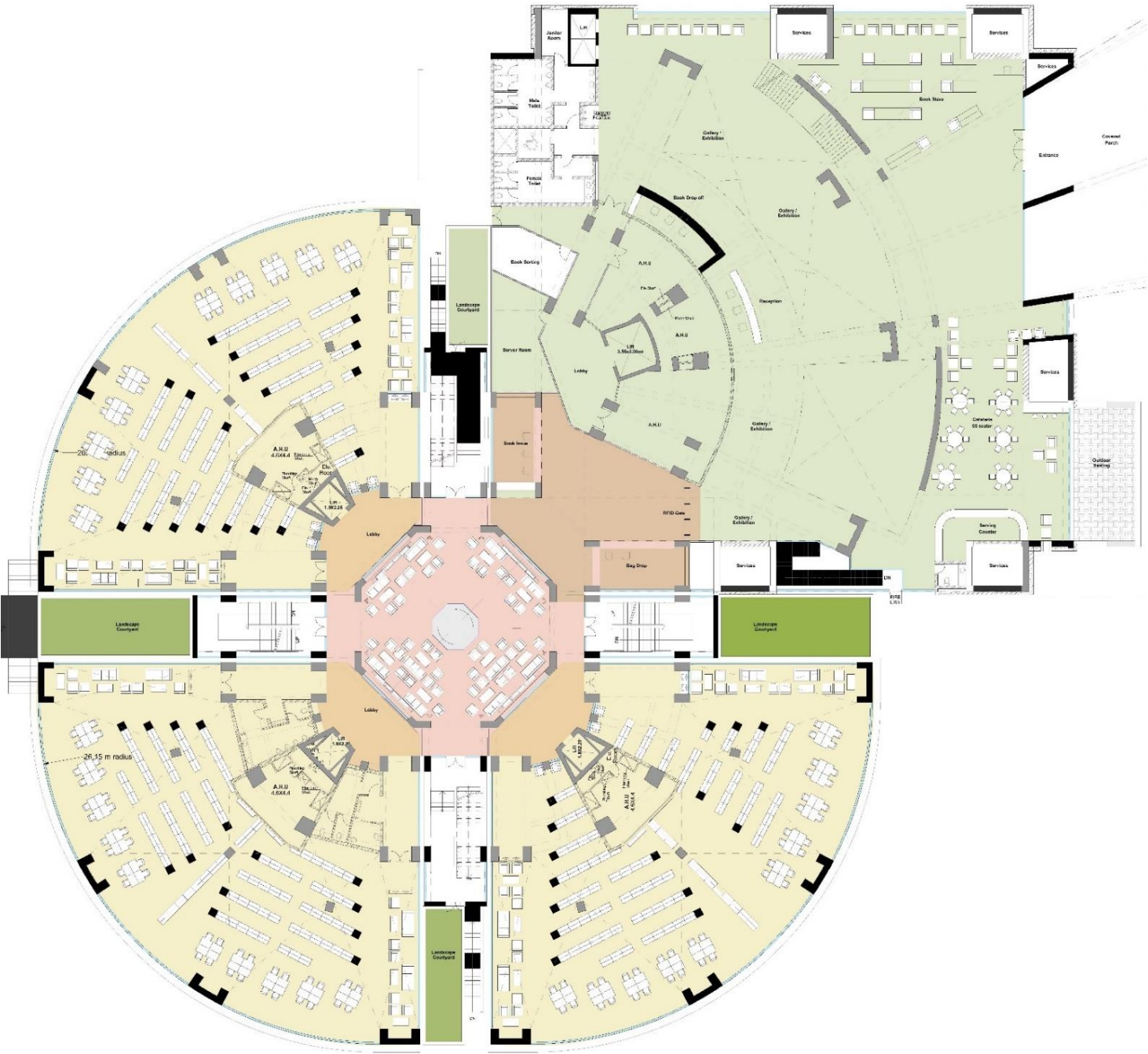


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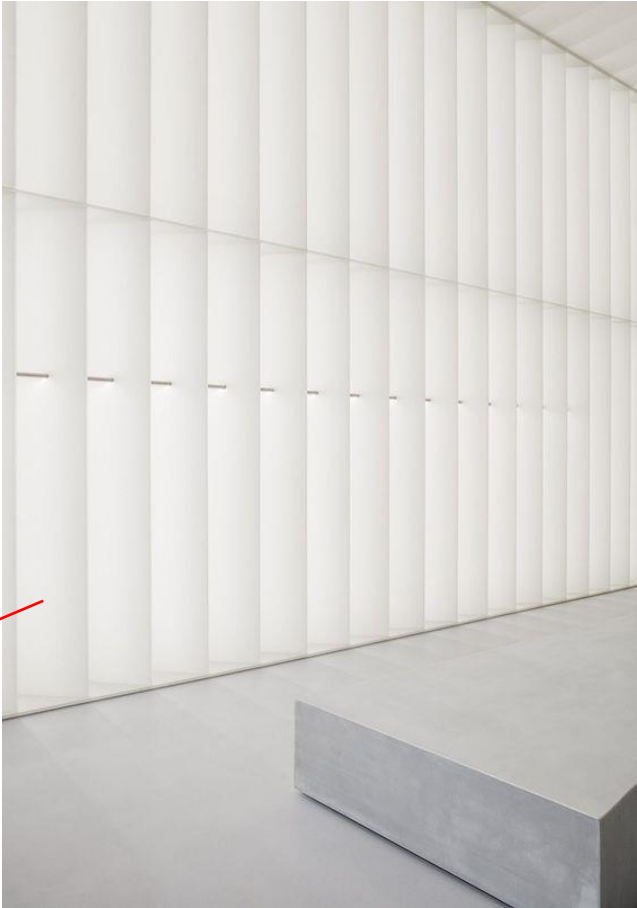
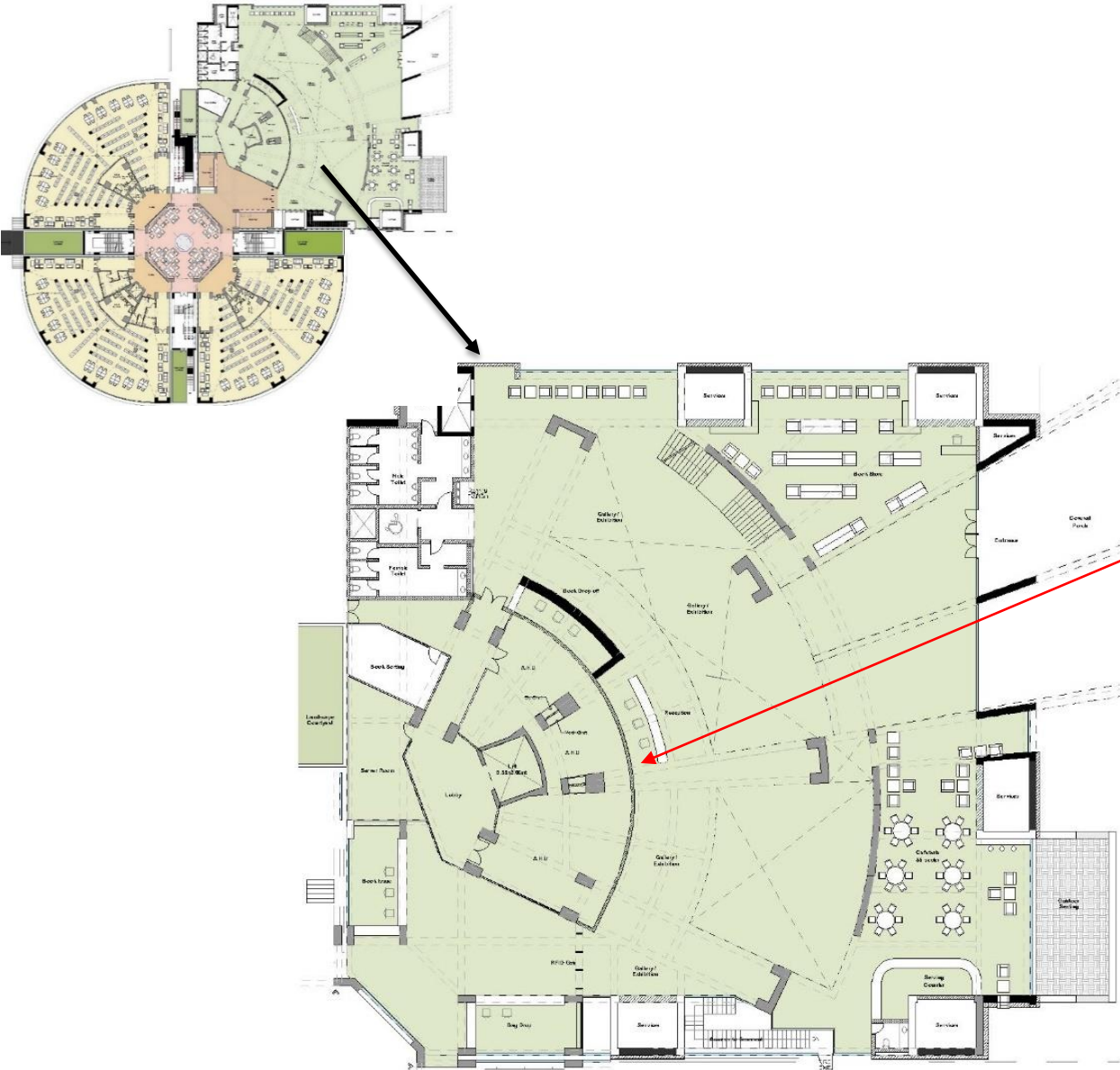


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Ground Floor



Ground Floor



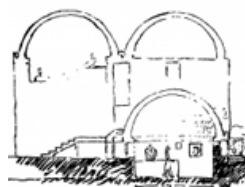
Reception back wall option
Of finish wood or glass



Ground Floor



Reception back wall option of finish wood or glass



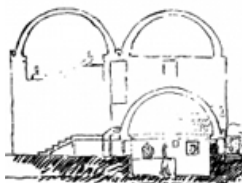
Ground Floor



Reception area gallery for art and history



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Library Preliminary Architecture Report
Nalanda University , Rajgir

Ground Floor



Reception area gallery for art and history display with pictures

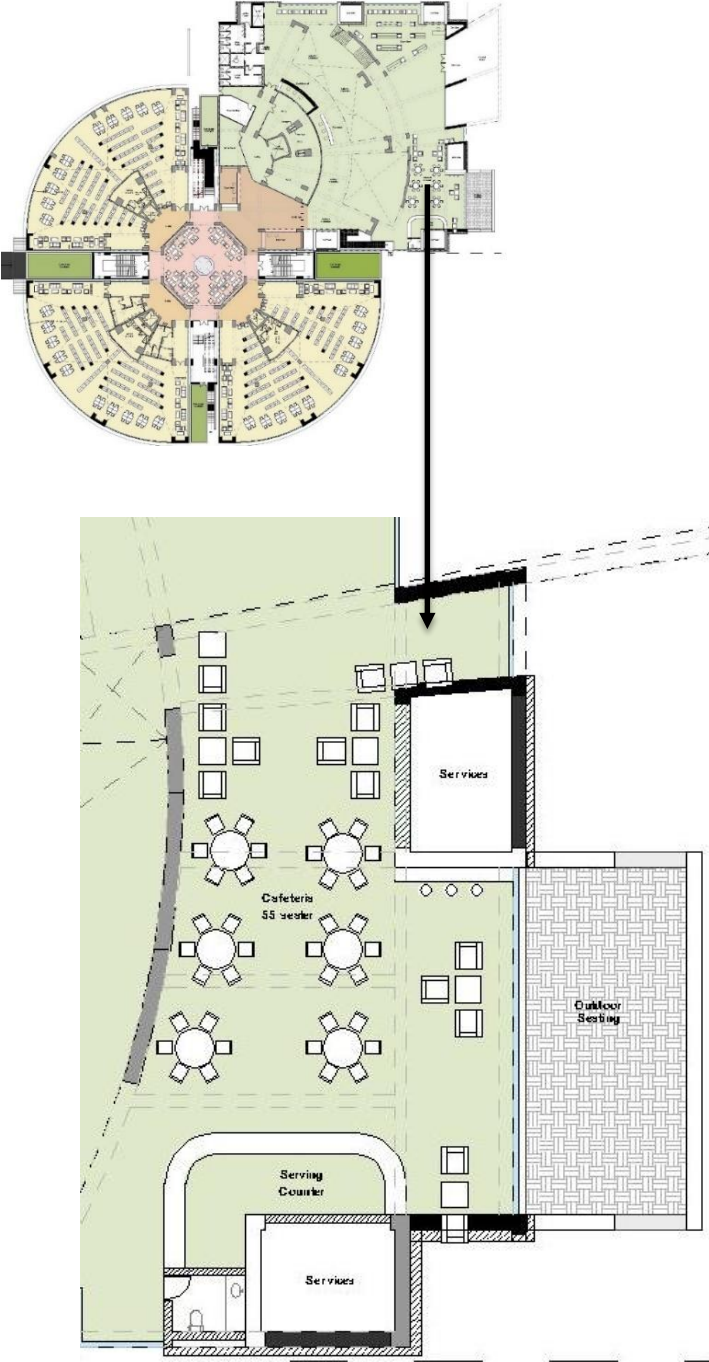
Ground Floor



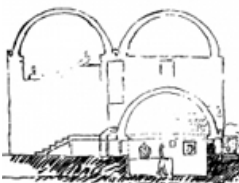
Gallery for art and history



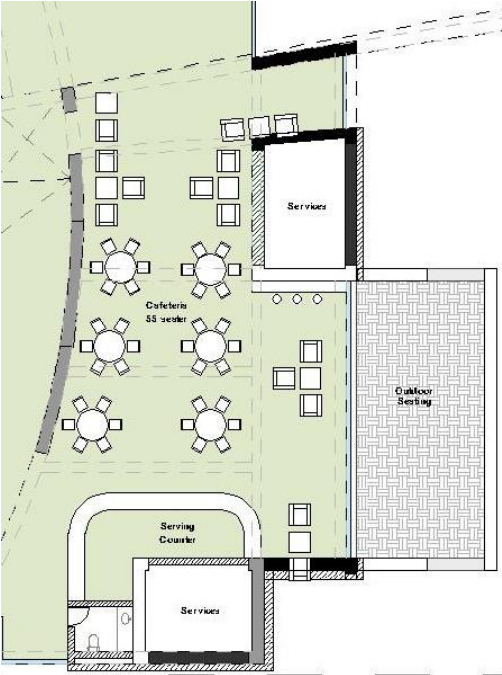
Ground Floor Café Area



Refreshment or café area at entrance



Ground Floor Café Area



Refreshment or café
at entrance



Ground Floor Waiting Area



Waiting area at reception lobby

Ground Floor



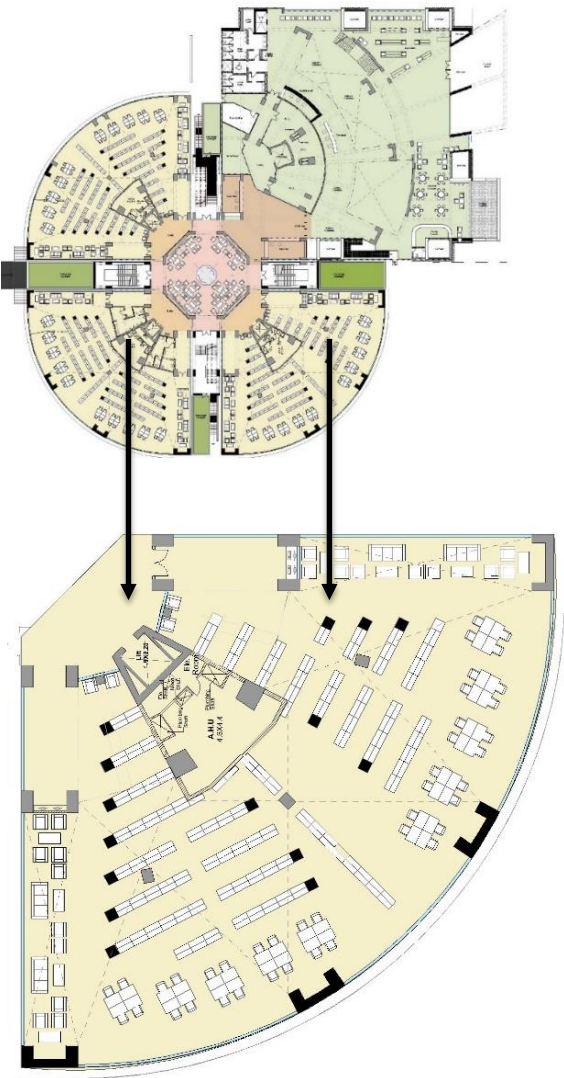
Waiting area seating option at reception lobby

Ground Floor



Staircase

Ground Floor Library Area



Reading space with book display

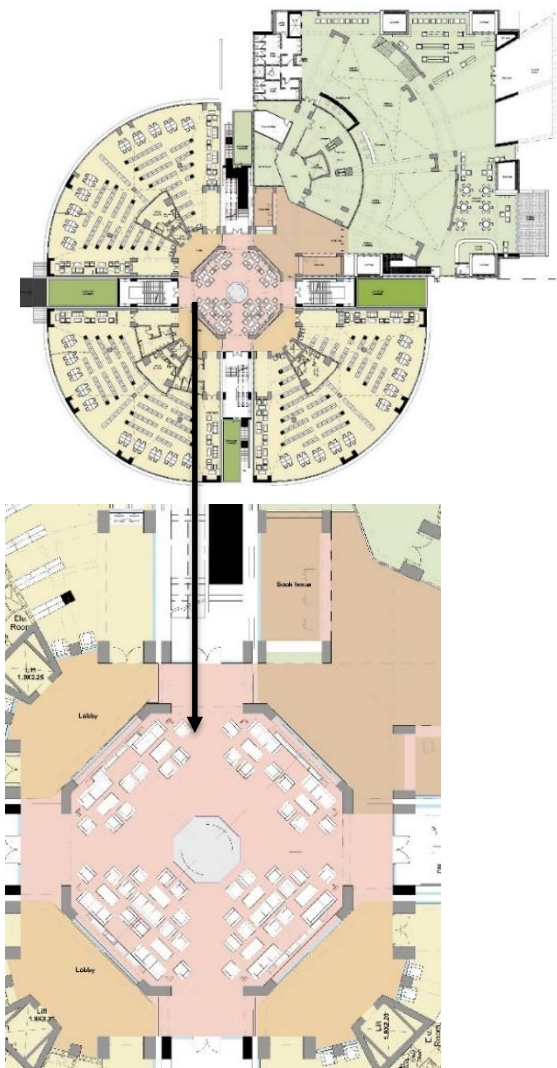
Ground Floor Library Area Seating



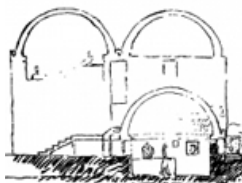
Reading space with book display



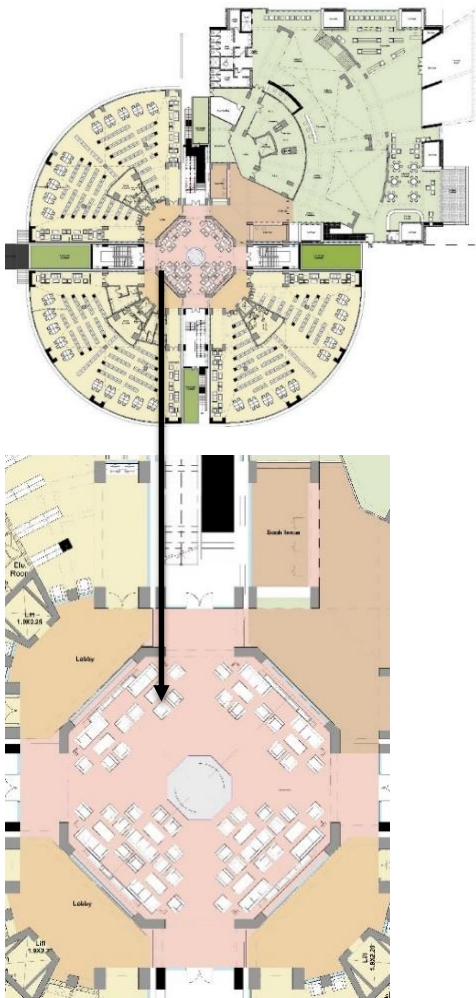
Ground Floor



Open to sky reading space

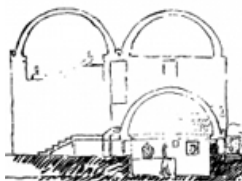
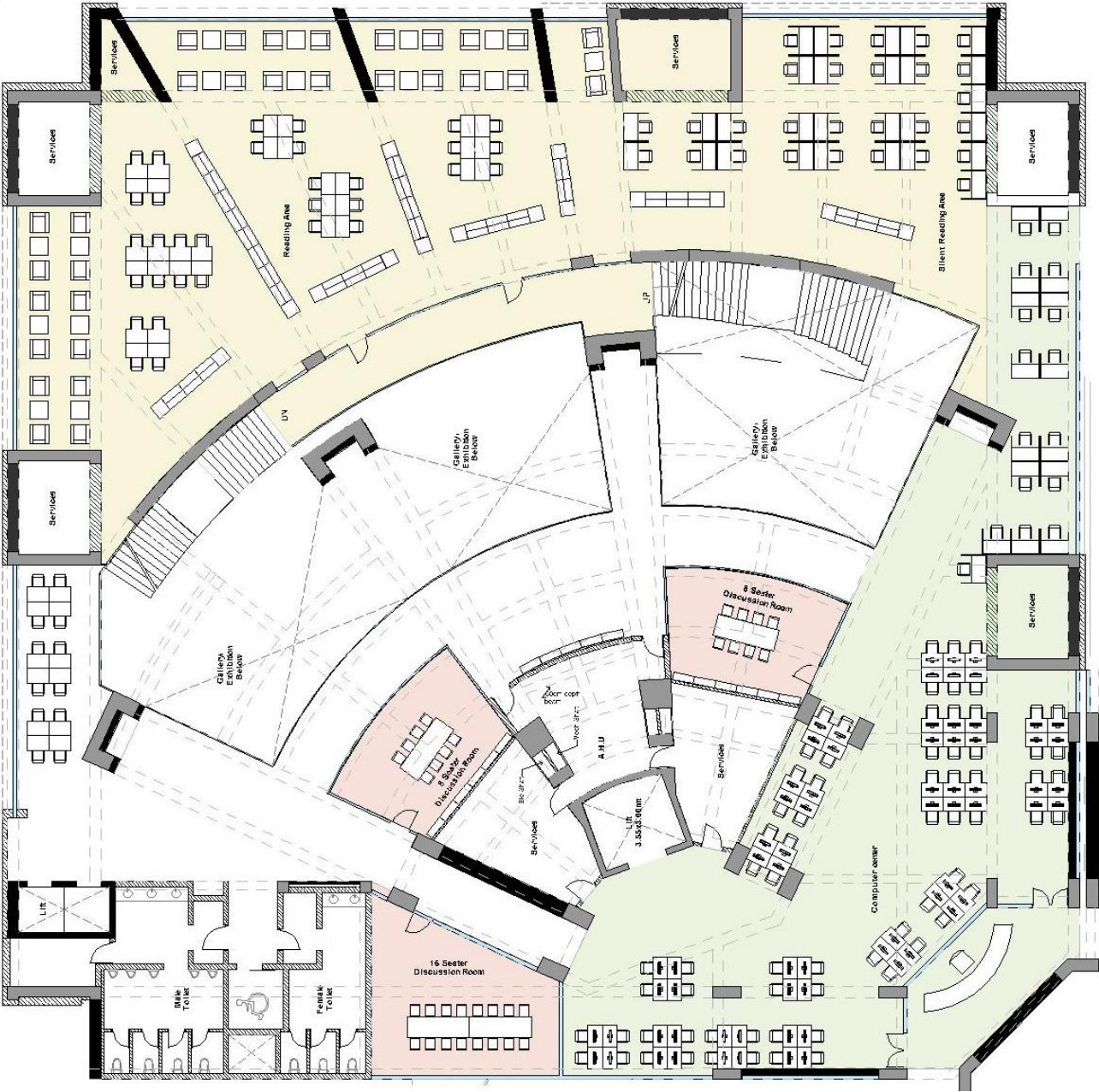


Ground Floor

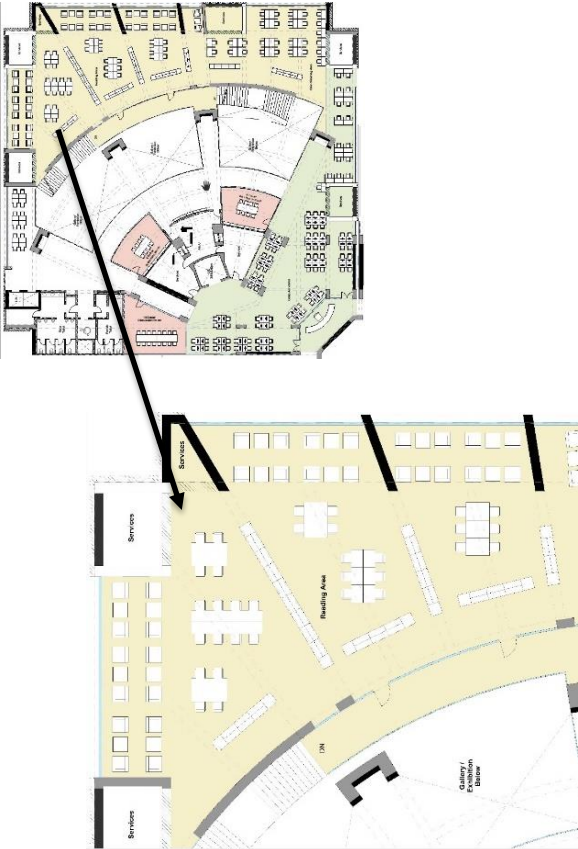


Open to sky reading space

First Floor

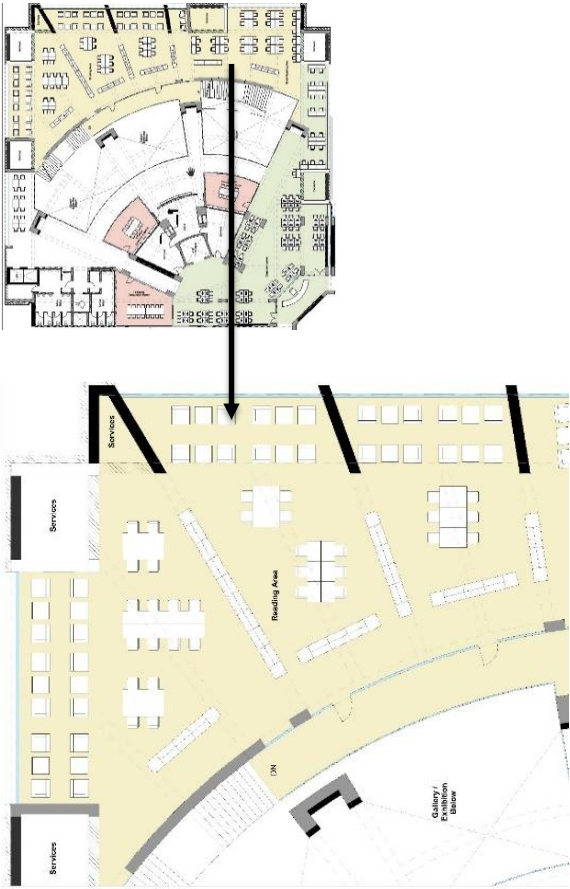


First Floor



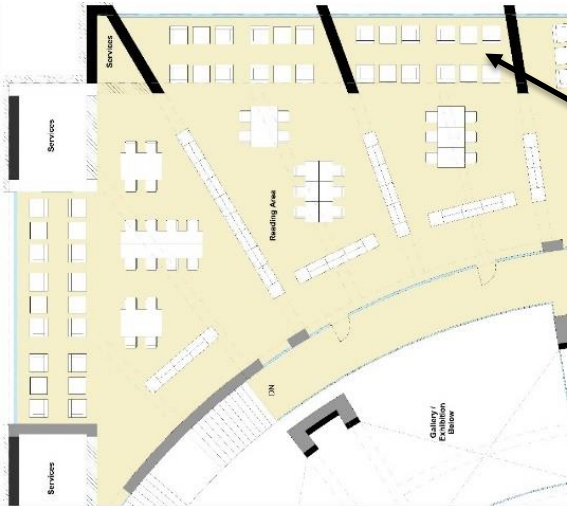
Reading space with book storage unit

First Floor



Reading space with book storage unit

First Floor



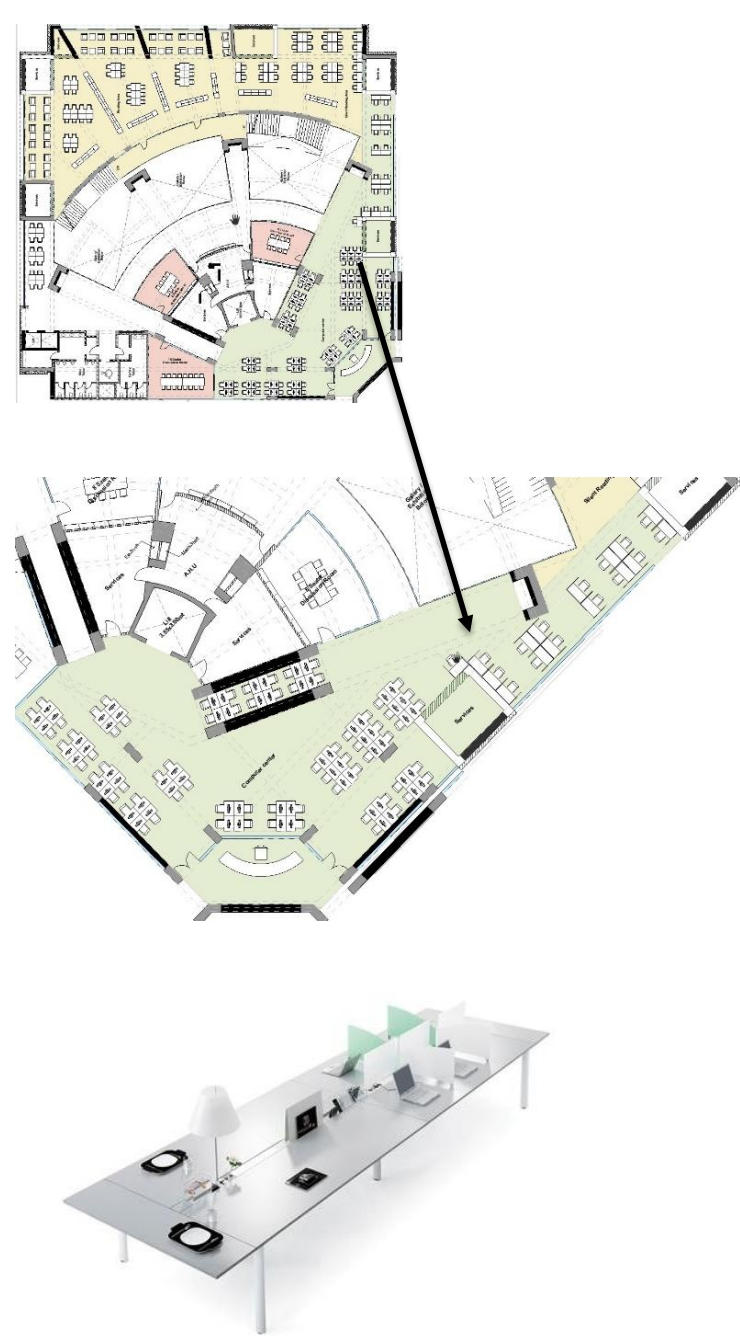
Reading lounge sofa seating

First Floor



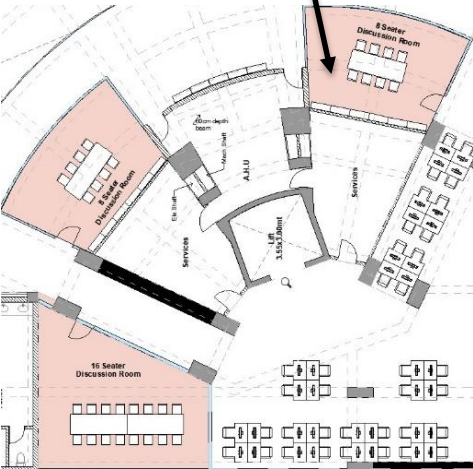
Booth type reading space for silent zone

First Floor



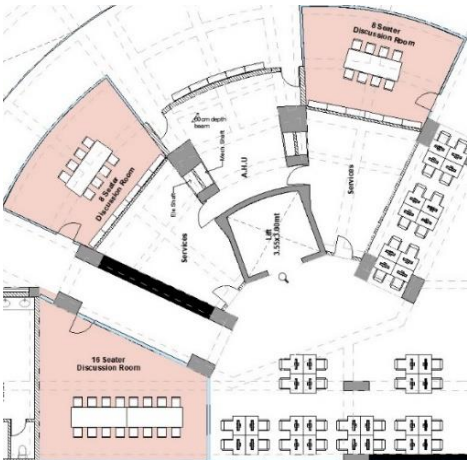
Computer lab

First Floor



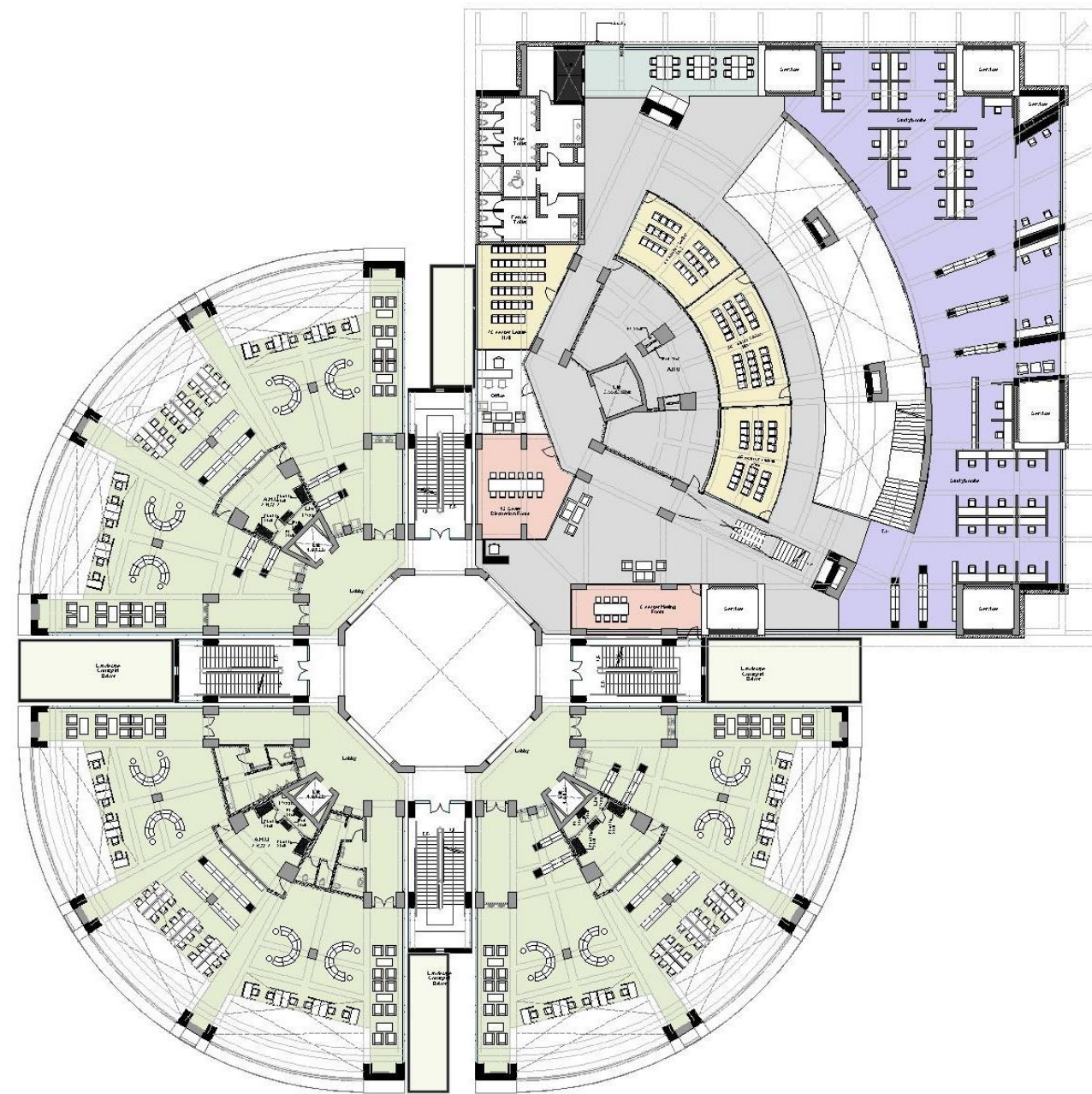
Small meeting
Space

First Floor

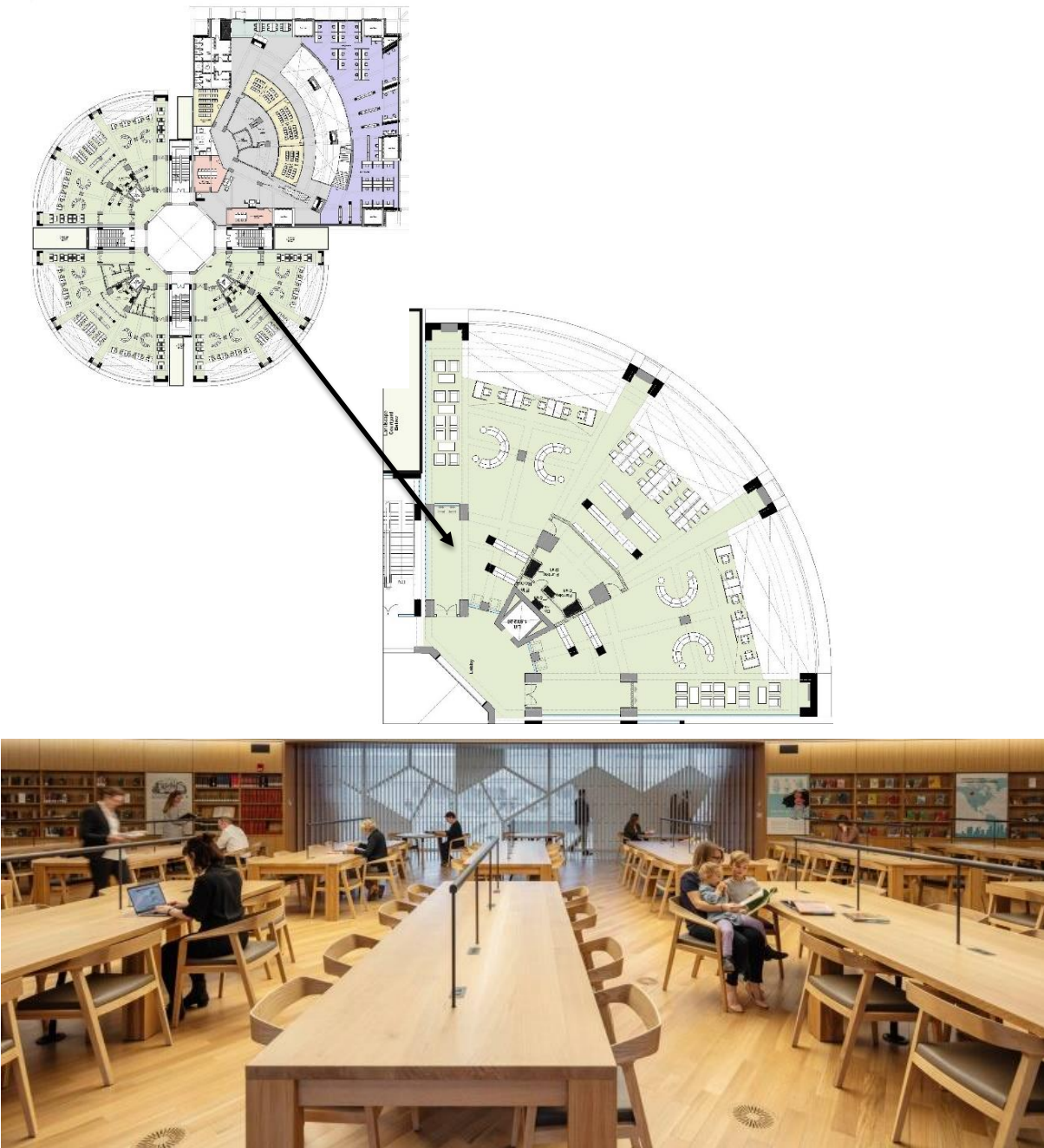


Large meeting space

Second Floor



Second Floor

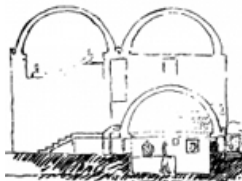


Library & reading space

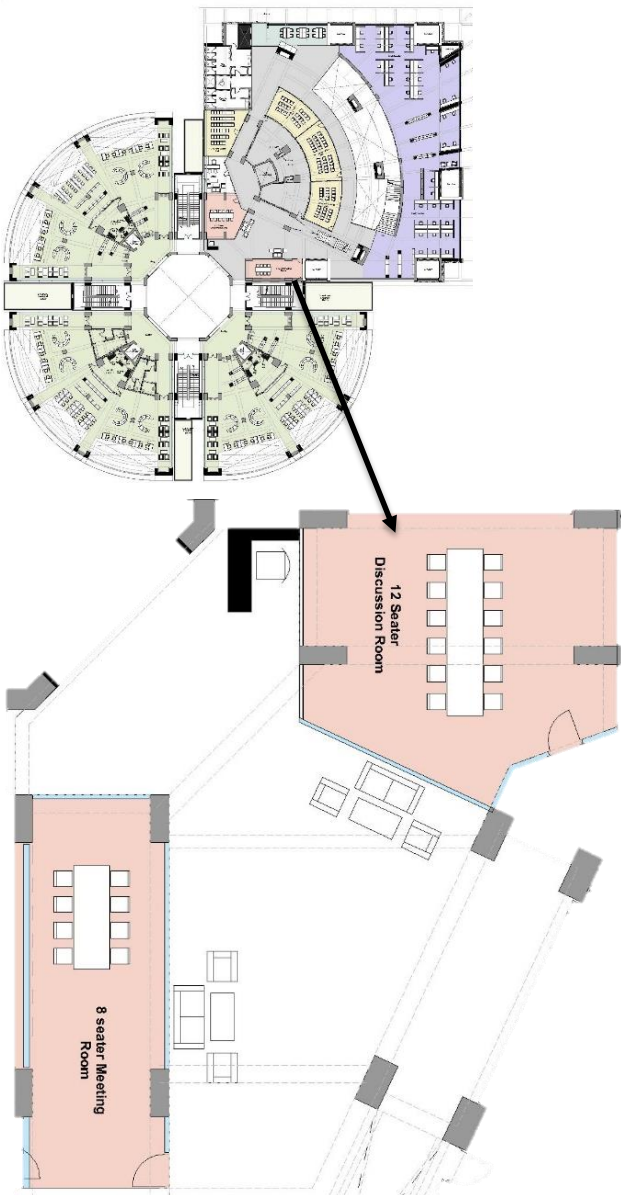
Second Floor



Library & reading space

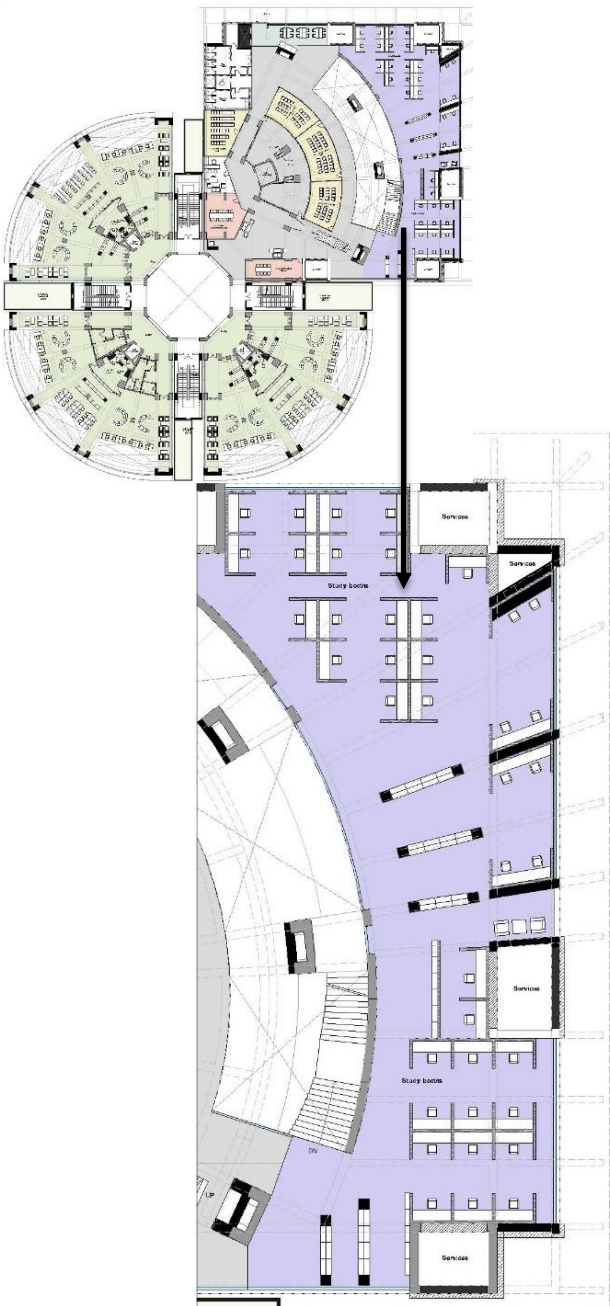


Second Floor



Discussion room

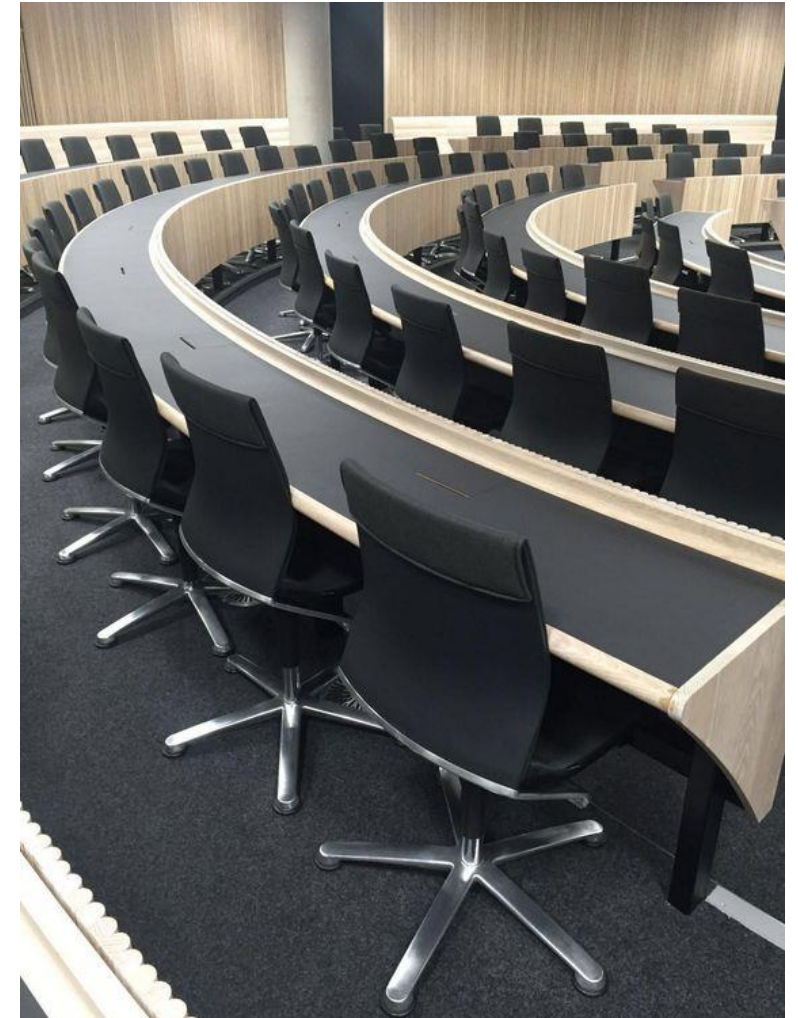
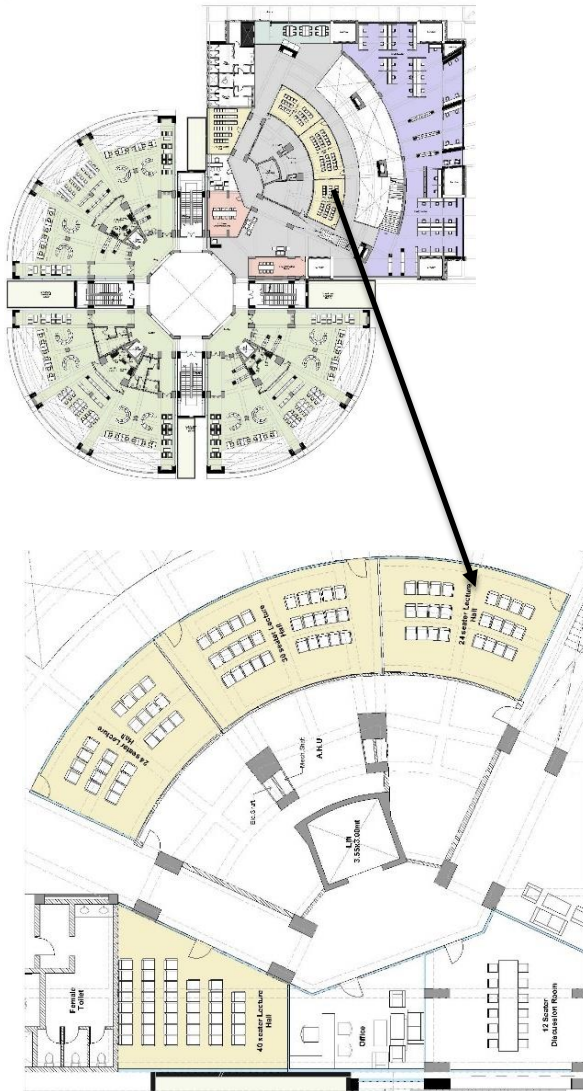
Second Floor



Student booth



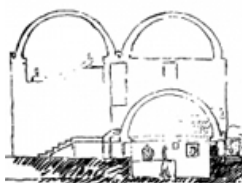
Second Floor



Lecture hall

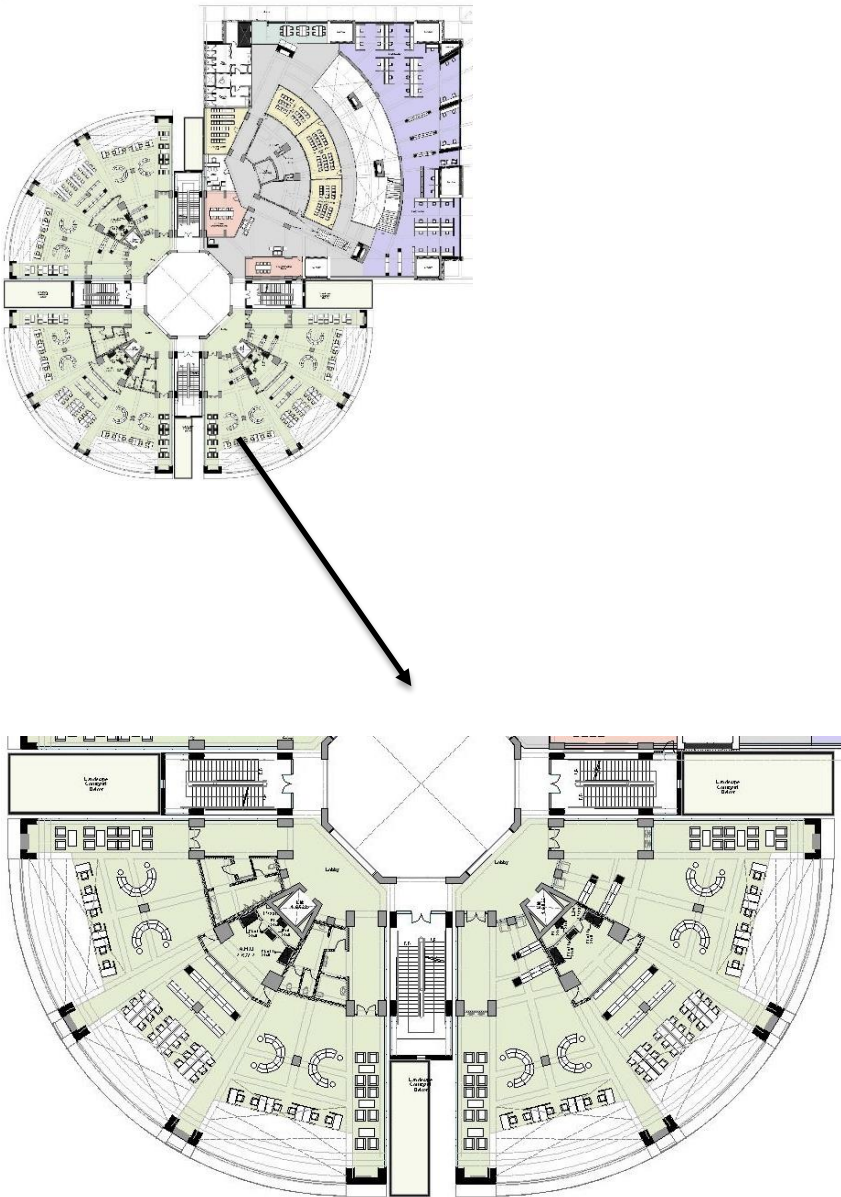


NALANDA
University



Library Preliminary Architecture Report
Nalanda University , Rajgir

Second Floor

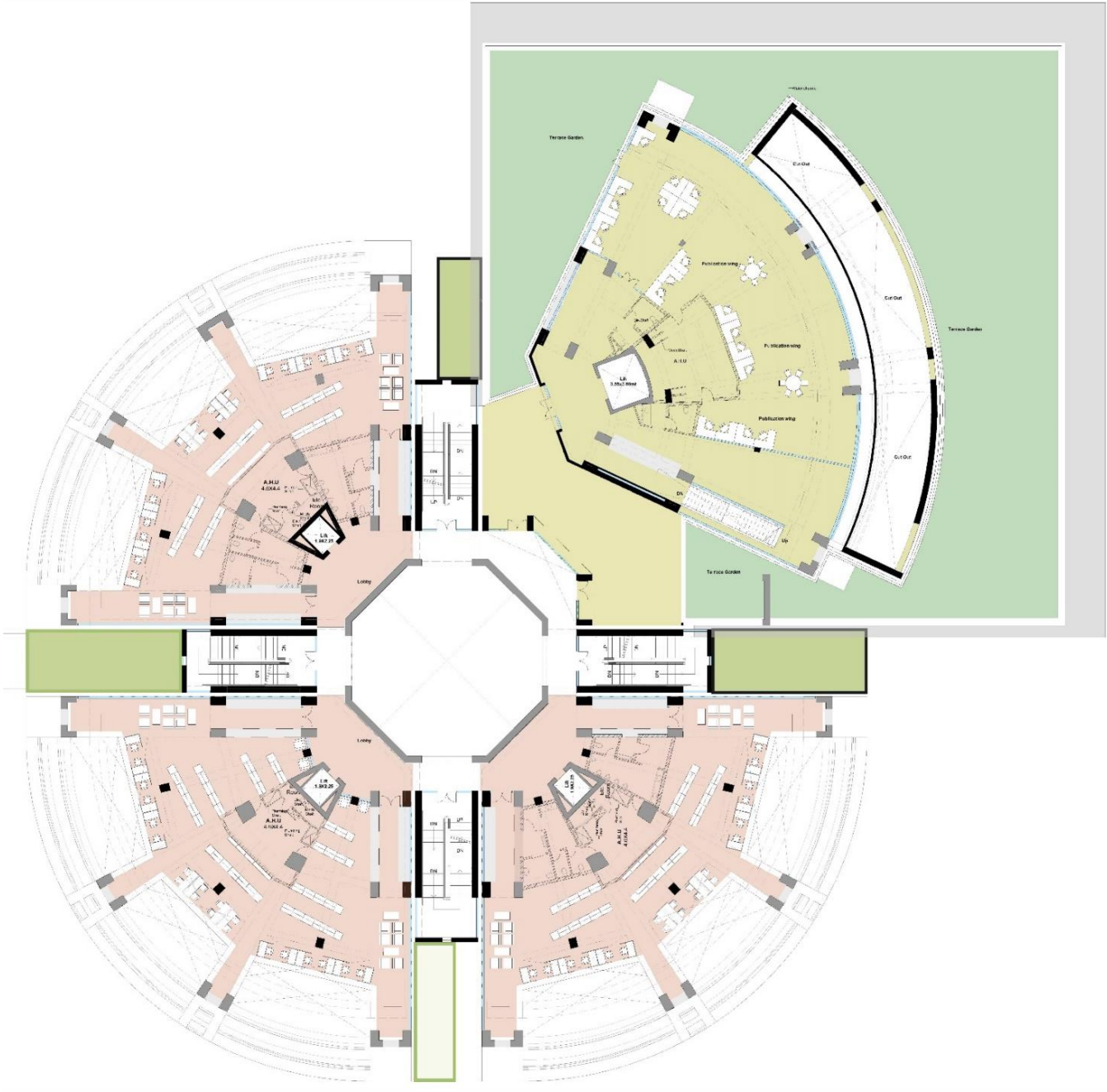


Collaborative space

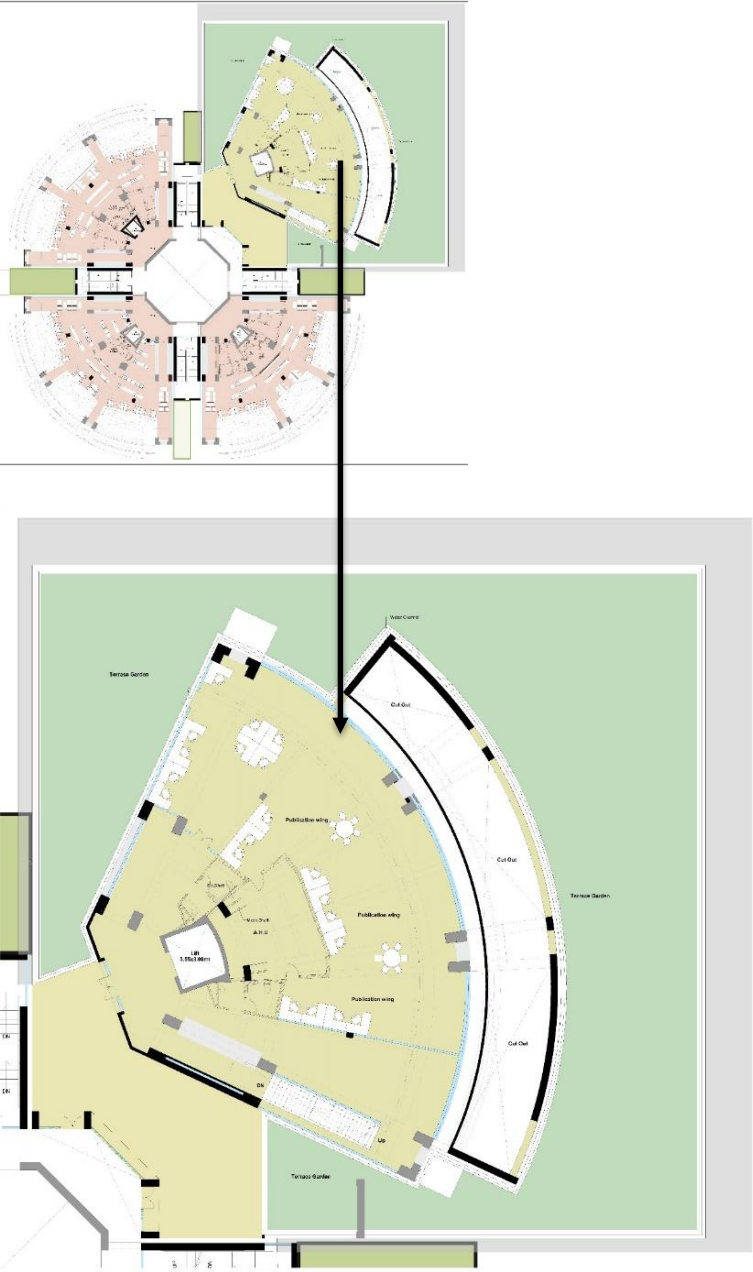
Second Floor



Third Floor

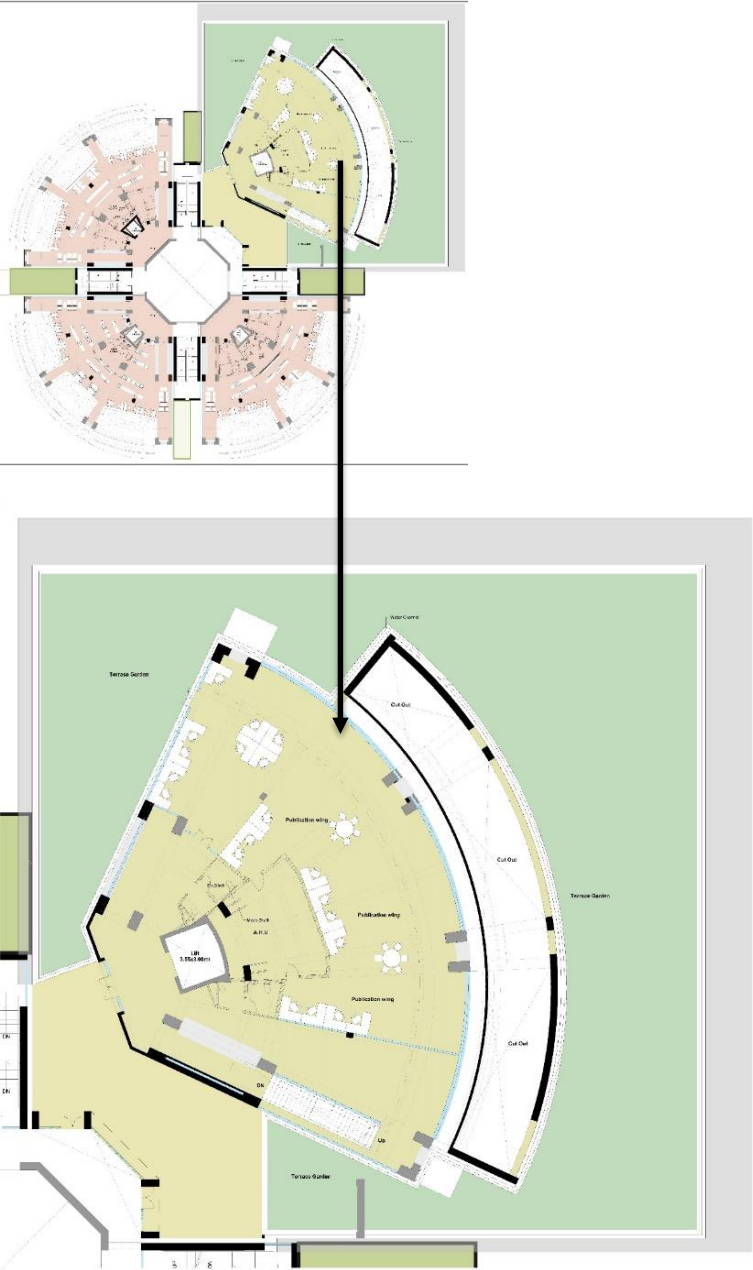


Third Floor



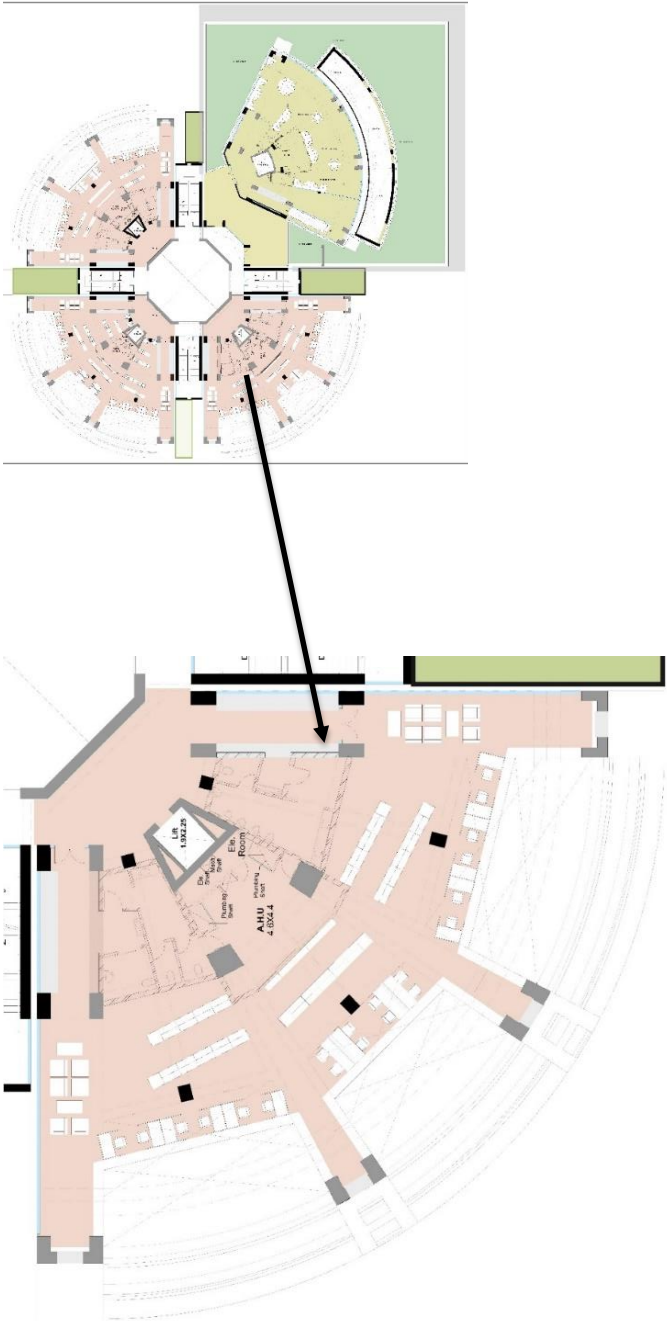
Publication centre

Third Floor

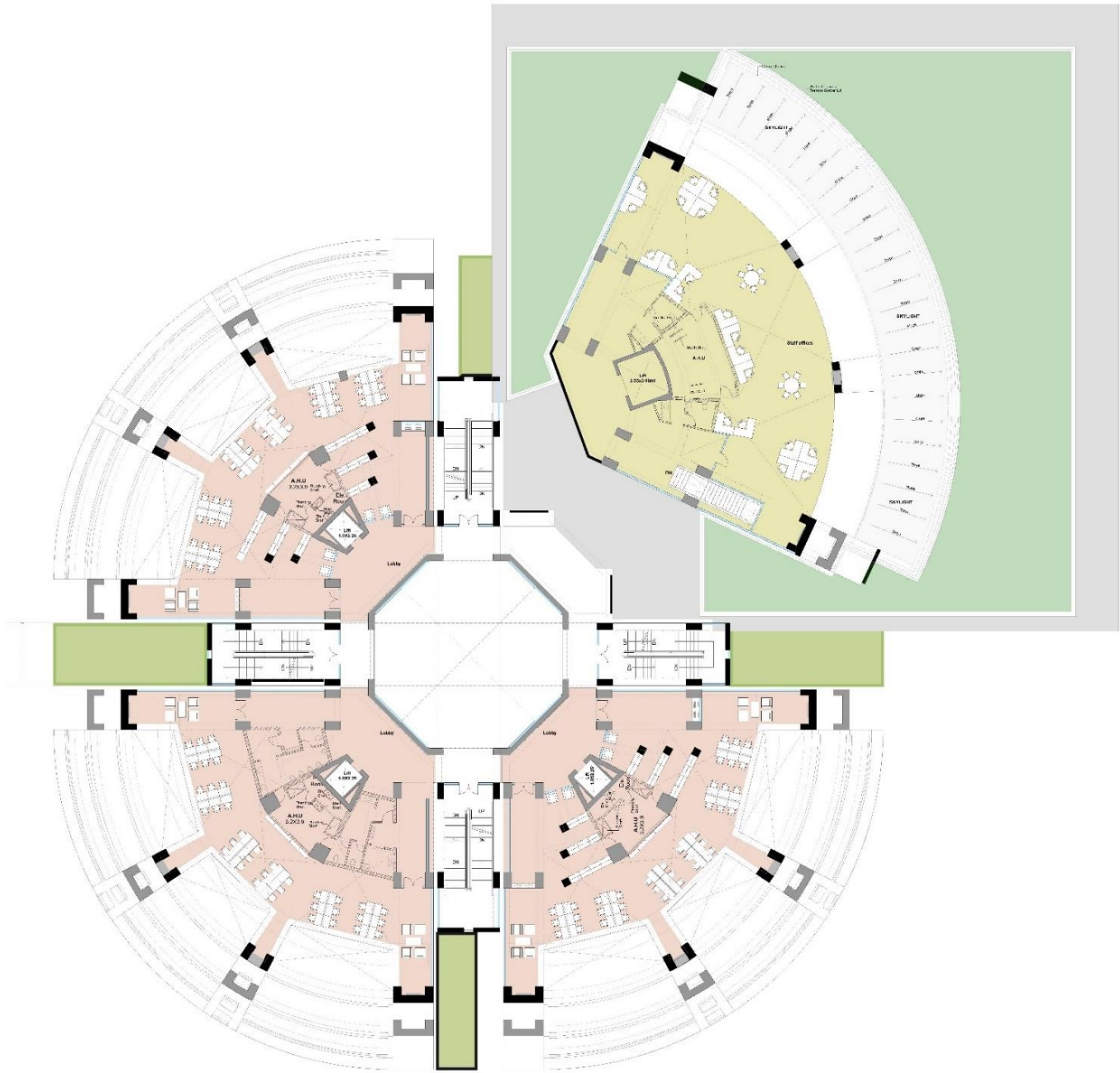


Publication centre

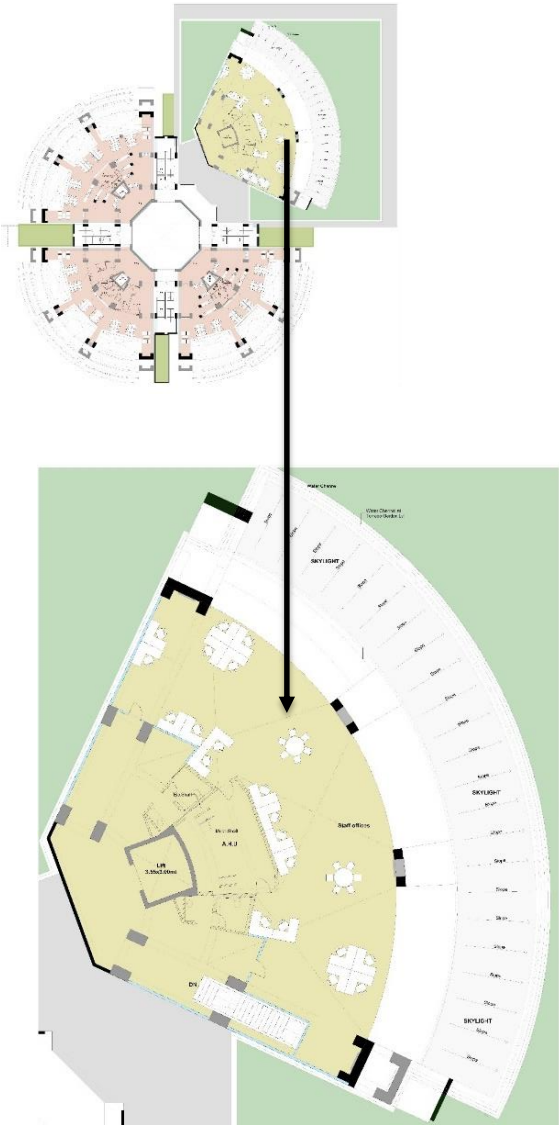
Third Floor



Fourth Floor

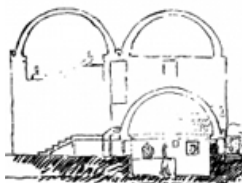
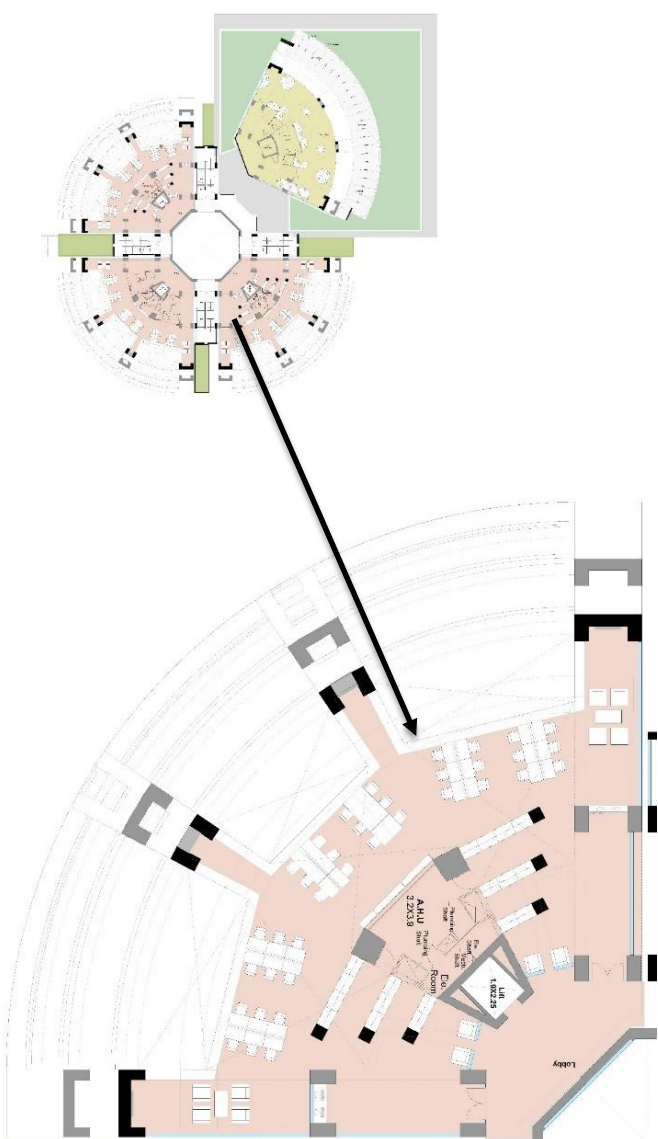


Fourth Floor



Staff room

Fourth Floor

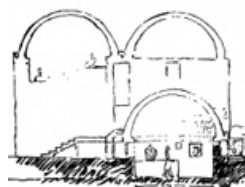


Daylight Optimization for Library Block at Nalanda University

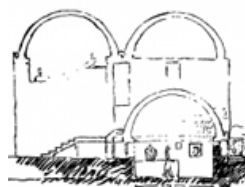
Stage 1: Climate Study & Base case daylight evaluation

Stage 2, PART 1: Design Iterations for improving daylight performance

Stage 2, PART 2: New Design Iterations for improving daylight performance



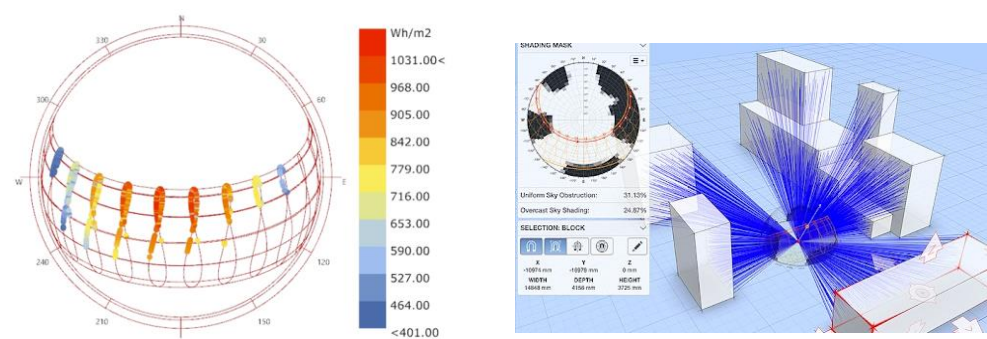
Stage 1: Climate Study & Base case daylight evaluation



Daylight Analysis | Stage 1

Overall workflow for the iterative process – 1) Base case

1. Preliminary study (project brief + climate & context study)



Solar Radiation with sun path to understand the effect of time and orientation

Shadow mask analysis from the context buildings on the library block

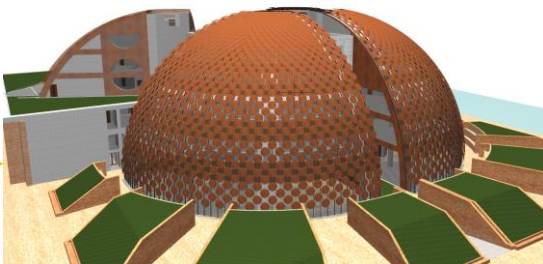
Key Metrics to Analyze Minimum performance targets from building Codes

E.g. UDI: >75% (ECBC compliant), DGP<35, SDA>75%, ASE<10%

Design targets/ Goals

Maximize Visual Comfort.
Improve Uniformity ratio,
Achieve minimum Lux levels, Glare free

2. Base Case Design Evaluation

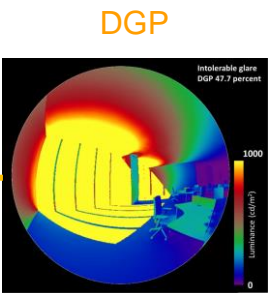


Develop 3D geometry of the Base Case / As designed by Architect. With Exterior and permanent interior features (not modelling furniture and temporary partitions). Model will include the façade layers as designed and default interior reflectance values (0.7 for ceiling, 0.2 for floor and 0.5 for walls)

4. Problem identification

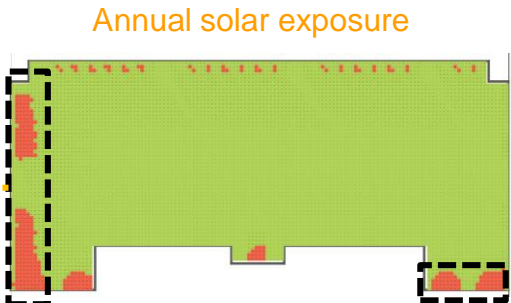
Identify problems

Potential areas of improvement in base case

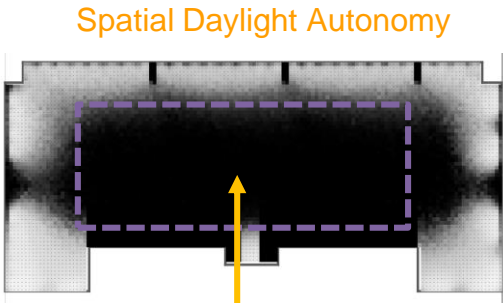


Glare analysis for Over lit areas on high illuminance hours of the year (typically summer solstice at 3pm and 9am)

3. Base Case Daylight simulation



Over lit /over exposed areas – prone to glare



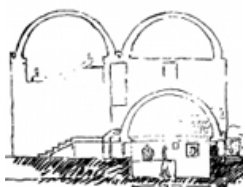
Underlit areas (below sDA threshold)

Two phase Daylight simulation

Dynamic sky with a suitable grid resolution e.g.- 0.3m x 0.3m at the work plane height e.g. – 0.9m

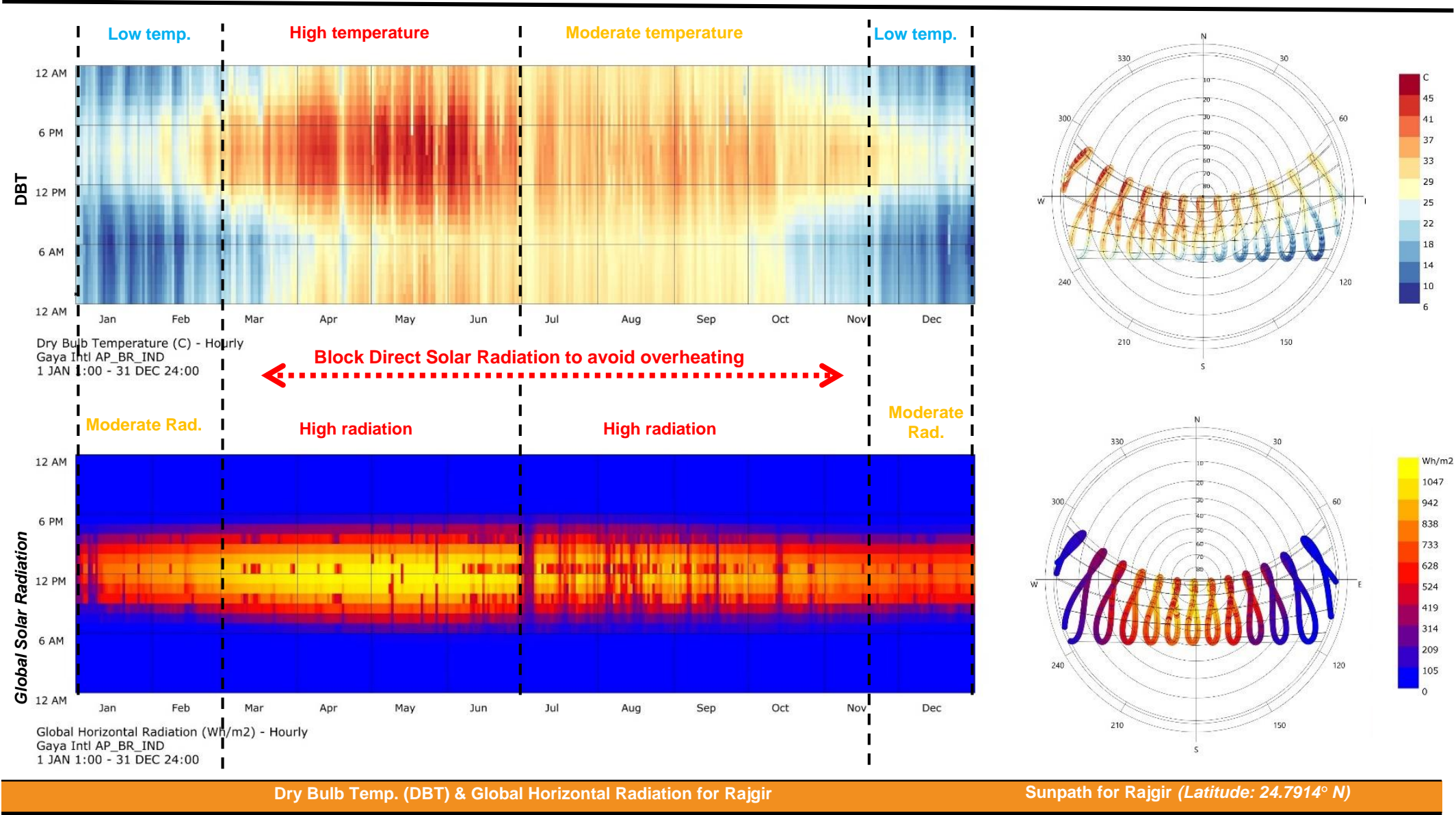
Climate Analysis

Intent: The intent of the climate study is to do understand the solar geometry, sun path & weather pattern of Nalanda district and identify environmental parameters that needs to be mitigated to maximize all the evaluation criteria.



Climate Analysis | Climate Profile

Solar Radiation & DBT



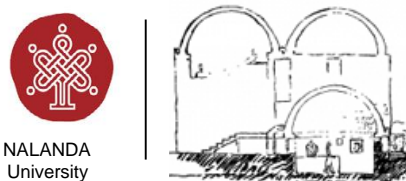
Project:- Nalanda University Library

Location:- Rajgir, Bihar

Coordinates:- 25.039 N, 85.39 E, Elevation – 73m

Weather Data available for nearest location – Gaya (70km from Rajgir)

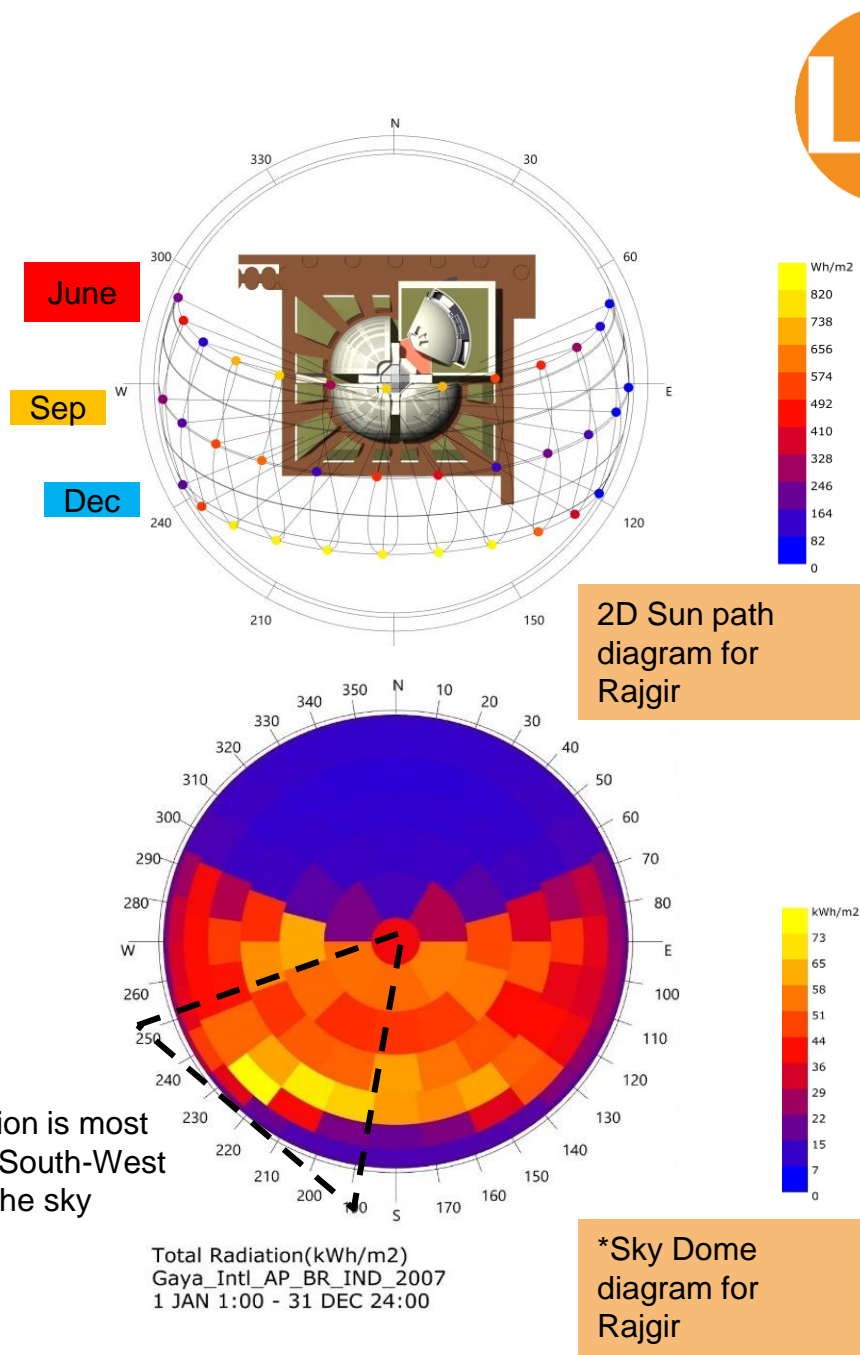
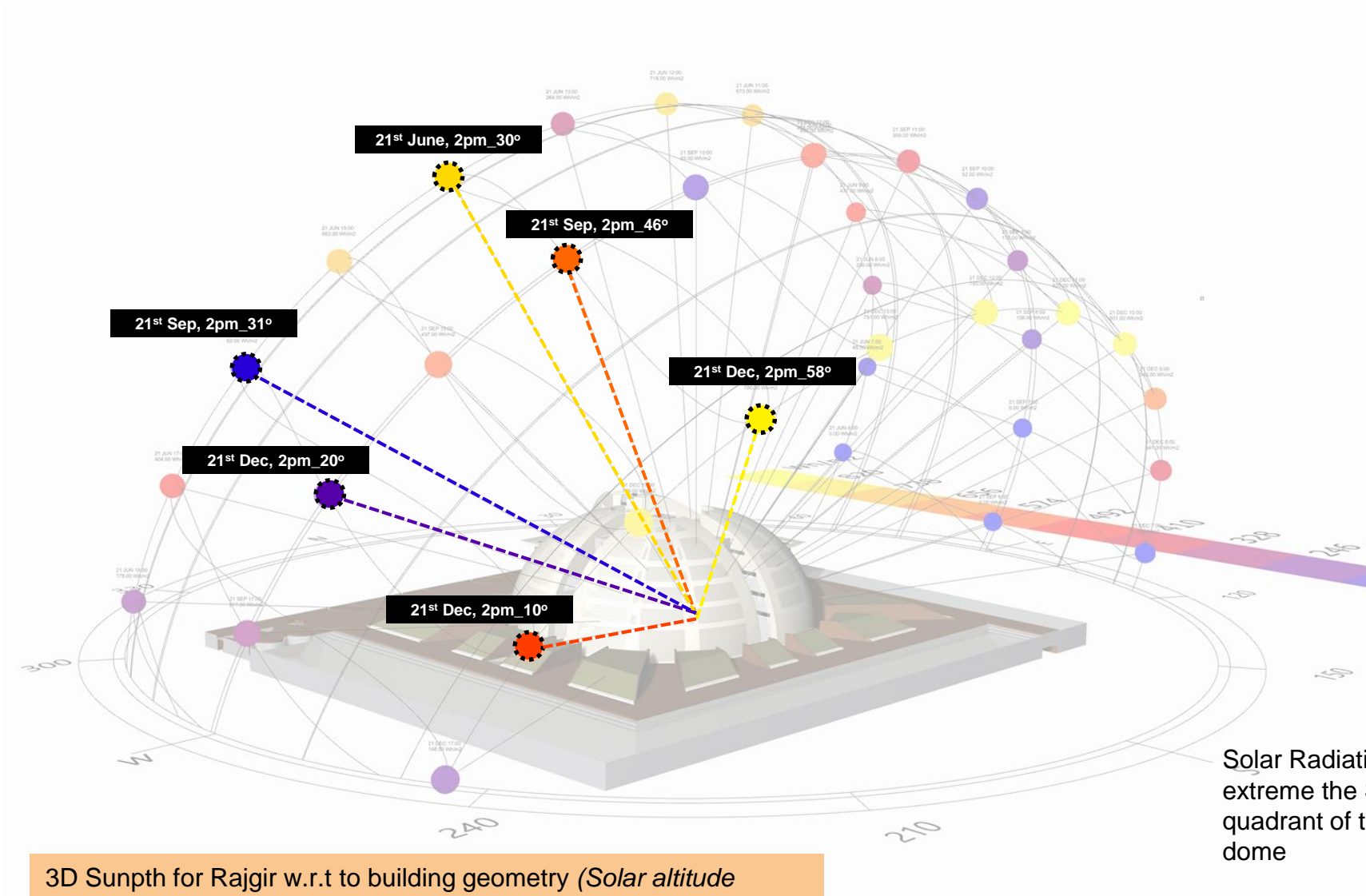
Coordinates - 24.7914° N, 85.0002° E, Elevation – 111m



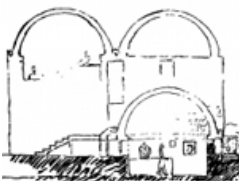
*the heatmaps represent 8760 hours of the Year with X axis having the 365 days and Y axis having the 24 hours

Climate Analysis | Solar Geometry

Building Geometry w.r.t Solar Orientation

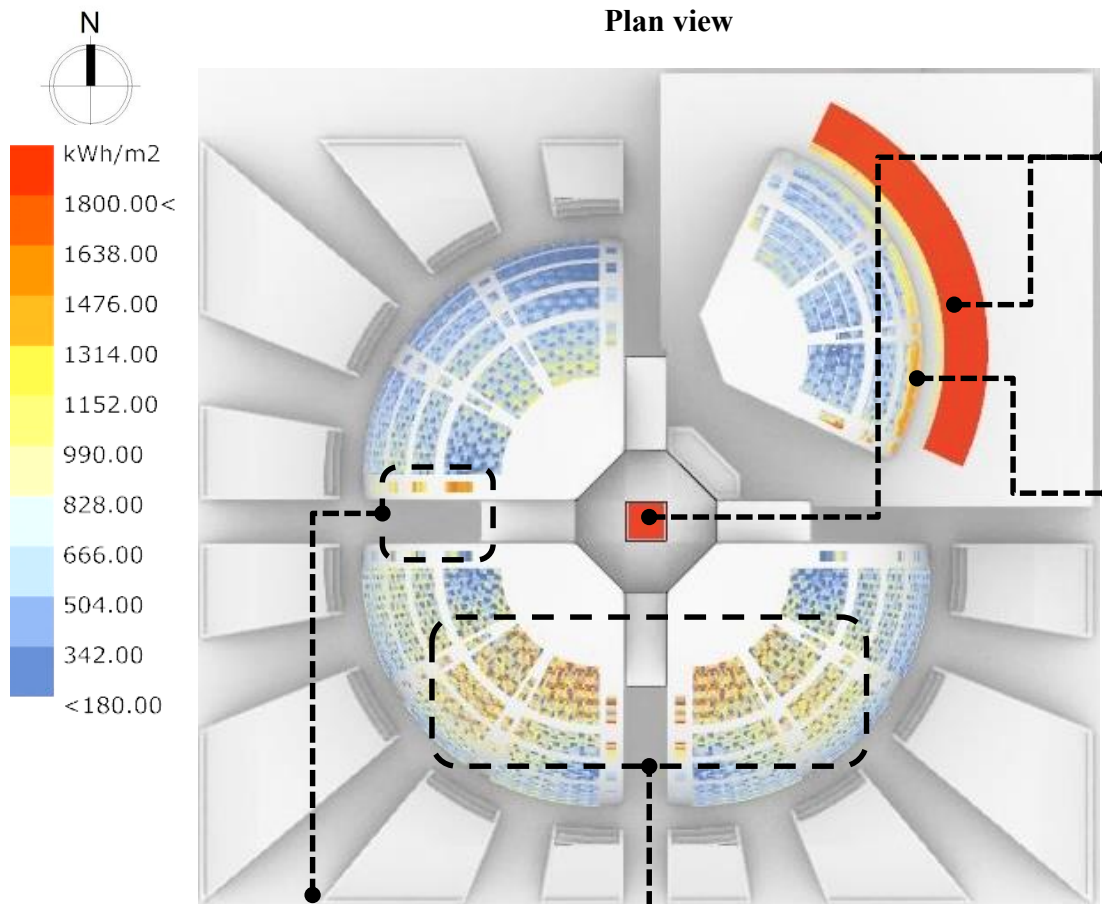


*Sky dome is divided into 156 sky patches and its color represents cumulative solar radiation from that path of the sky



Climate Analysis | Annual Solar Insolation

Annual Solar insolation (incident solar radiation per unit area) was studied for the library block on all the Exterior Glazing. This analysis reports a cumulative (sum over 8760 hours of the year) of the total solar radiation per m2 of the Exterior glazing indicating the different parts of the façade over exposed to the sun. Through this analysis the effect of different shading strategies can be quickly analyzed.

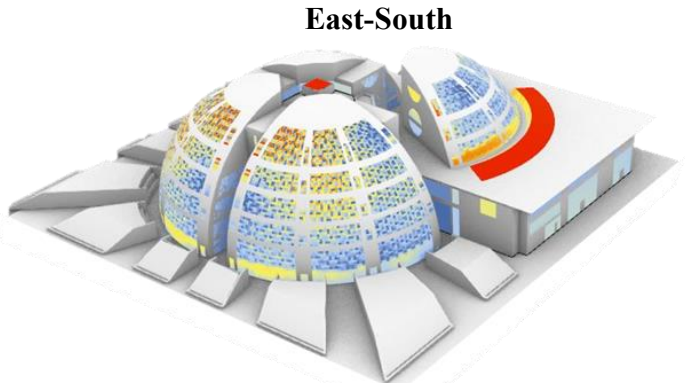


Skylights are overexposed and remain unshaded throughout the year

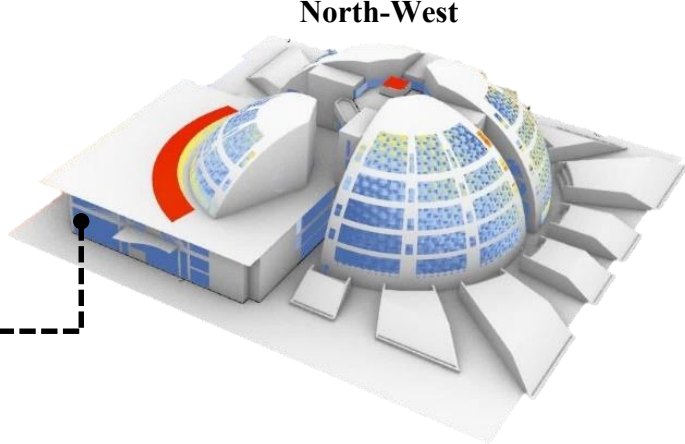
Lower part of the dome that is unshaded is overexposed to the morning east sun

West Façade is also exposed and unshaded for majority of the year. The discs are incapable of blocking the steep solar angles from the west during late afternoon.

Curved glass from 2nd floor onwards receives high radiation from the South-East to South-west despite the shading from the façade. The exposure to the sun increases as we move up.



East to South-west face of the building will be highly vulnerable to direct solar radiation causing glare and heating up of periphery spaces inside. Despite the shading the steep solar angles especially on the upper stories are exposed to direct sun.



Shaded adequately by the canopy structures Infront

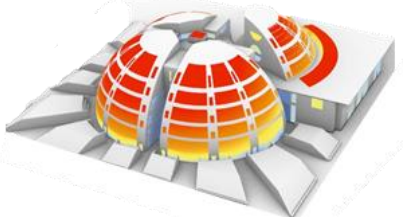
Inference

Due to a spherical shape the building is exposed to direct sun for most of the time of the year. The curvature of the building makes it difficult to block the solar angles at upper floors which will experience harsh sun. However the external shading / discs help reduce 50% of the Insolation when compared to an unshaded scenario.

Total Annual radiation combined on all faces = **2.5991 e+6 kWh/m2**

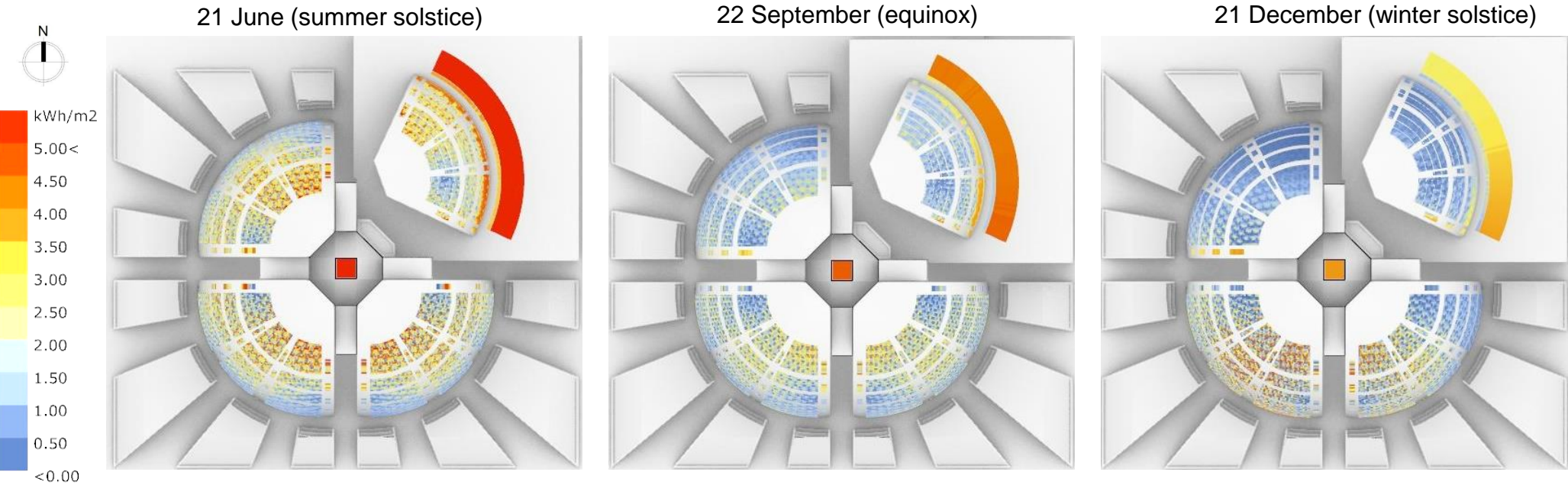
Total Annual radiation combined on all faces (without shading) = **4.6279 e+6 kWh/m2**

Radiation analysis without shading



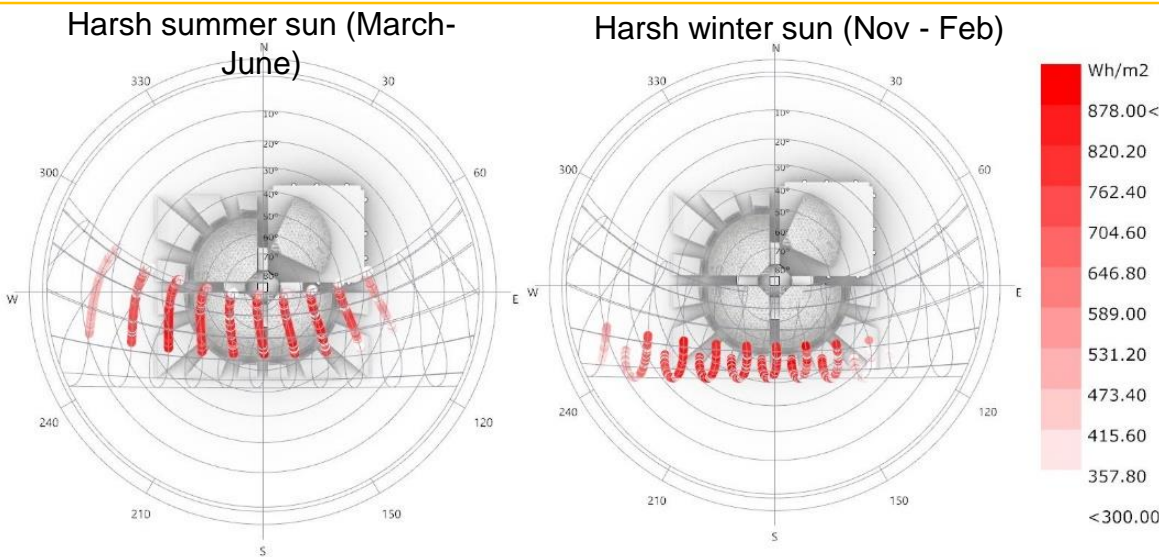
Climate Analysis | Solar Insolation on specific days

Solar insolation for specific days including the summer and winter solstice and Equinox was studied to identify difference in radiation on specific days. Analysis on these days will help determine the harsh solar angles that need to be blocked specifically. The solar angles can be derived from the sun path and then translated into the horizontal and vertical shading angles.



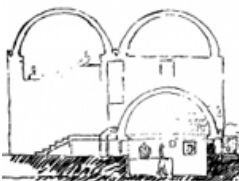
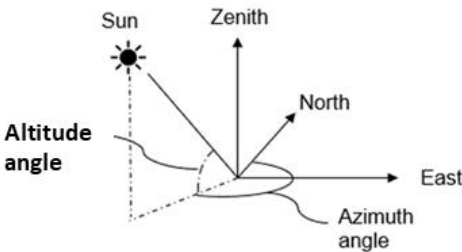
Inference

From the results of the Radiation analysis on the special days and the sun path analysis for the harsh summer and winter months (having high radiation and low cloud cover) a threshold of solar radiation was derived. The solar radiation per hour per m² recorded on 22 September i.e. Equinox was found to be the least out of all the harsh sun hours. Thus the hourly maximum of 500 Wh/m² was selected as a threshold beyond which direct sun needs to be blocked for minimum solar insolation on the glazing. This will also resonate with the results from the Annual Glare finder discussed ahead. The solar azimuth and altitude angles for these days (min and max marked in table) will help derive the shading angles on the glazing in different orientations.



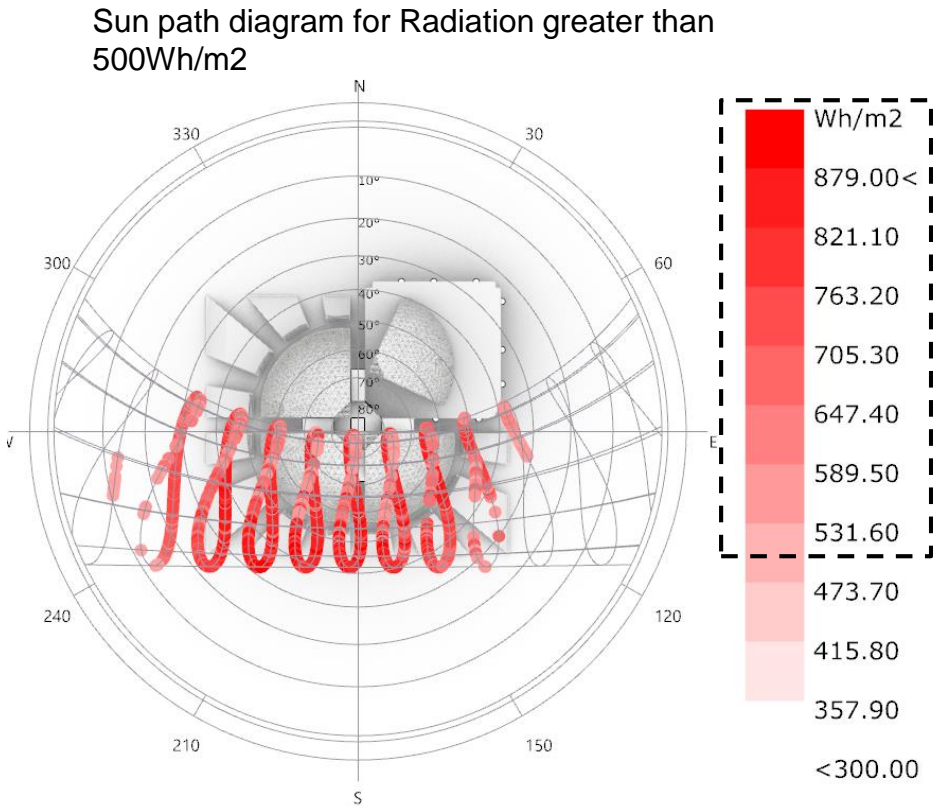
Solar Angles of harsh days – required to be blocked

Time	08:00	09:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00
Altitud										
e angle	41	54	68	81	85	71	58	44	31	18
21st Azimut										
June h angle	80	84	89	99	252	269	275	279	283	288
Altitud										
e angle	34	46	57	64	64	57	46	34	20	7
21st Azimut										
Sep h angle	107	118	135	163	198	225	242	252	260	267
Altitud										
e angle	19	29	36	41	41	37	30	21	10	-
21st Azimut										
Dec h angle	129	139	153	169	188	205	219	230	238	-

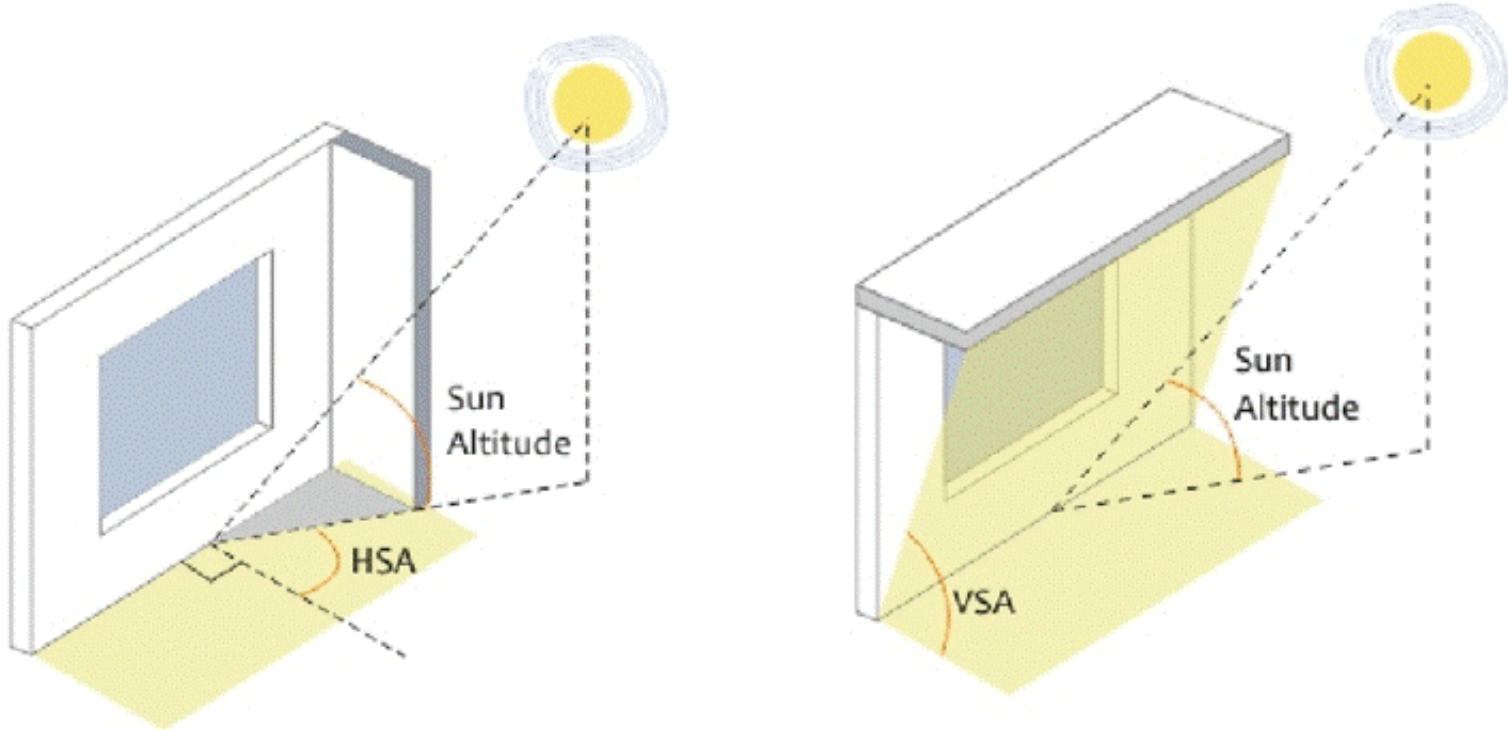


Shading Analysis | Shading thresholds based on simulation results

Shading Mask analysis was performed on typical windows in all directions to understand how much sun is blocked by the adjacent context or the façade i.e. the discs. The shading mask was overlaid with a Sun path diagram having hours of the year with radiation above the threshold of 500Wh/m2. The shading mask plus the sun path helps to derive the Horizontal and Vertical Shading angles that need to be subtended from the glazing to block the sun.

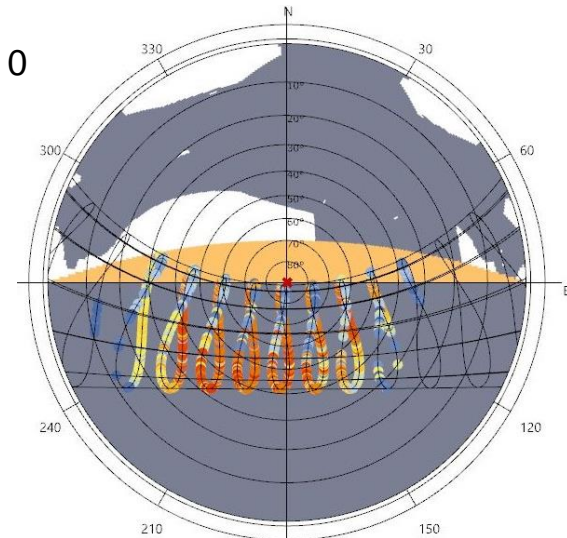


Vertical and horizontal shading angles are derived from the solar Altitude and Azimuth angles.

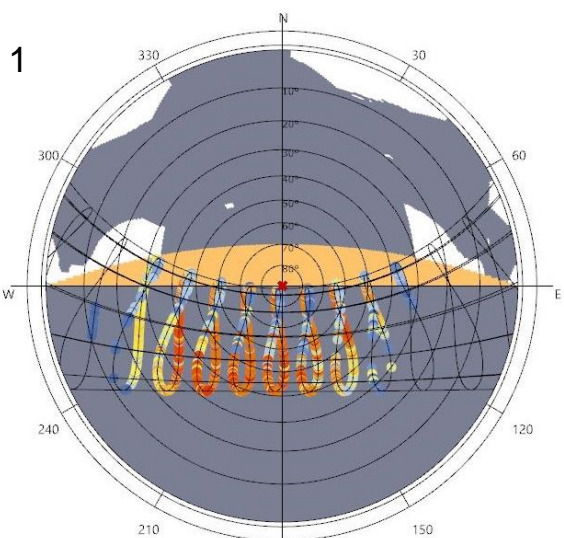


The following slides present a shading mask drawn at the specified points on the external glazing's center. Each point is taken on the center of a representative glazing in different directions. The shading mask changes if the point is considered on the center vs on the edges, however the center point is the most exposed part of the window and thus this will be a comprehensive analysis for the worst-case scenario.

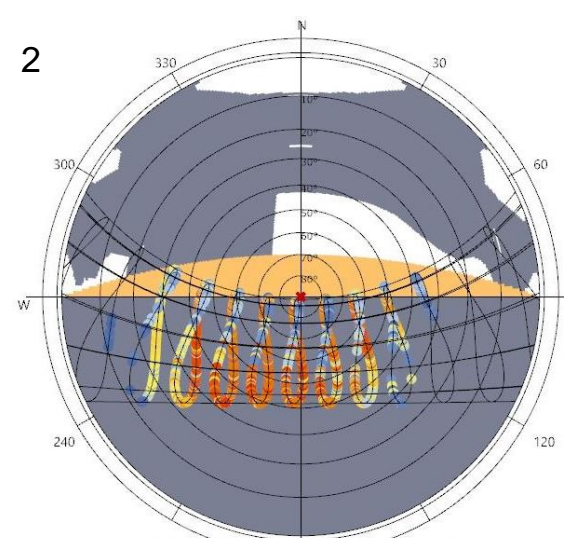
Shading Analysis | Shading masks for rectangular pedestal



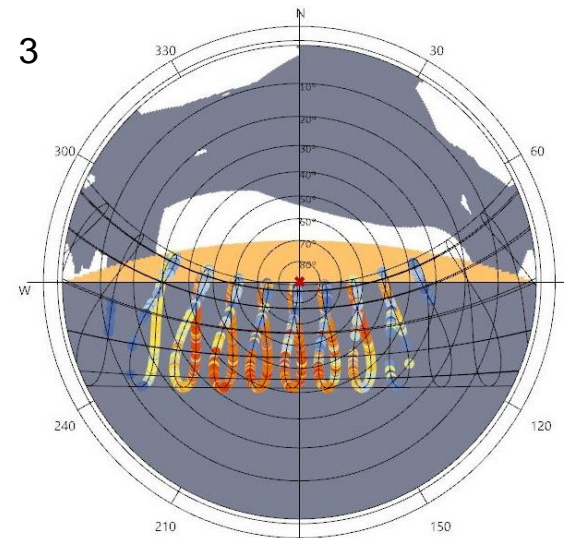
Orientation – 0
VSA = 20
HSA (Left) = 0, HSA(Right) = 0



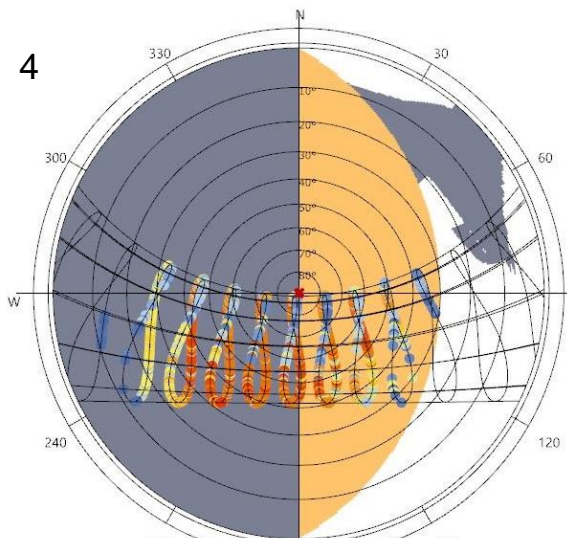
Orientation – 0
VSA = 20
HSA (Left) = 0, HSA(Right) = 0



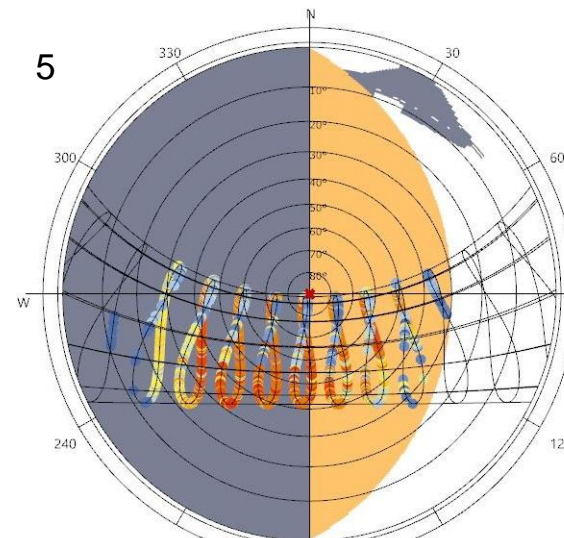
Orientation – 0
VSA = 20
HSA (Left) = 0, HSA(Right) = 0



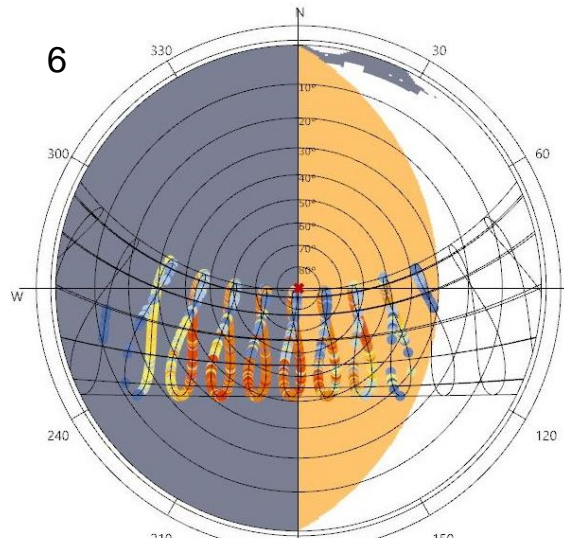
Orientation – 0
VSA = 20
HSA (Left) = 0, HSA(Right) = 0



Orientation – 90
VSA = 60
HSA (Left) = 0, HSA(Right) = 0



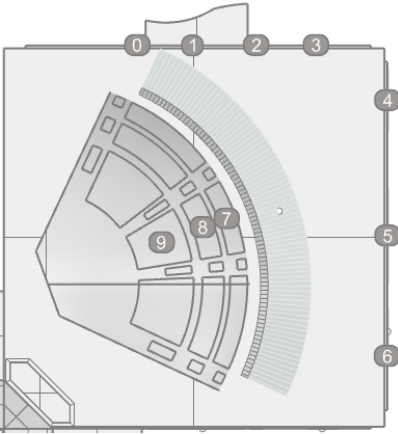
Orientation – 90
VSA = 60
HSA (Left) = 0, HSA(Right) = 0



Orientation – 90
VSA = 60
HSA (Left) = 0, HSA(Right) = 0

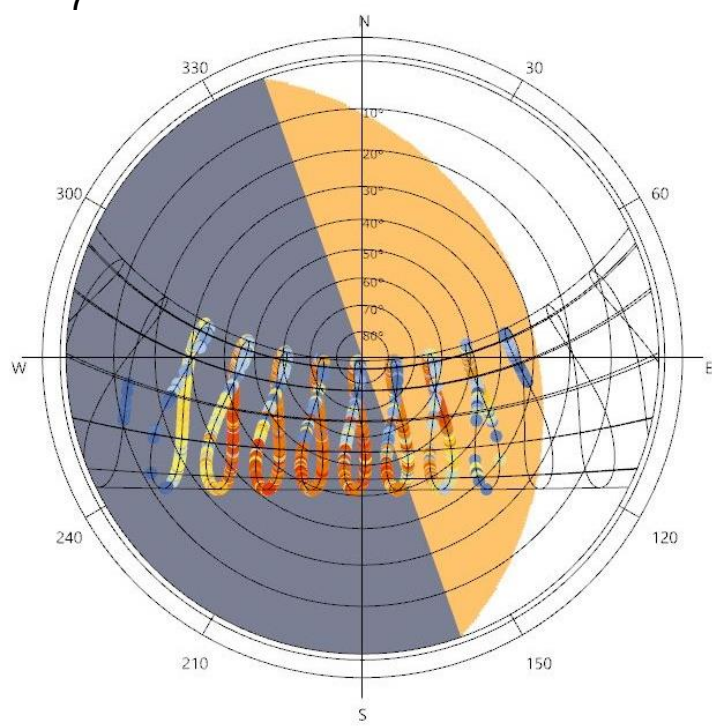
Shaded
Recommended

Key plan



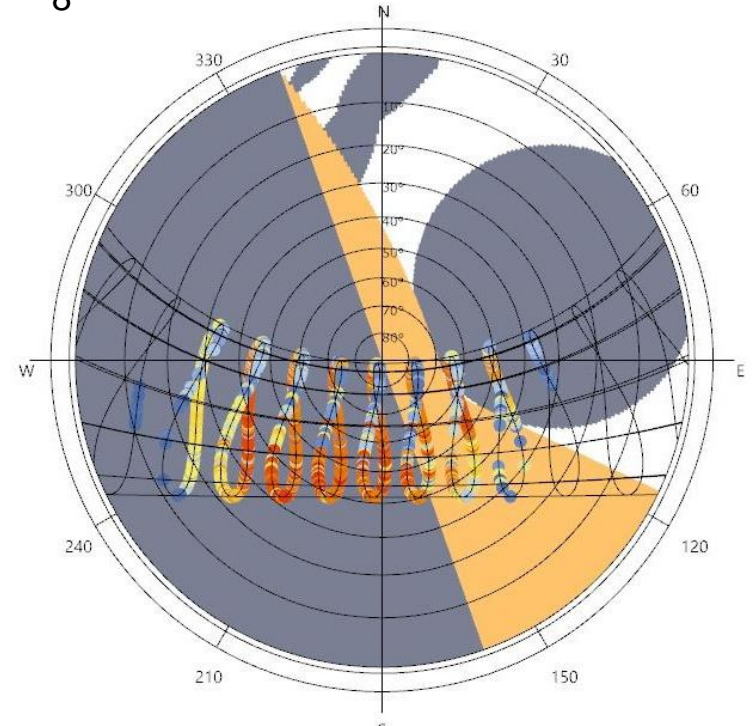
Shading Analysis | Shading masks for North-East Quadrant

7



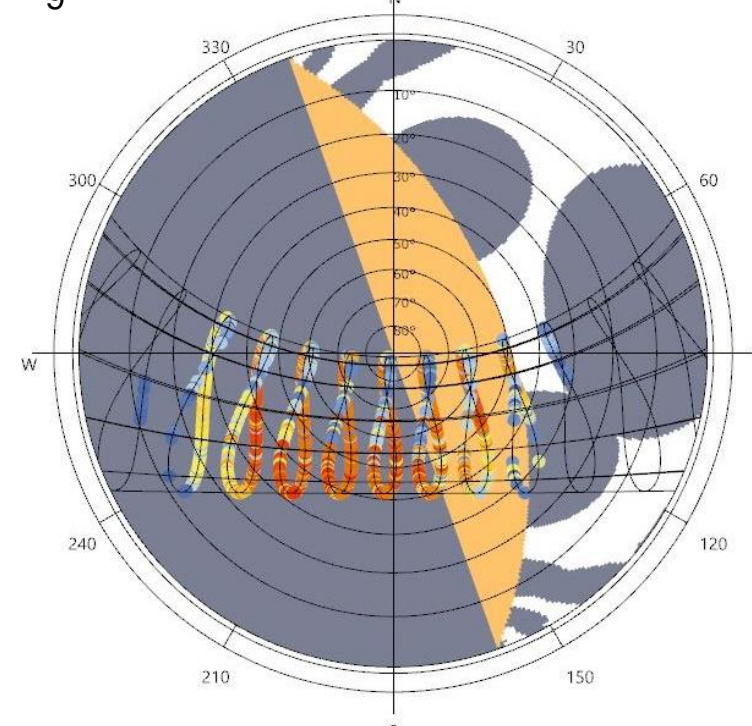
Orientation – 70.5
VSA = 60
HSA (Left) = 0, HSA(Right) = 0

8

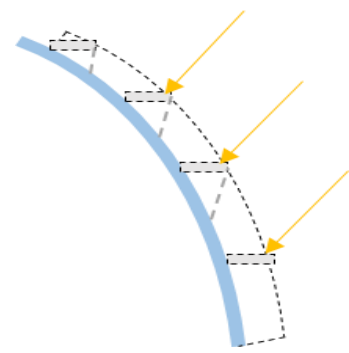


Orientation – 70.5
VSA = 20
HSA (Left) = 0, HSA(Right) = 45

9

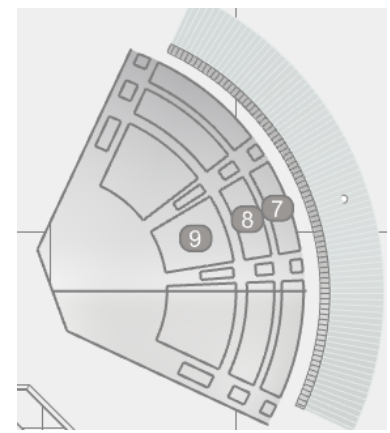


Orientation – 70.5
VSA = 40
HSA (Left) = 0, HSA(Right) = 0

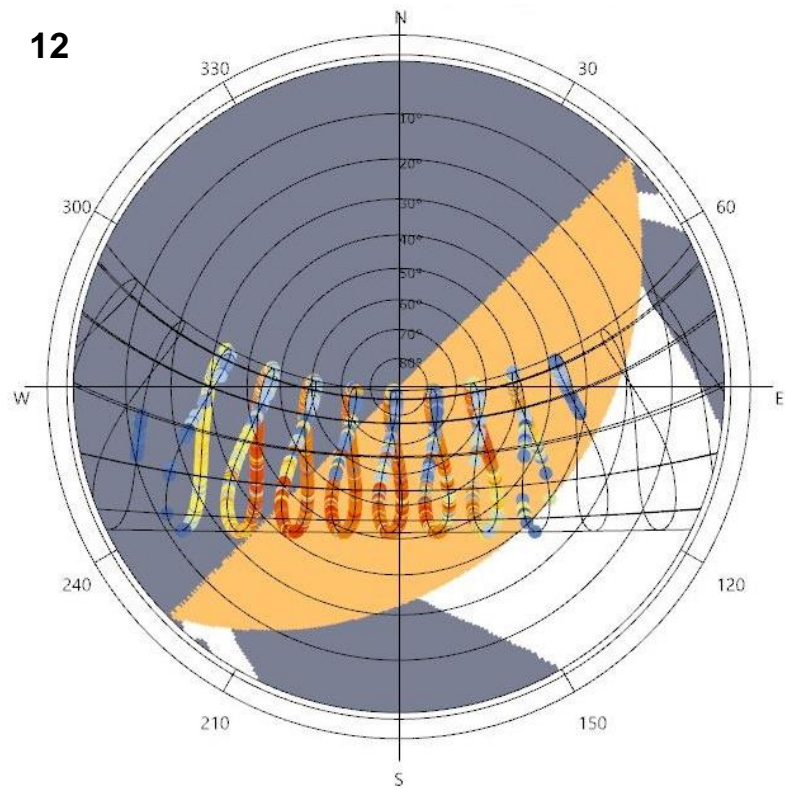
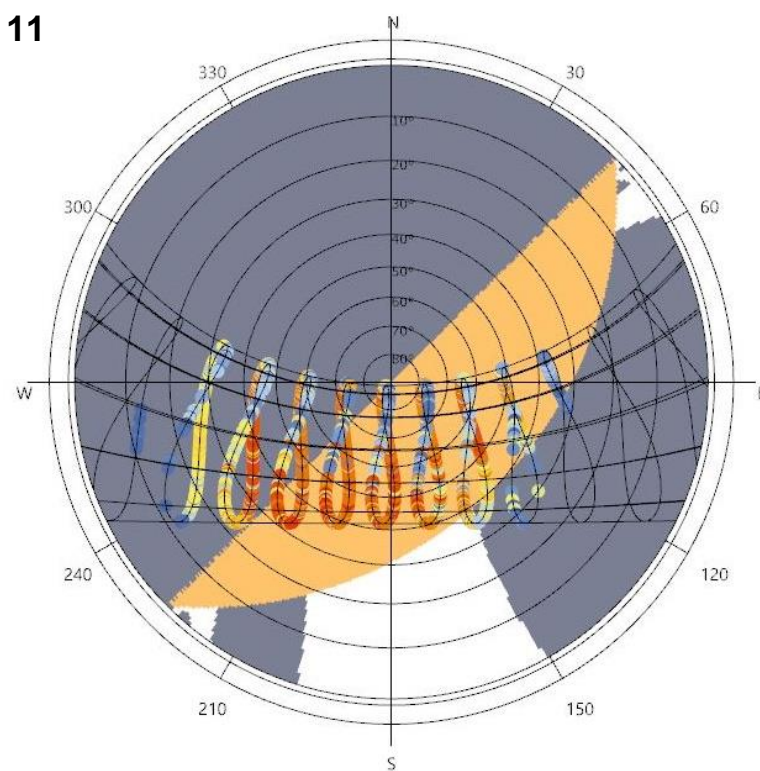
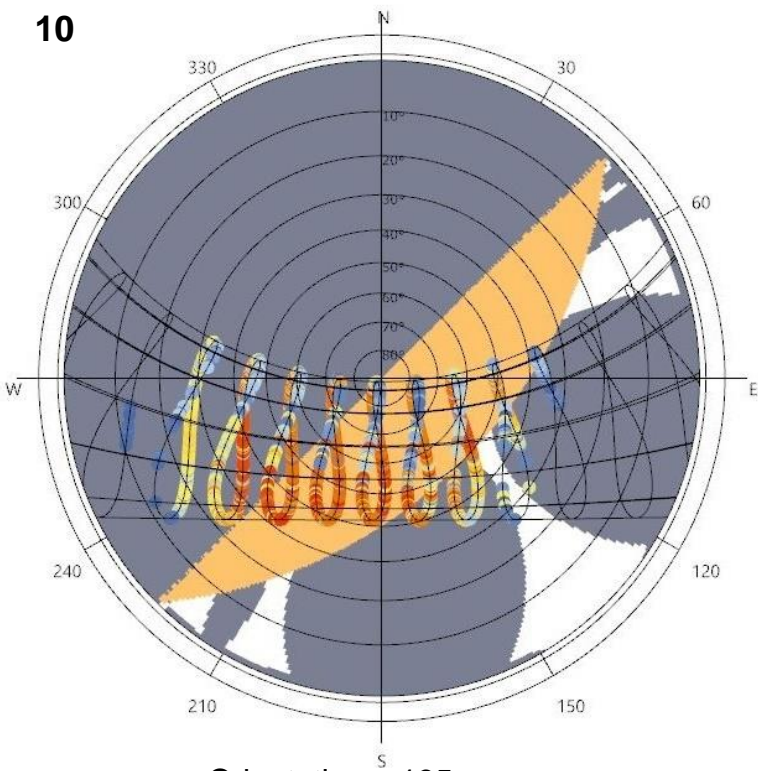


The façade / discs designed currently have huge gaps in between which allow a lot of harsh sun to penetrate inside directly. Thus shading in the form of an egg-crate structure as shown might help in cutting off the harsh sun. The highest angles are observed on the lowest and the topmost glazing panes.

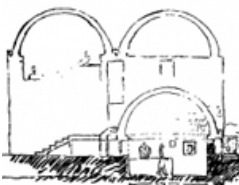
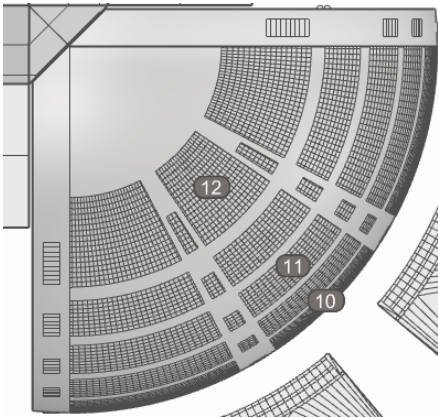
Key plan



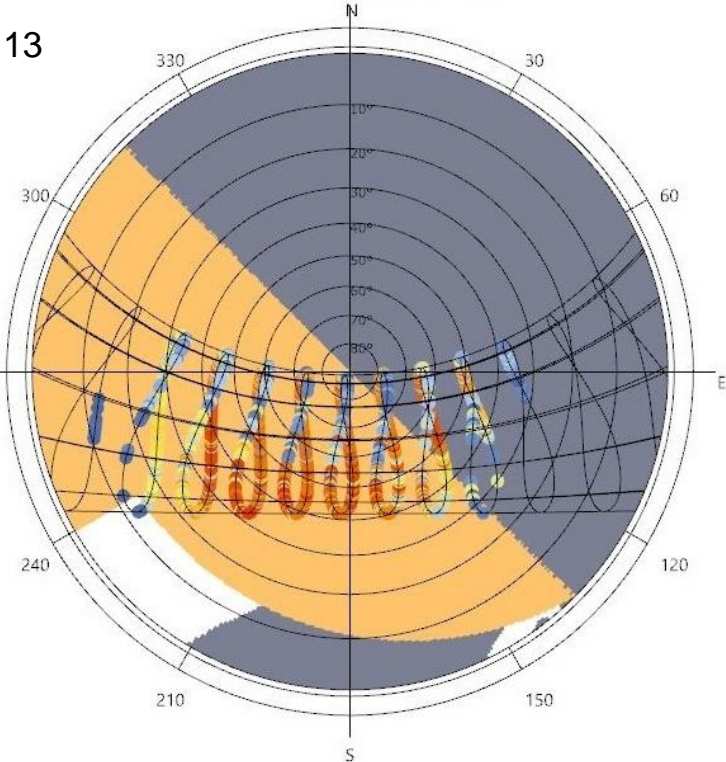
Shading Analysis | Shading masks for South-East Quadrant



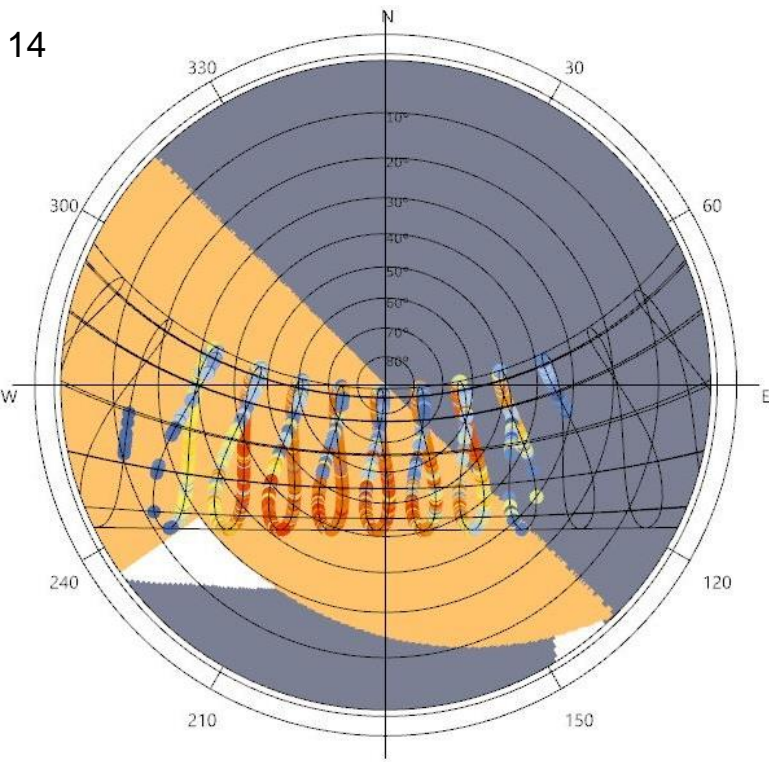
Key plan



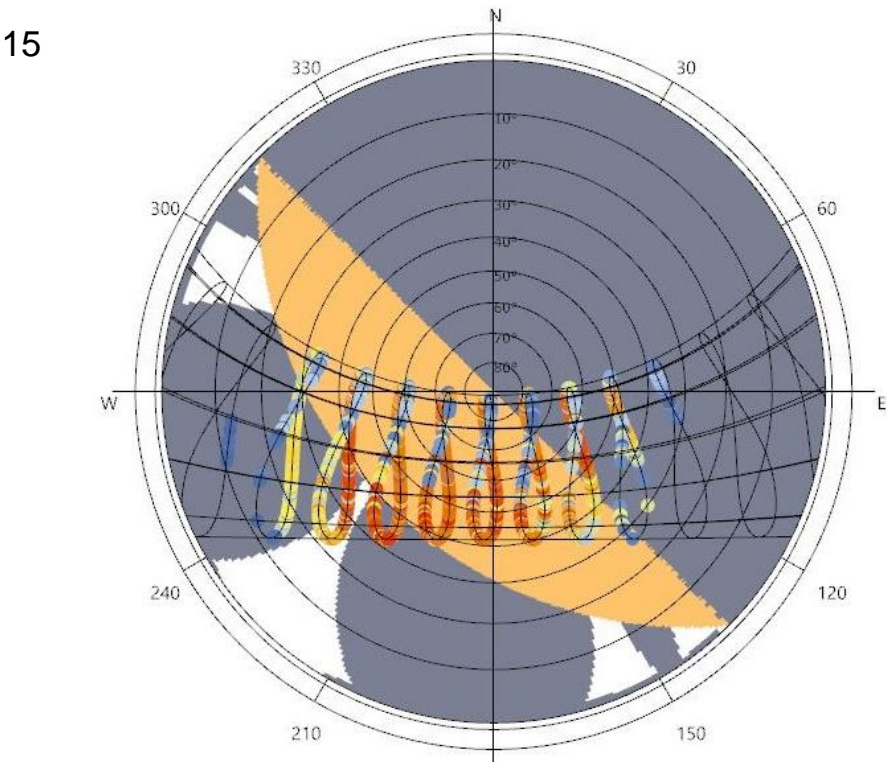
Shading Analysis | Shading masks for South-West Quadrant



Orientation – 225
VSA = 75
HSA (Left) = 0, HSA(Right) = 75

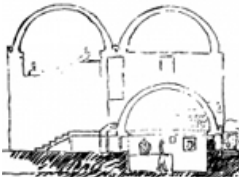
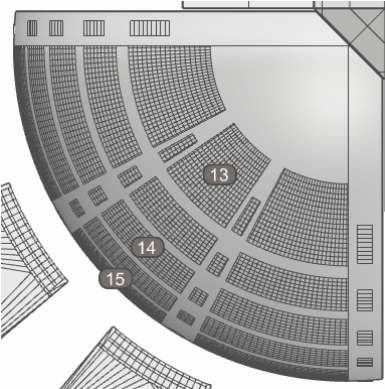


Orientation – 225
VSA = 70
HSA (Left) = 0, HSA(Right) = 80

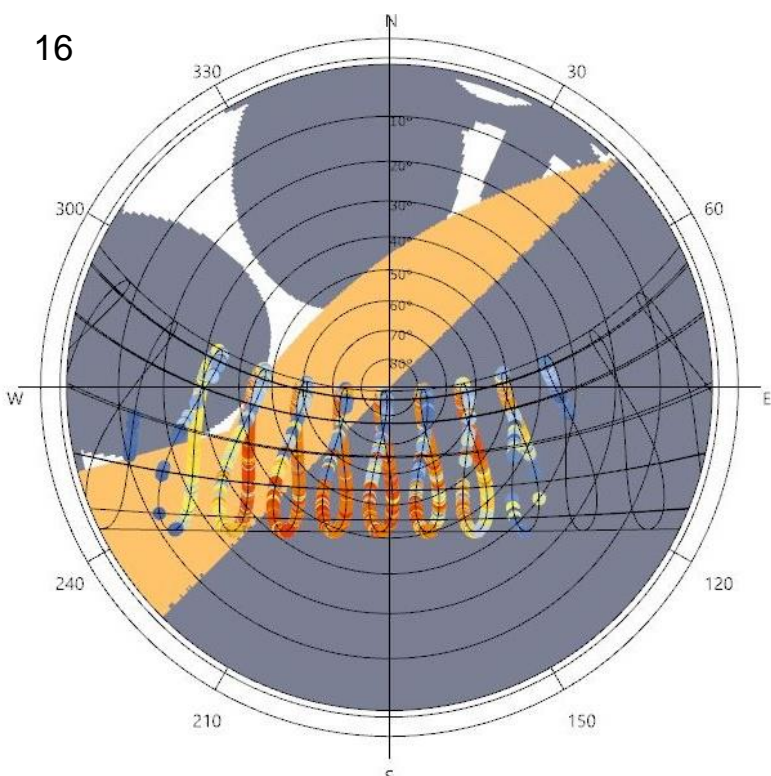


Orientation – 225
VSA = 50
HSA (Left) = 0, HSA(Right) = 0

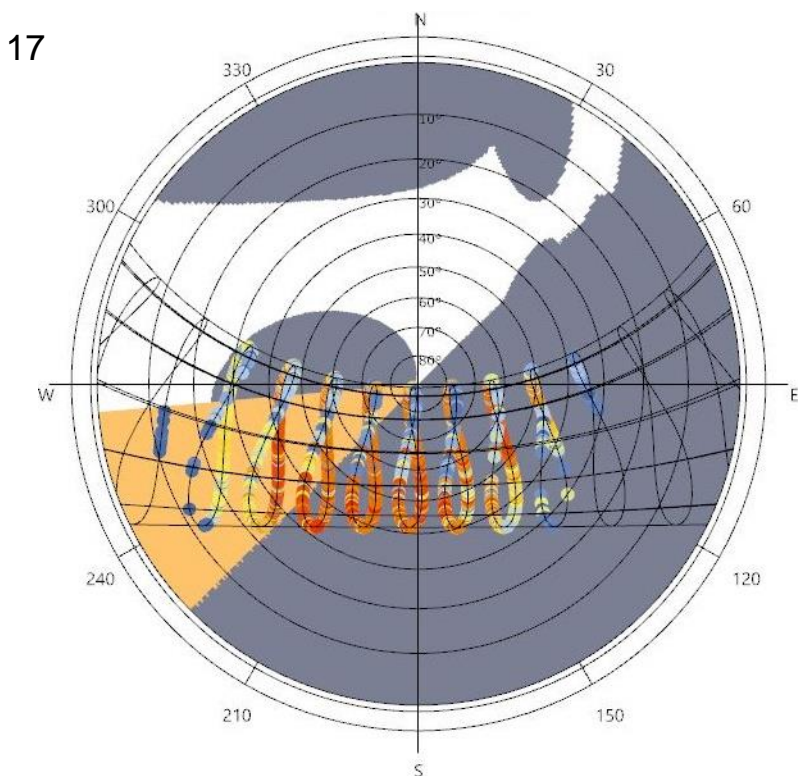
Key plan



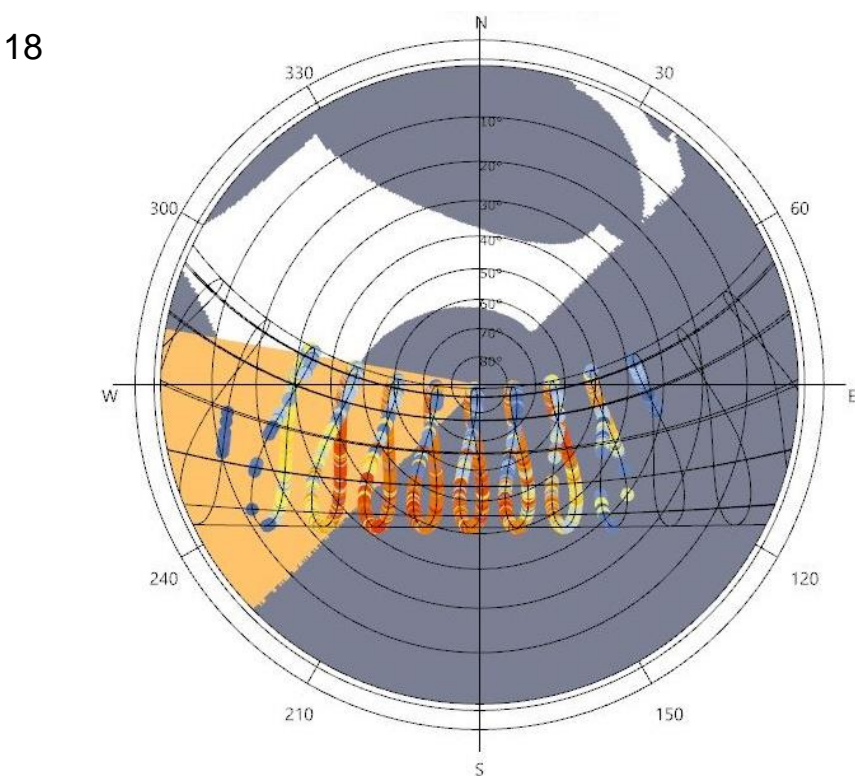
Shading Analysis | Shading masks for North-West Quadrant



Orientation – 315
VSA = 30
HSA (Left) = 0, HSA(Right) = 30

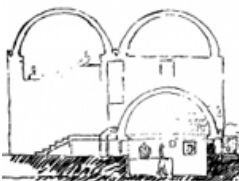
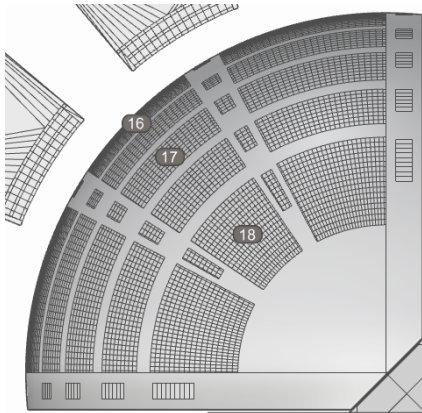


Orientation – 315
VSA = 0
HSA (Left) = 0, HSA(Right) = 40

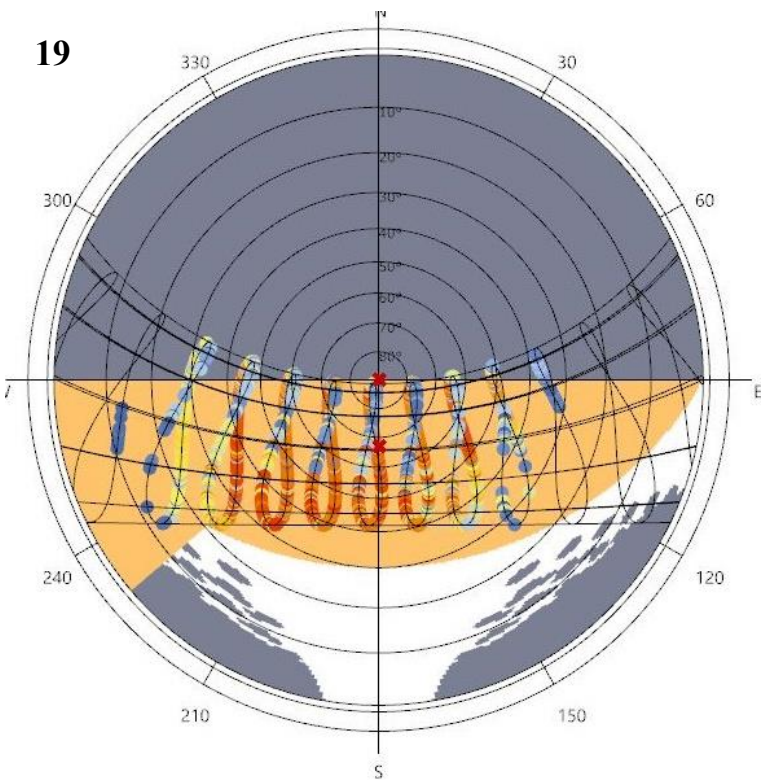


Orientation – 315
VSA = 0
HSA (Left) = 0, HSA(Right) = 55

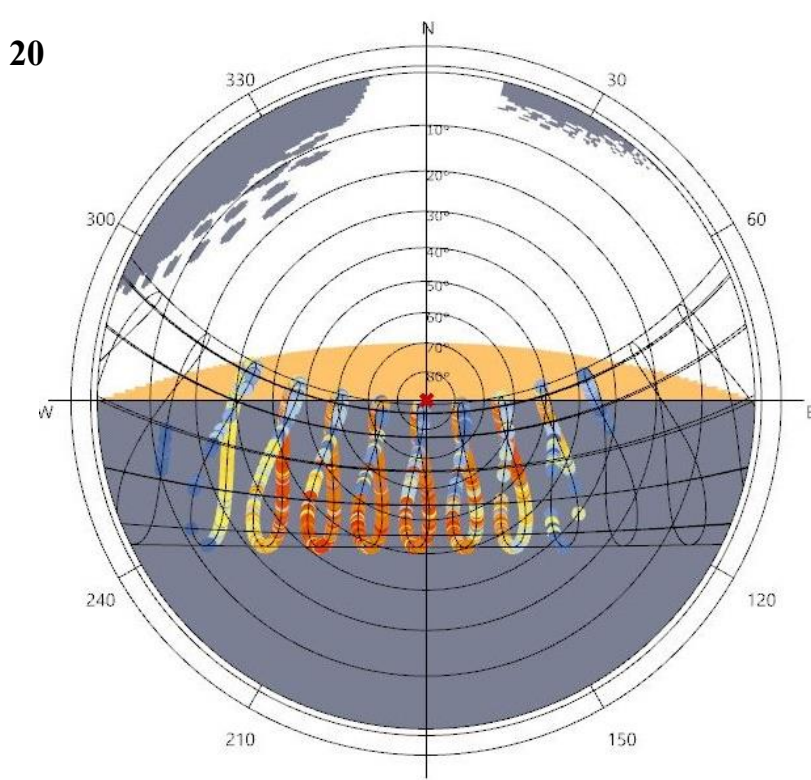
Key plan



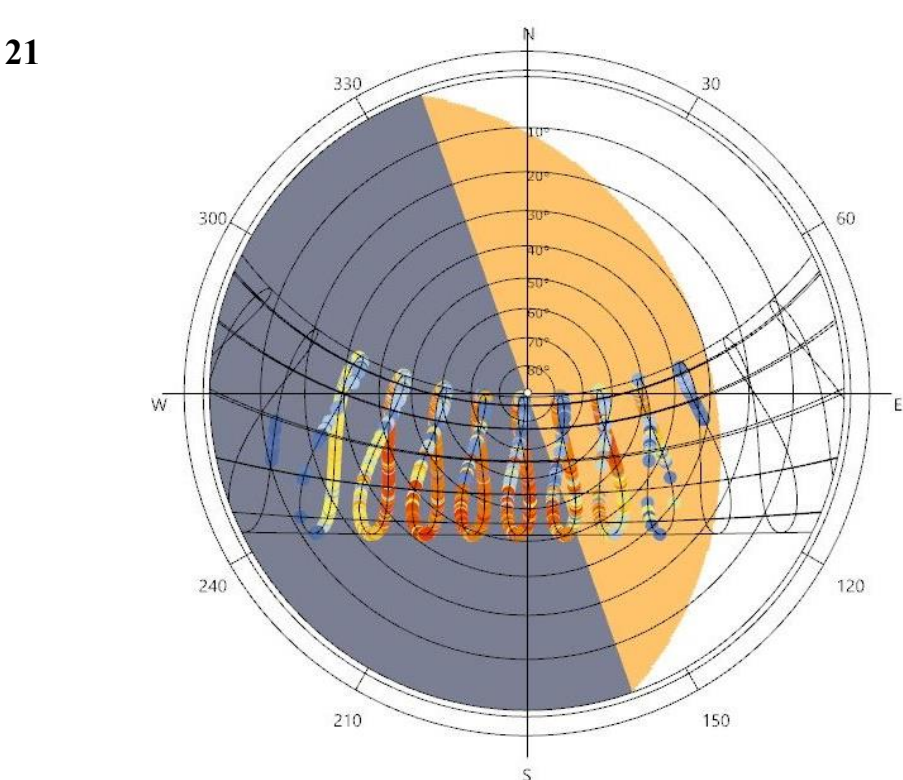
Shading Analysis | Shading masks for Skylights



Orientation – 315
VSA = 30
HSA (Left) = 0, HSA(Right) = 30



Orientation – 0
VSA = 20
HSA (Left) = 0, HSA(Right) = 0

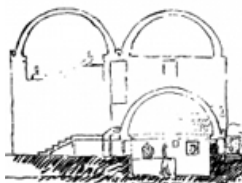
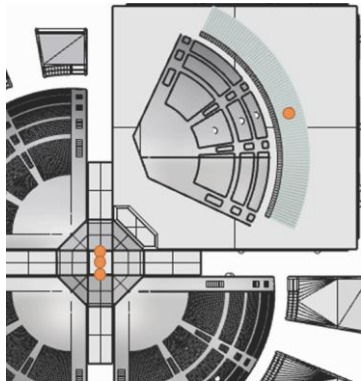


Orientation – 315
VSA = 0
HSA (Left) = 0, HSA(Right) = 55

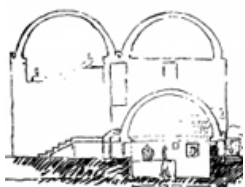
End points of the central atrium skylight

Key plan

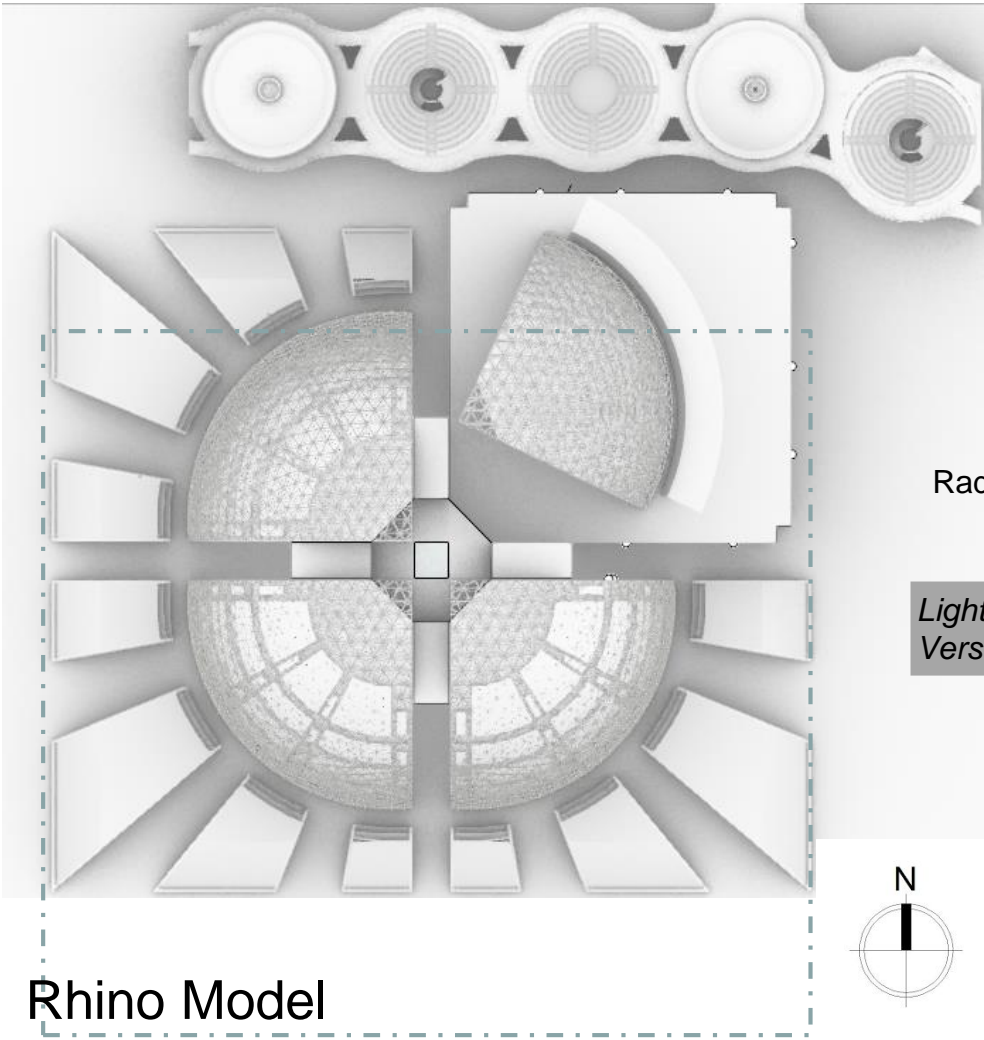
Curved skylight center point



Daylight Simulation model & inputs for Baseline Case



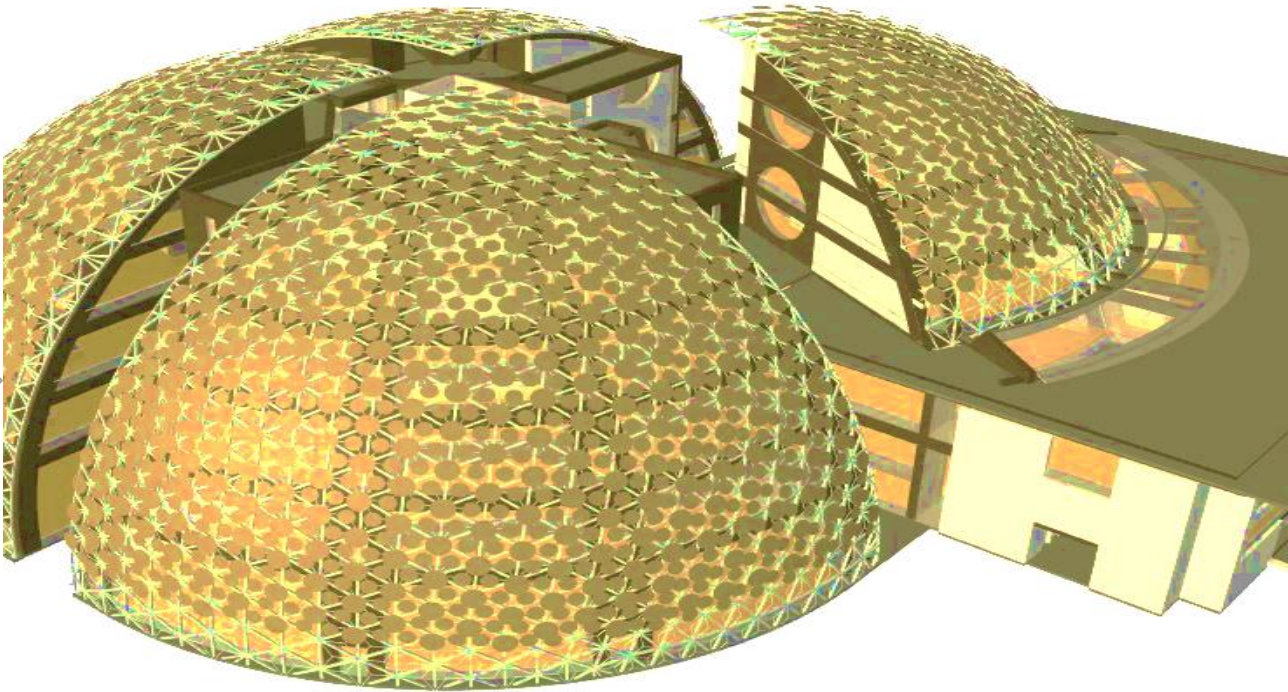
Baseline Case | Geometry, input parameters & basic assumptions



Rhino Model

Radiance Version: 5.2

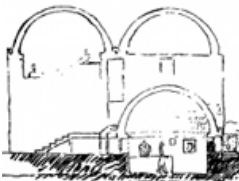
LightStanza Software
Version: 4.30.3



Climate file: IND_BR_Gaya.Intl.AP.425910_TMYx.2004-2018.epw (24.744°, 84.951°)

- Materials:
- Glass:
Curved glazing (60% VT), External glazing straight (60% VT), Interior Single Pane Glass (85% VT), Skylights (60% VT)
 - Opaque:
Concrete (15% Ref.), Corten steel (40% Ref.), Flooring Granite (30% Ref.), Site context & landscape (20% Ref.), Steel strc (70% Ref.), White plaster (82% Ref.)
 - Radiance parameters
Details: -aa = 0.15; -ab = 6; -ad = 1000; -ar = 300; -as = 500; -dc = 0.75; -dp = 2048; -dr = 3; -ds = 0.2; -dt = 0.05; -lr = 12; -lw = 0.0005; -ms = 0.063; -st = 0.01

Performance goals & benchmarks

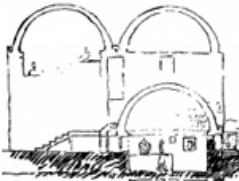


Performance goals & benchmarks

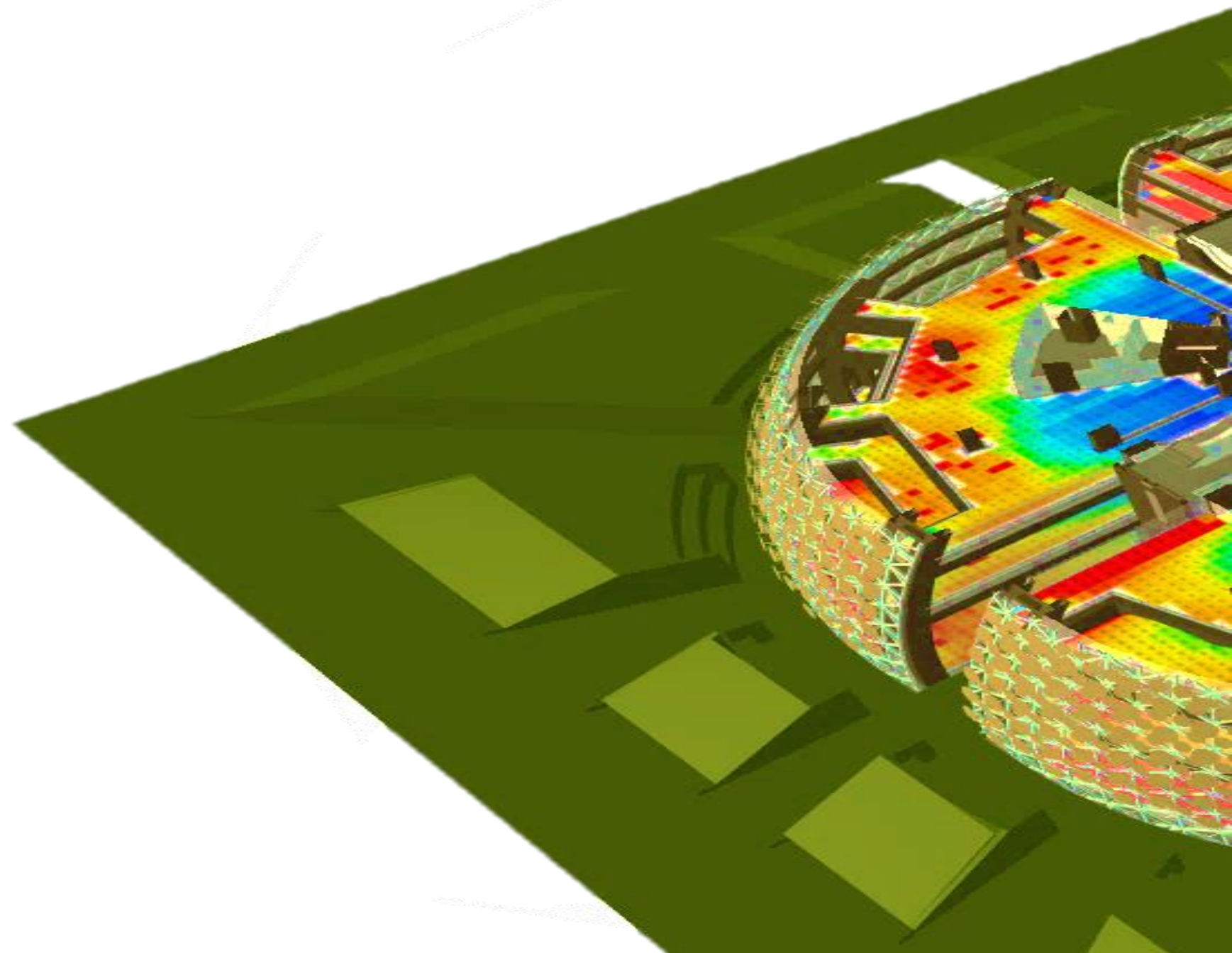
Recommended Lux levels for Library Building: 300Lx (NBC, 2016)

- Daylight Performance goals
- 100% Daylit (useful daylight) reading spaces
 - 100% Visual Comfort i.e. *Glare & blinds free spaces*
 - DGP<35 across the year

Code/ Green building cert.	Metric	Recommended thresholds	Thresholds as per the Performance goal	Definition of metrics
LEED v4 3 Credits	Spatial Daylight Autonomy (sDA _{300Lx,50%})	>55% (2 Credits) >75% (3 credits)	~100% (for the reading spaces)	Spatial daylight autonomy (sDA) is defined as the percentage of an analysis area that meets a minimum daylight illuminance level for a specified fraction of the operating hours per year. The sDA value is expressed as a percentage of area. sDA300/50% the percentage of analysis points across the analysis area that meet or exceed this 300-lux value for at least 50% of the analysis period
	Annual Sunlight Exposure (ASE _{1000Lx,250hrs})	<10%	<2%	Annual sunlight exposure (ASE) a metric that describes the potential for visual discomfort in interior work environments. It is defined as the percentage of an analysis area that exceeds a specified direct sunlight illuminance level more than a specified number of hours per year. ASE _{1,000,250} reports the percentage of sensors in the analysis area, using a maximum 2-foot spacing between points, that are found to be exposed to more than 1000 lux of direct sunlight for more than 250 hours per year, before any operable blinds or shades are deployed to block sunlight, considering the same 10 hour/day analysis period as sDA and using comparable simulation methods
GRIHA	Useful Daylight Illuminance (UDI _{100-2000, 90%})	>40% Mandatory >50% 2 credits >60% 4 credits	~100 (for the reading spaces)	Percentage of floor area that has illuminance levels between 100-2000 Lux for more than 90% occupied hours. This daylight is most useful to occupants, glare free and when available, eliminates the need for artificial lighting.
ECBC	Useful Daylight Illuminance (UDI _{100-2000, 90%})	>40% ECBC >50% ECBC + >60% Super ECBC	~100 (for the reading spaces)	Percentage of floor area that has illuminance levels between 100-2000 Lux for more than 90% occupied hours. This daylight is most useful to occupants, glare free and when available, eliminates the need for artificial lighting.

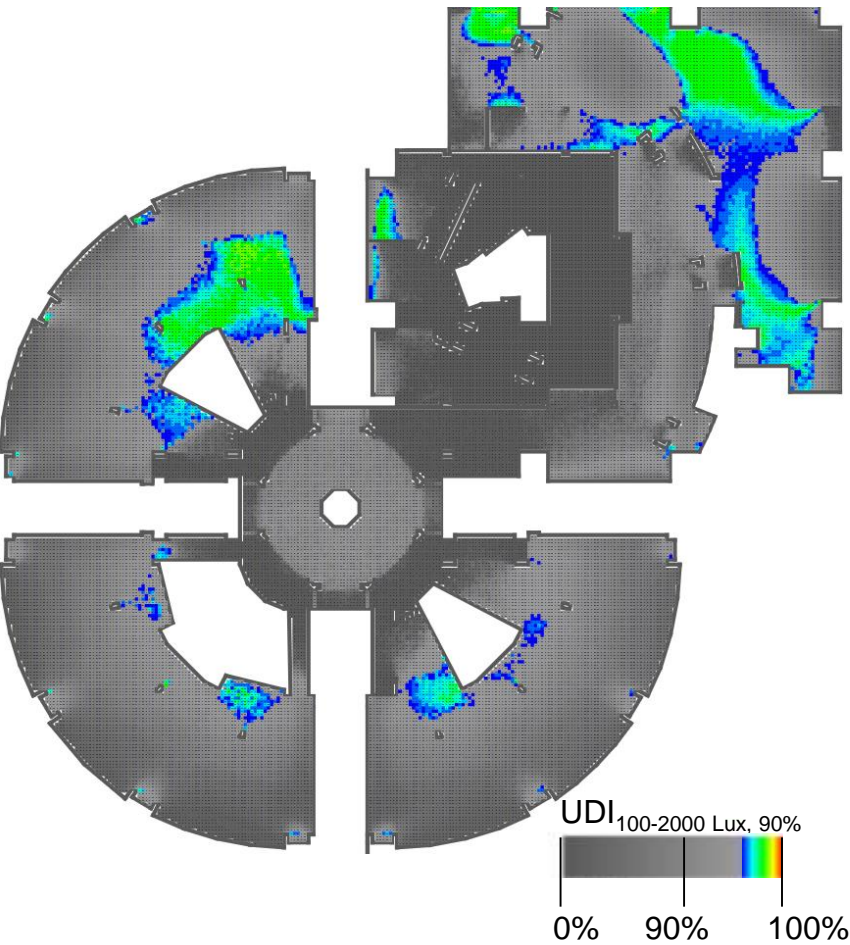


Daylight Simulation Results



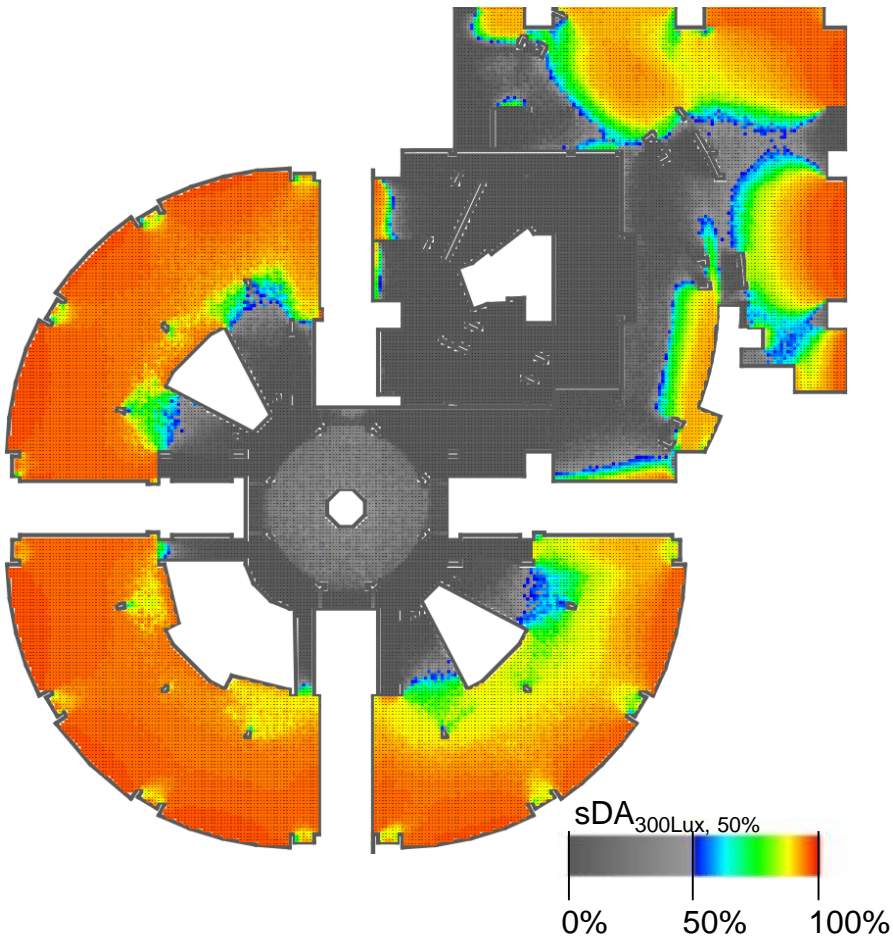
Daylight Results | Baseline Case

UDI, SDA & ASE – Ground Floor



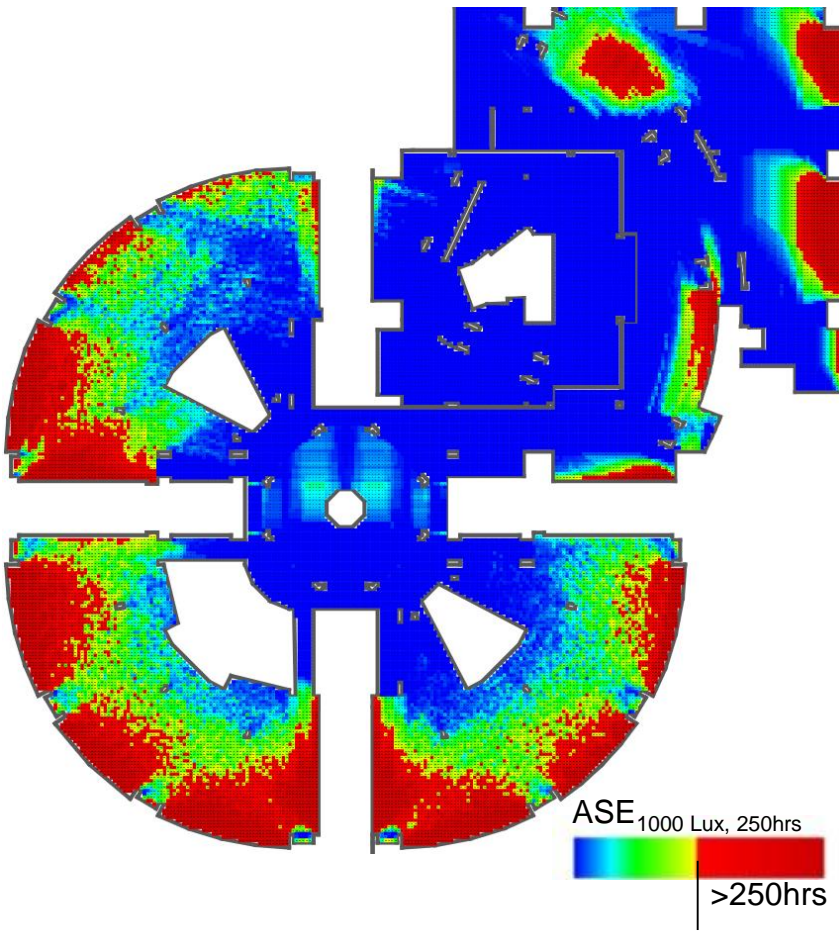
Useful Daylight Autonomy: 12.9%

ECBC Standard- Not Met
GRIHA- Mandatory Not Met
Performance goal- Not met



Spatial Daylight Autonomy: 59.6%

LEED Credit met
Note- No Credit given due to High ASE in LEED Certification

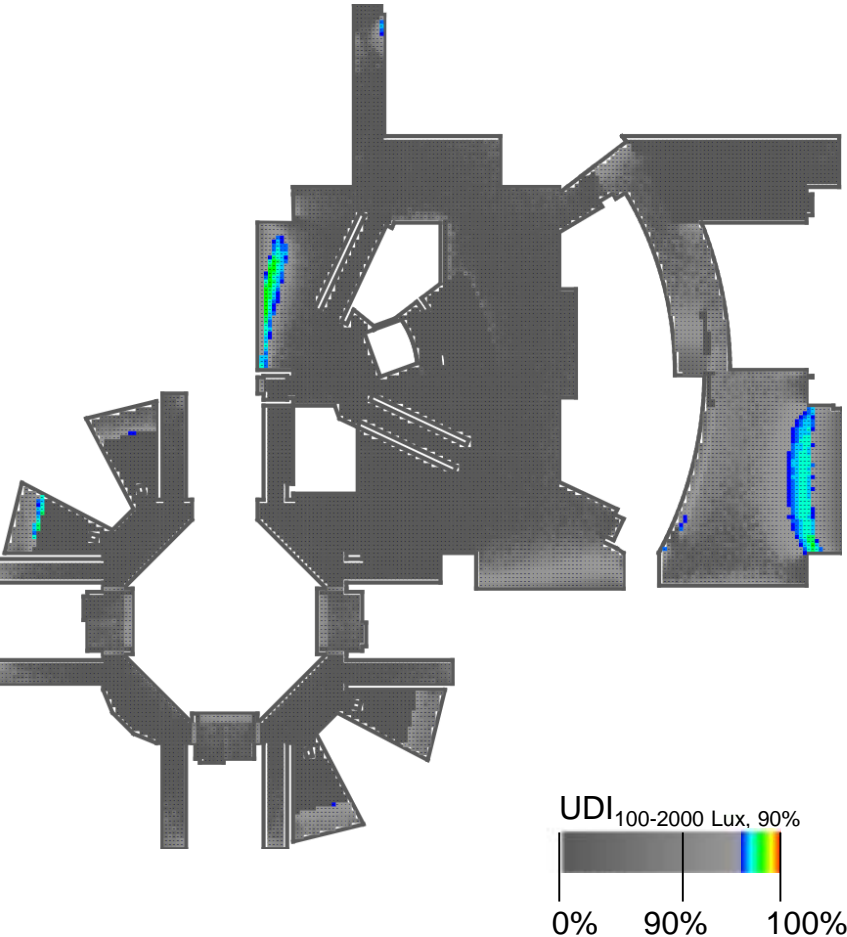


Annual Sunlight Exposure: 18%

LEED Credit: Not met
Note- No Credit given due to High ASE in LEED Certification

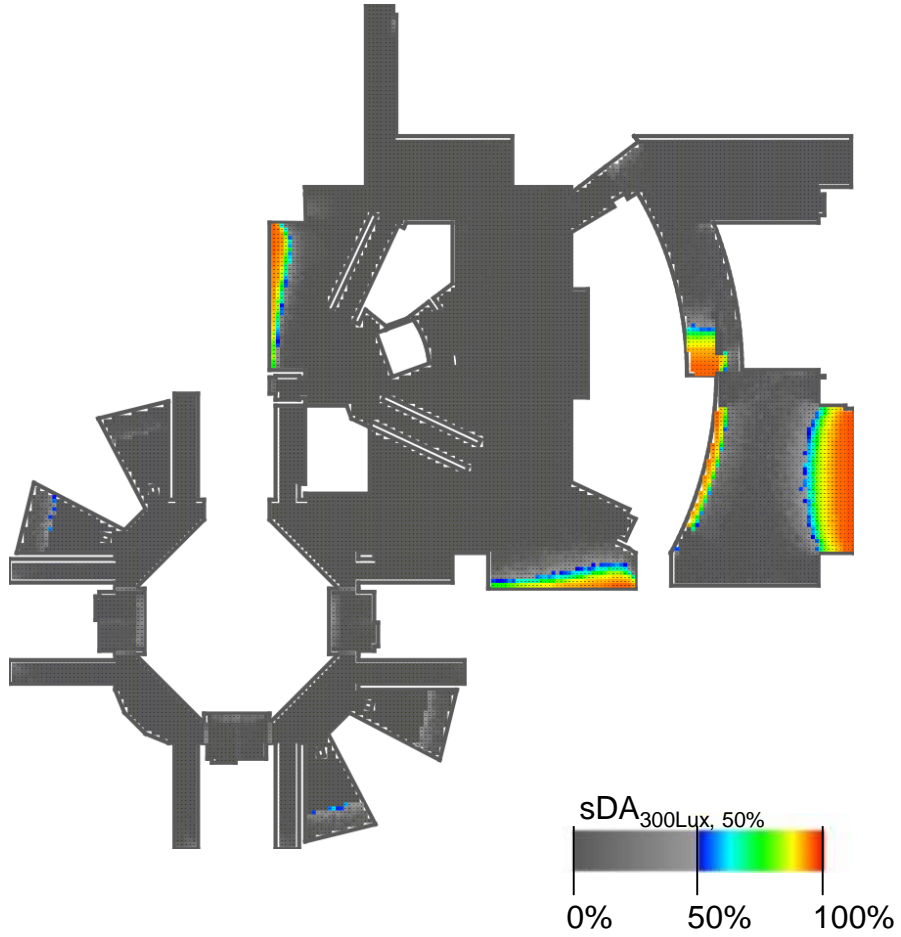
Daylight Results | Baseline Case

UDI, SDA & ASE – First Floor



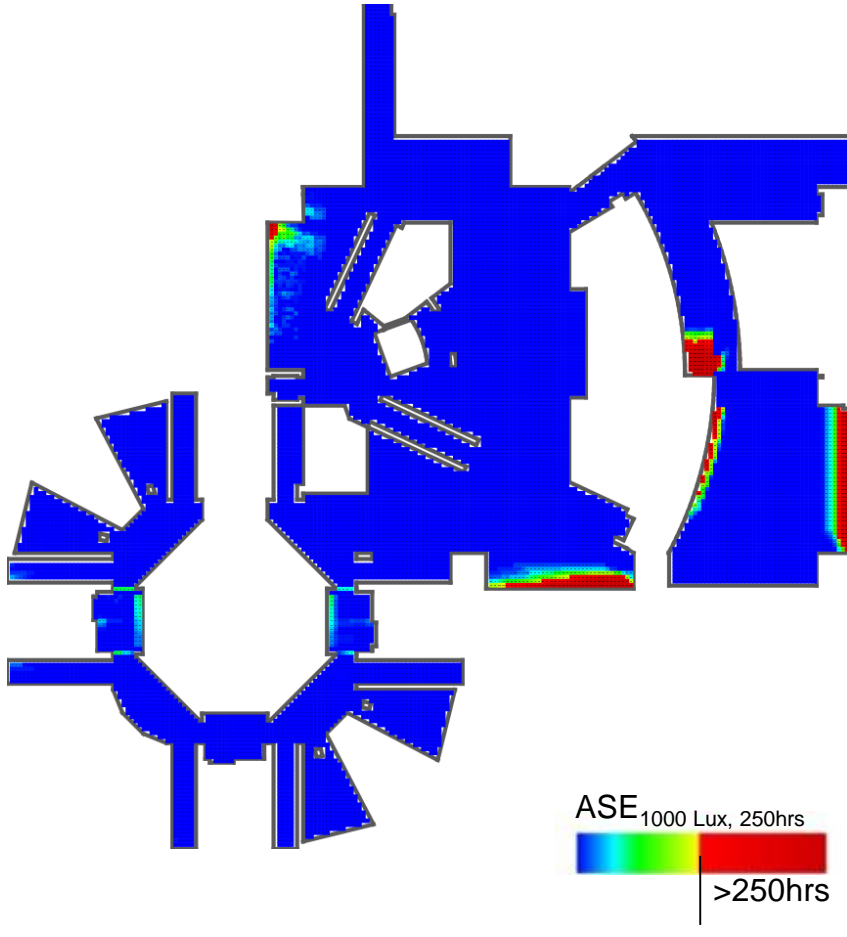
Useful Daylight Autonomy: 2.4%

ECBC Standard- Not Met
GRIHA- Mandatory Not Met
Performance goal- Not met



Spatial Daylight Autonomy: 6.29%

LEED Credit: Not met

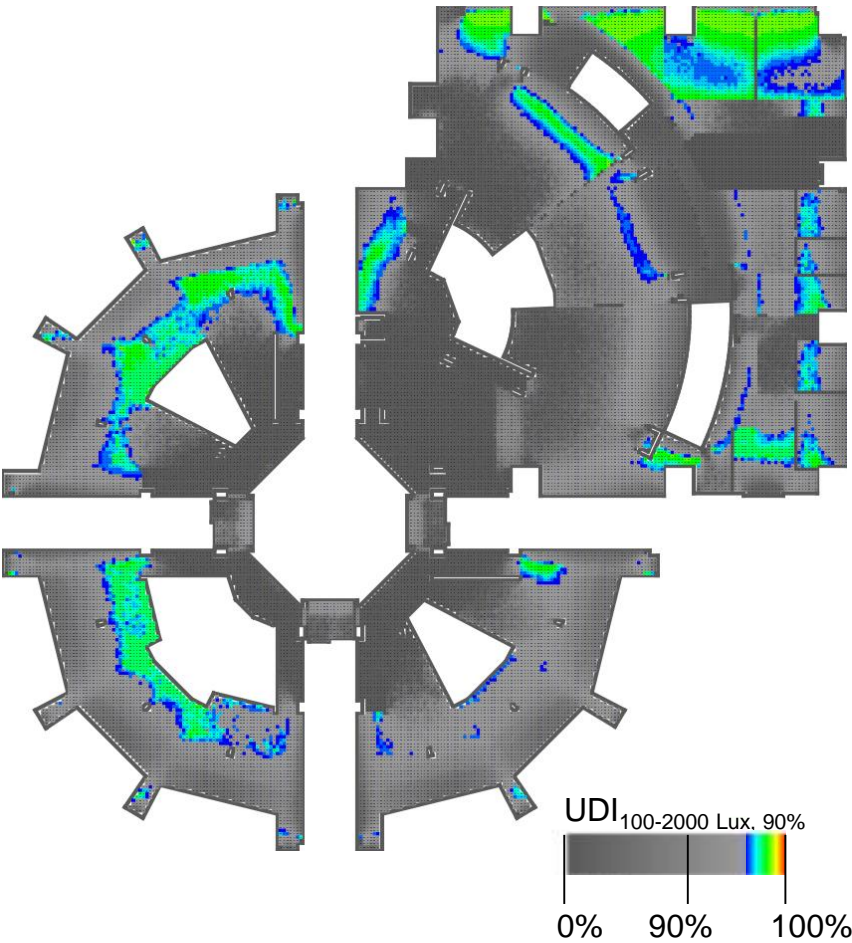


Annual Sunlight Exposure: 2.1%

LEED Credit: Met
Note- No Credit given due to low sDA in LEED Certification

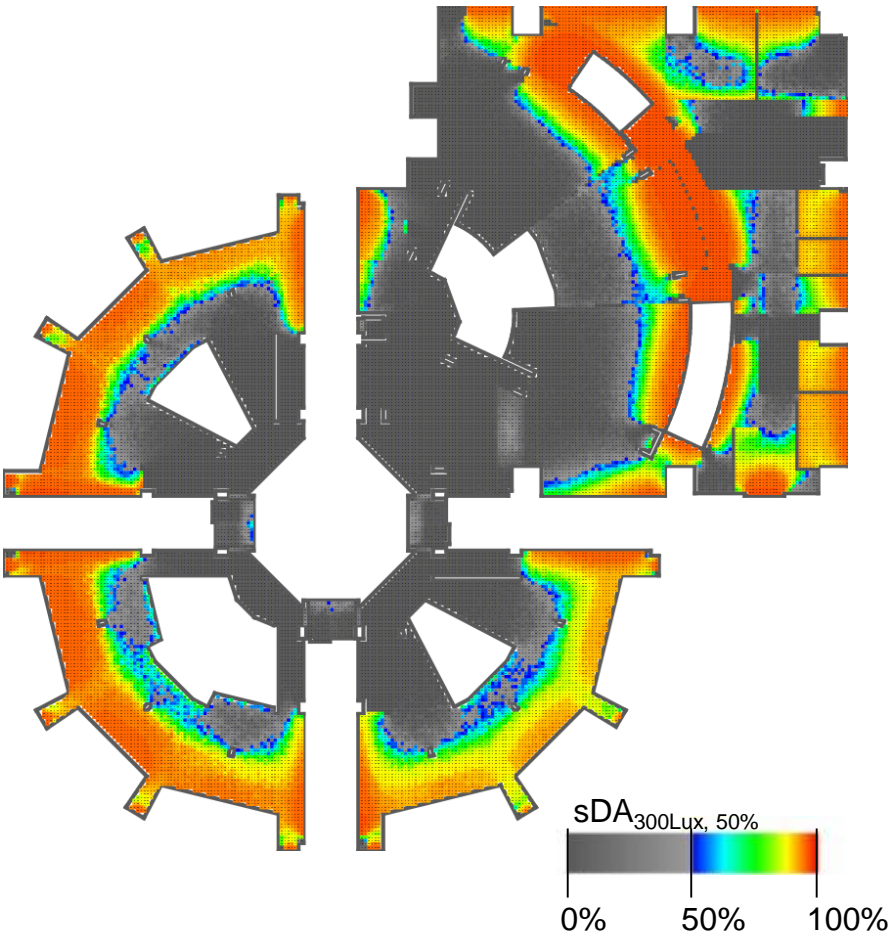
Daylight Results | Baseline Case

UDI, SDA & ASE – Second Floor



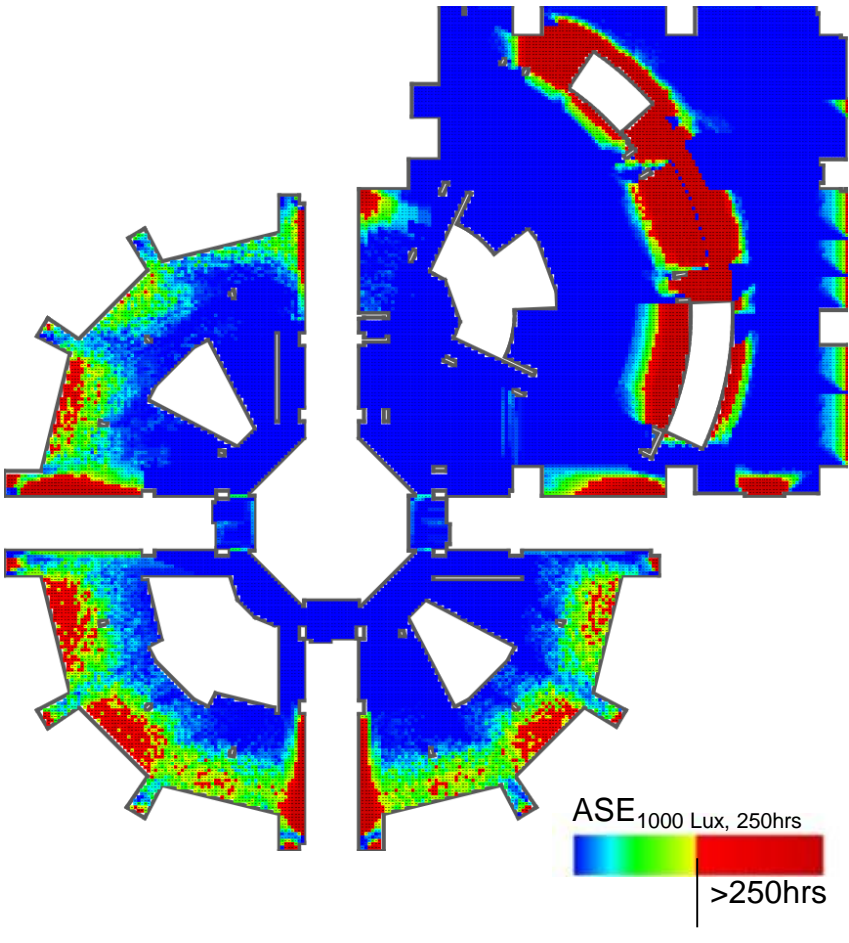
Useful Daylight Autonomy: 16.6%

ECBC Standard- Not Met
GRIHA- Mandatory Not Met
Performance goal- Not met



Spatial Daylight Autonomy: 47.9%

LEED Credit: Not met

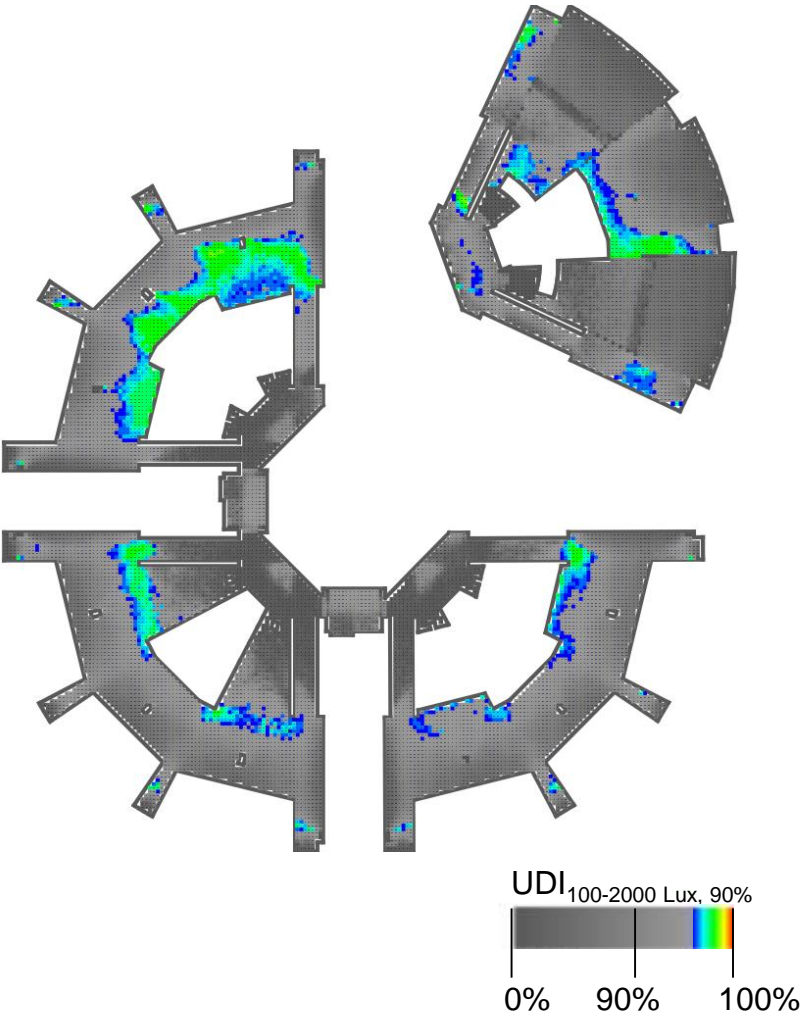


Annual Sunlight Exposure: 11.95%

LEED Credit: Not Met

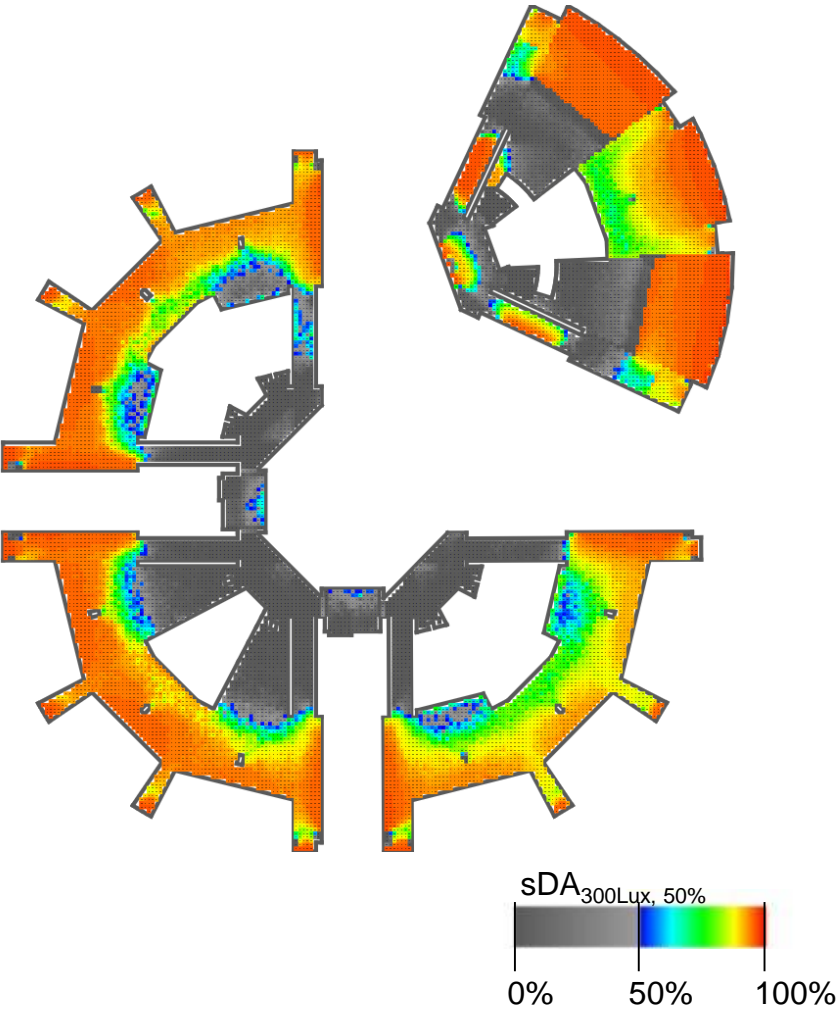
Daylight Results | Baseline Case

UDI, SDA & ASE – Third Floor



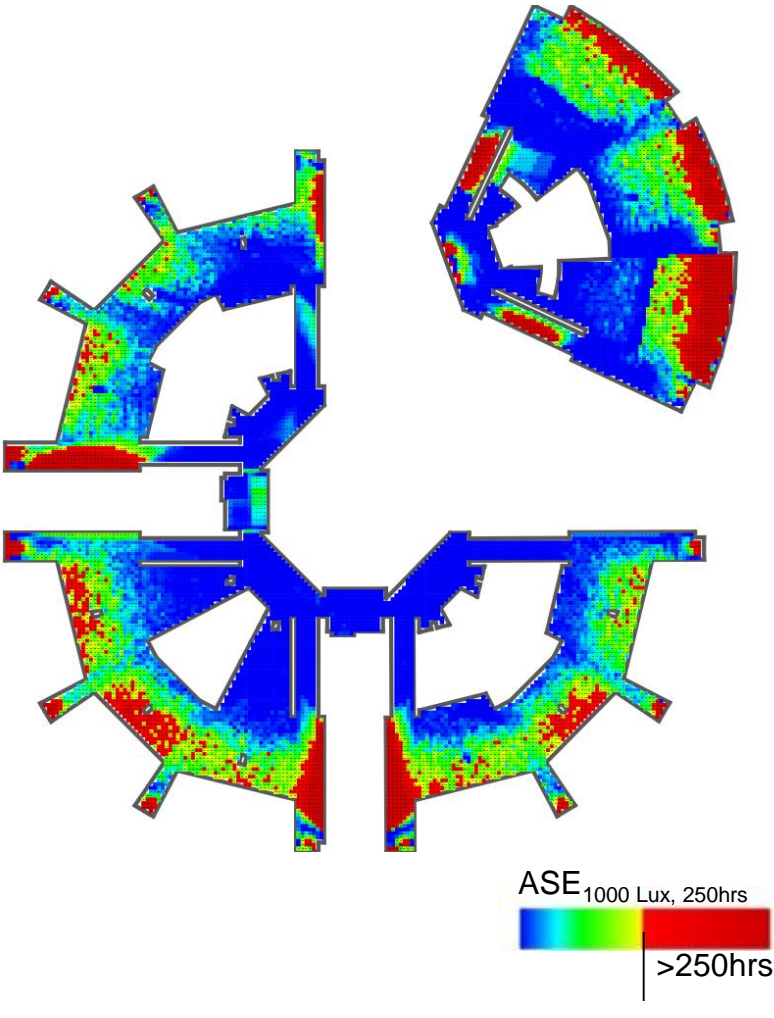
Useful Daylight Autonomy:
13.8%

ECBC Standard- Not Met
GRIHA- Mandatory Not Met
Performance goal- Not met



Spatial Daylight Autonomy:
68.4%

LEED Credit: Met
Note- No Credit given due to High ASE in LEED Certification

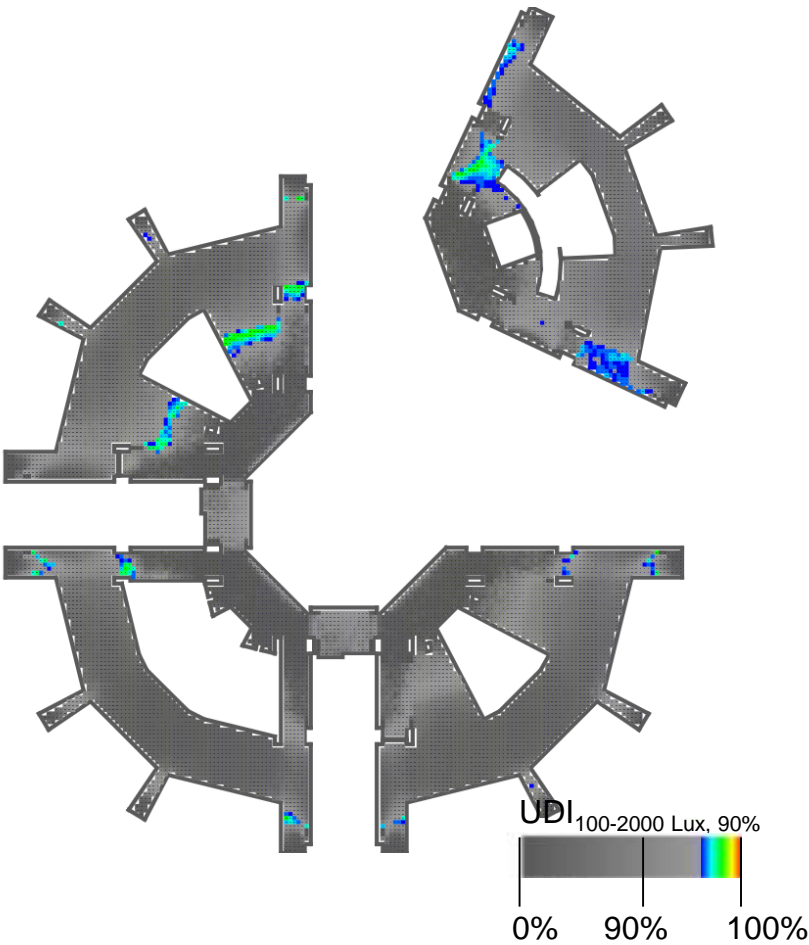


Annual Sunlight Exposure:
14.6%

LEED Credit: Not Met

Daylight Results | Baseline Case

UDI, SDA & ASE – Fourth Floor

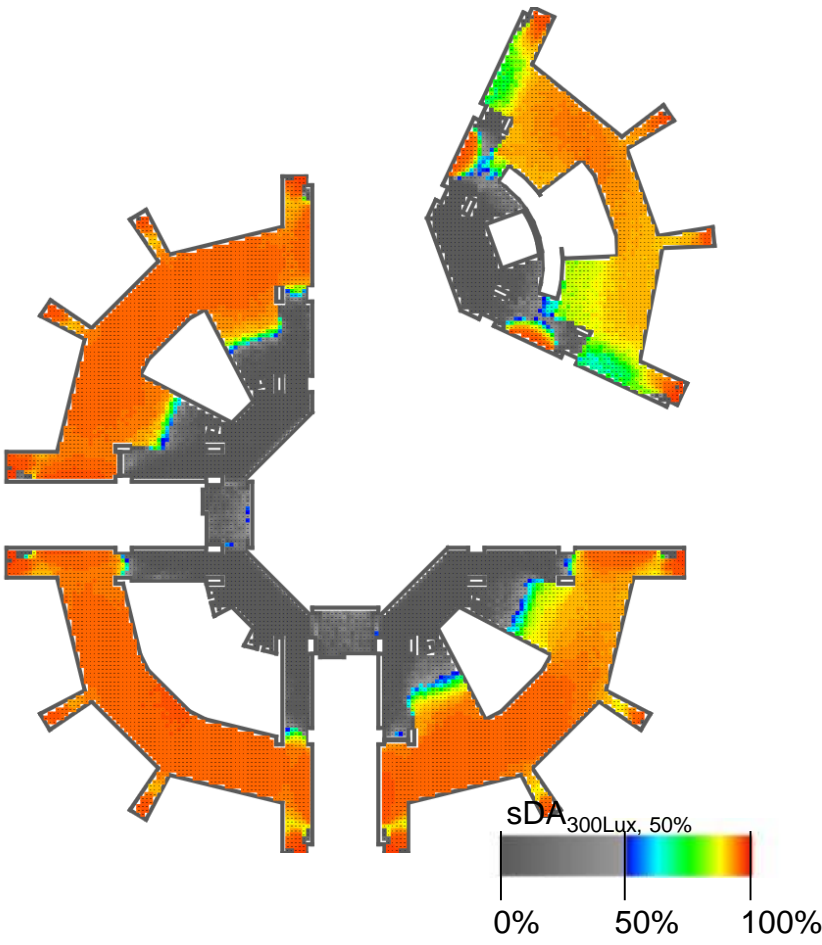


Useful Daylight Autonomy: 3.9%

ECBC Standard- Not Met

GRIHA- Mandatory Not Met

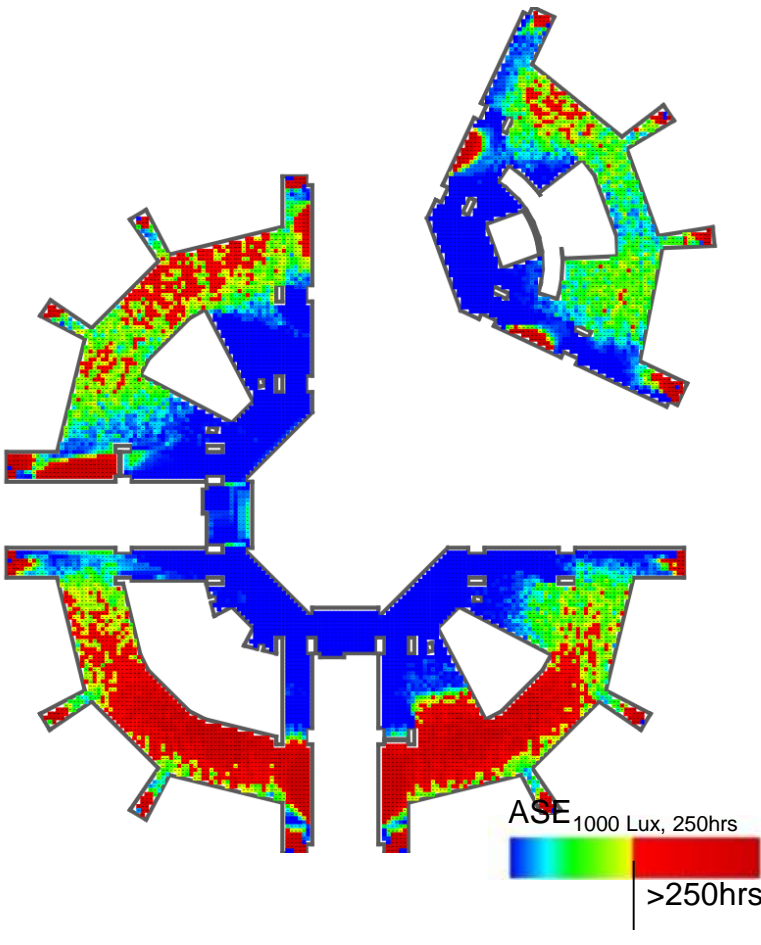
Performance goal- Not met



Spatial Daylight Autonomy: 67.6%

LEED Credit: Met

Note- No Credit given due to High ASE in LEED Certification

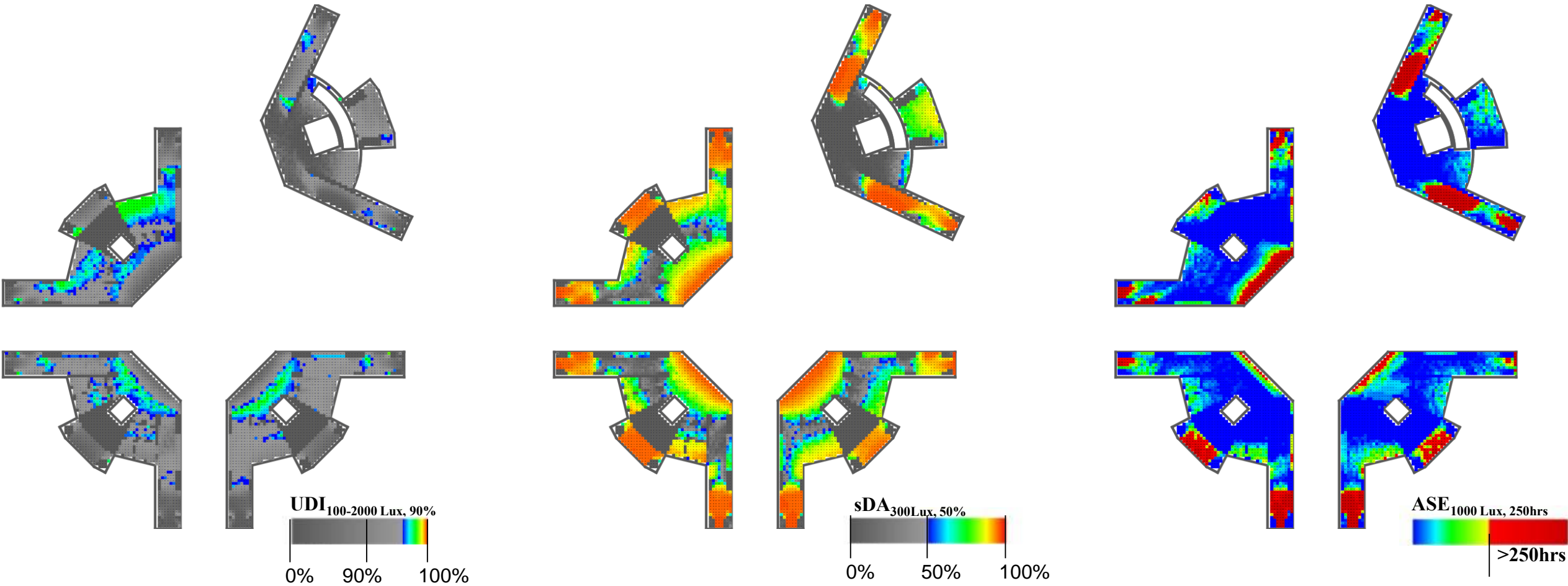


Annual Sunlight Exposure: 26.3%

LEED Credit: Not Met

Daylight Results | Baseline Case

UDI, SDA & ASE – Fifth Floor



Useful Daylight Autonomy:
18.3%

ECBC Standard- Not Met
GRIHA- Mandatory Not Met
Performance goal- Not met

Spatial Daylight Autonomy:
59.7%

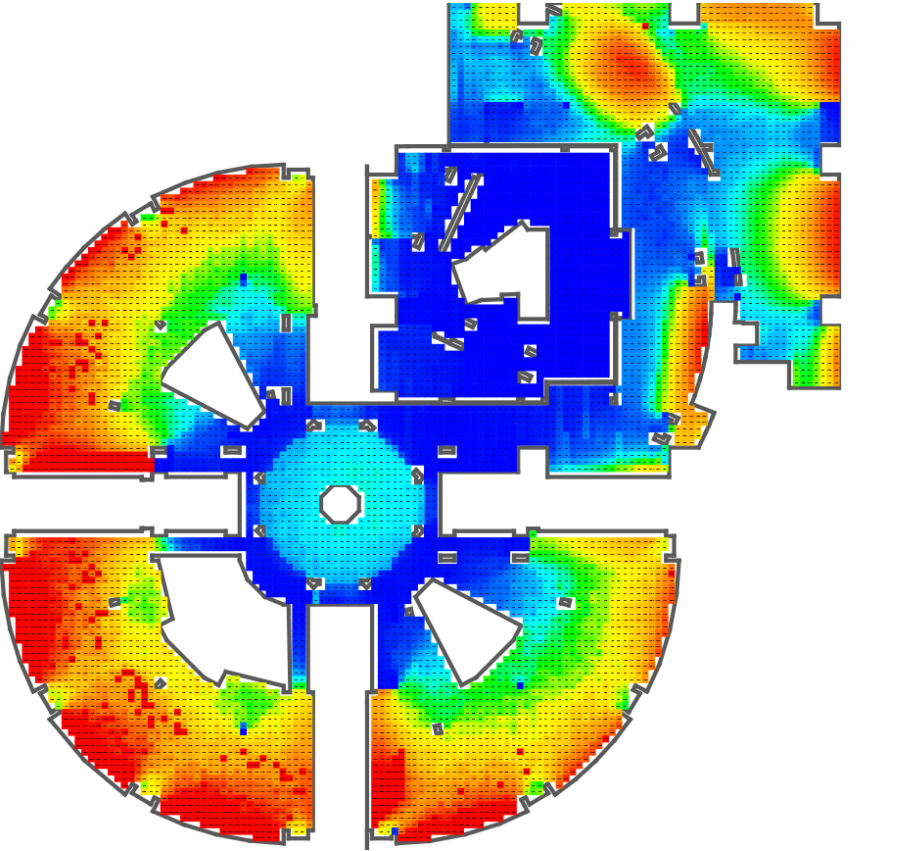
LEED Credit: 2 credits
Note- No Credit given due to High ASE in LEED Certification

Annual Sunlight Exposure:
12.7%

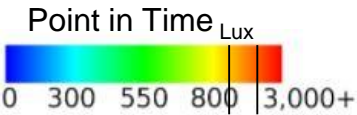
LEED Credit: Not Met

Daylight Results | Baseline Case

Point in Time Analysis – 21st September 2:00pm



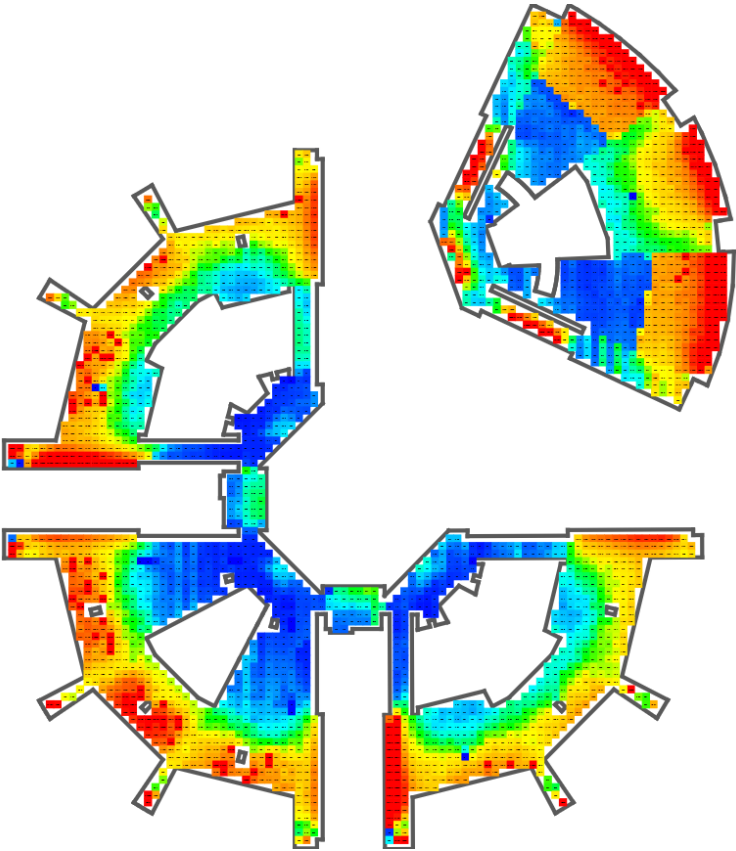
Ground Floor



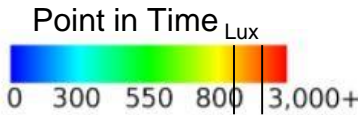
1000lux –ASE Upper Limit
2000lux – UDI Upper Limit

Point in Time (September at 2 pm)

Average – 1,512 lux
Maximum- 41,742 lux
Minimum – 0 lux



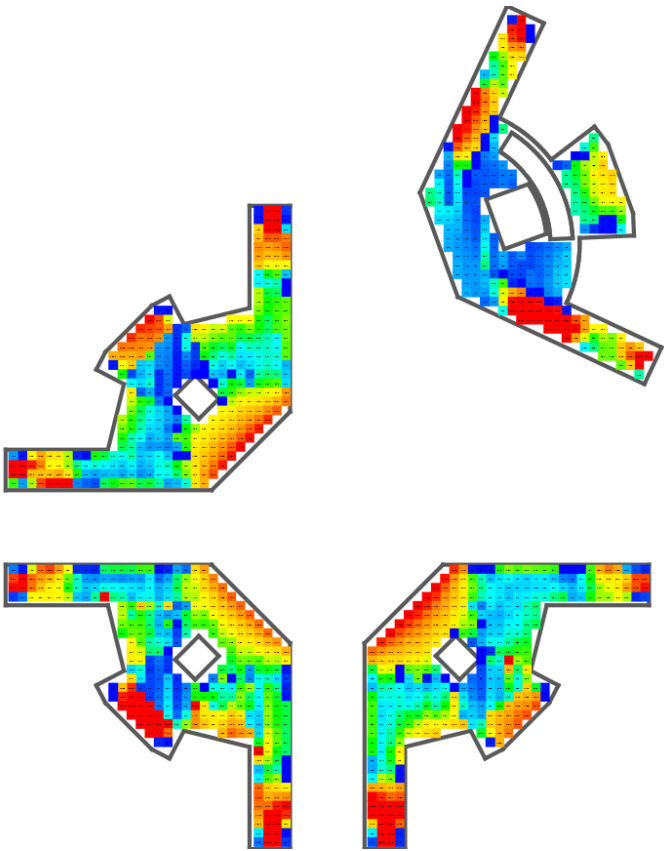
Third Floor



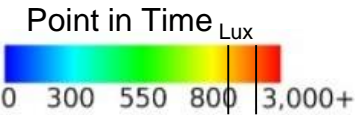
1000lux –ASE Upper Limit
2000lux – UDI Upper Limit

Point in Time (September at 2 pm)

Average – 1,753 lux
Maximum- 70,257 lux
Minimum – 0.4 lux



Fifth Floor



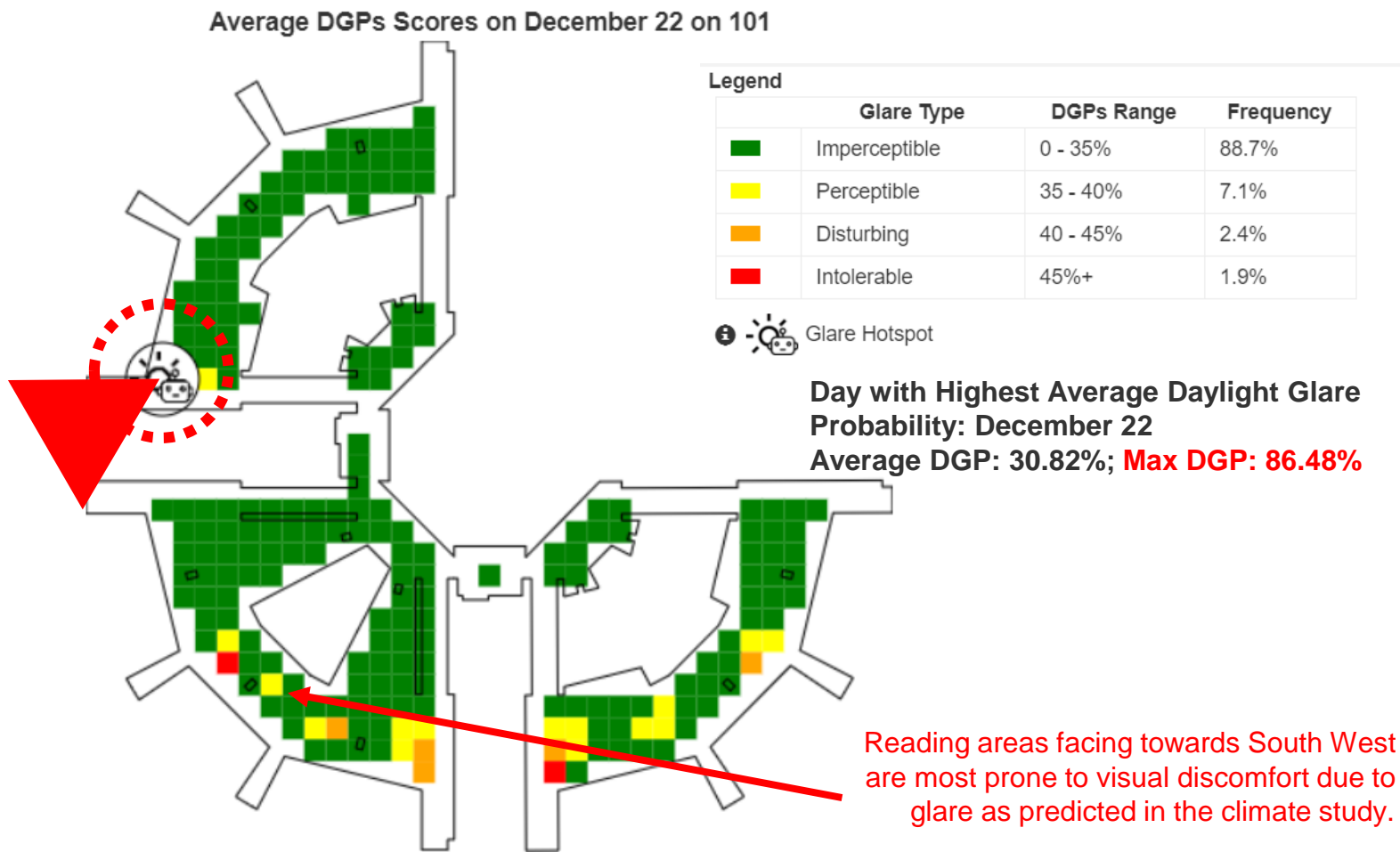
1000lux –ASE Upper Limit
2000lux – UDI Upper Limit

Point in Time (September at 2 pm)

Average – 1,106 lux
Maximum- 45,786 lux
Minimum – 0 lux

Daylight Results | Baseline Case

Annual Glare finder study (DGP)

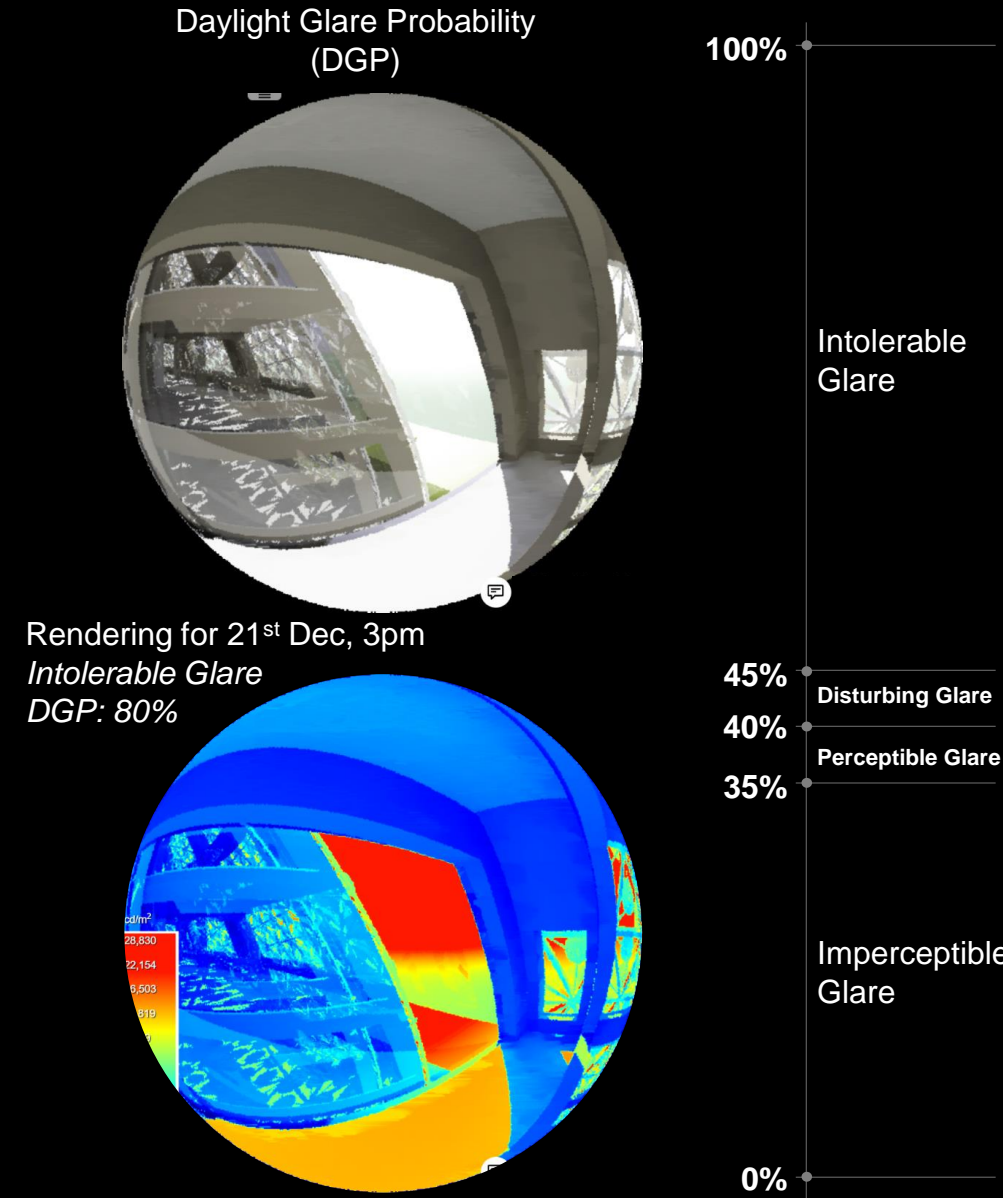


View Towards Worst Glare from the Glare Hotspot on December 22

Annual DGP score across 4th floor

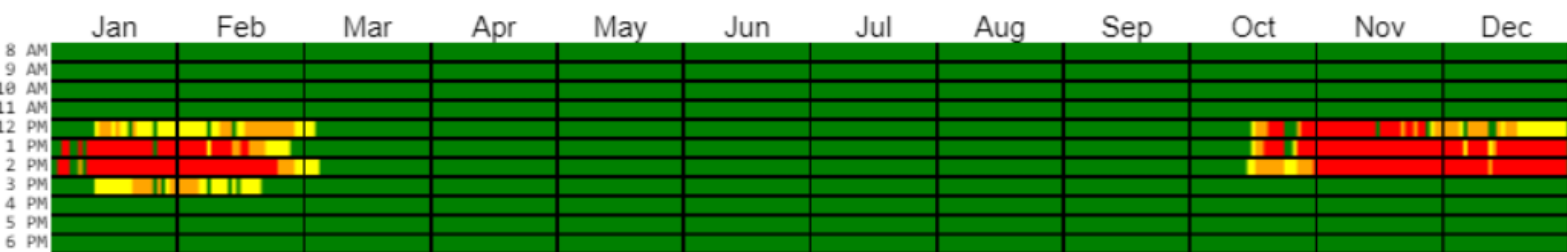
View towards worst glare from glare hotspot for Dec 22

DGP is a metric to predict the appearance of discomfort glare in day lit spaces. It calculates the luminance values in the field of view w.r.t. occupants' position. The results are in 'percentage of people disturbed' due to vertical eye illuminance.



Daylight Results | Baseline Case

Luminance based renderings, DGP & Annual glare charts



Annual Glare Chart

Legend

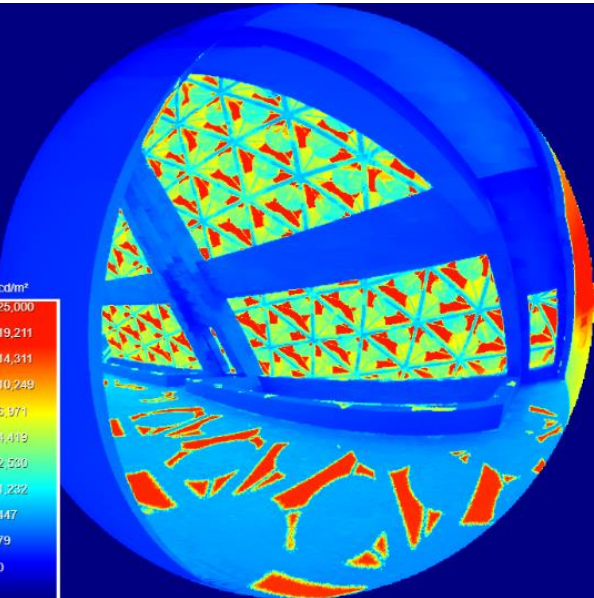
	Glare Type	DGP's Range	Frequency
■	Imperceptible	0 - 35%	88.7%
■	Perceptible	35 - 40%	7.1%
■	Disturbing	40 - 45%	2.4%
■	Intolerable	45%+	1.9%

Glare Hotspot

Reading spaces in the South West direction experience glare i.e. $DGP > 35$ from Nov-Feb (15% times annually) in the afternoon due to low altitude angle of the sun.

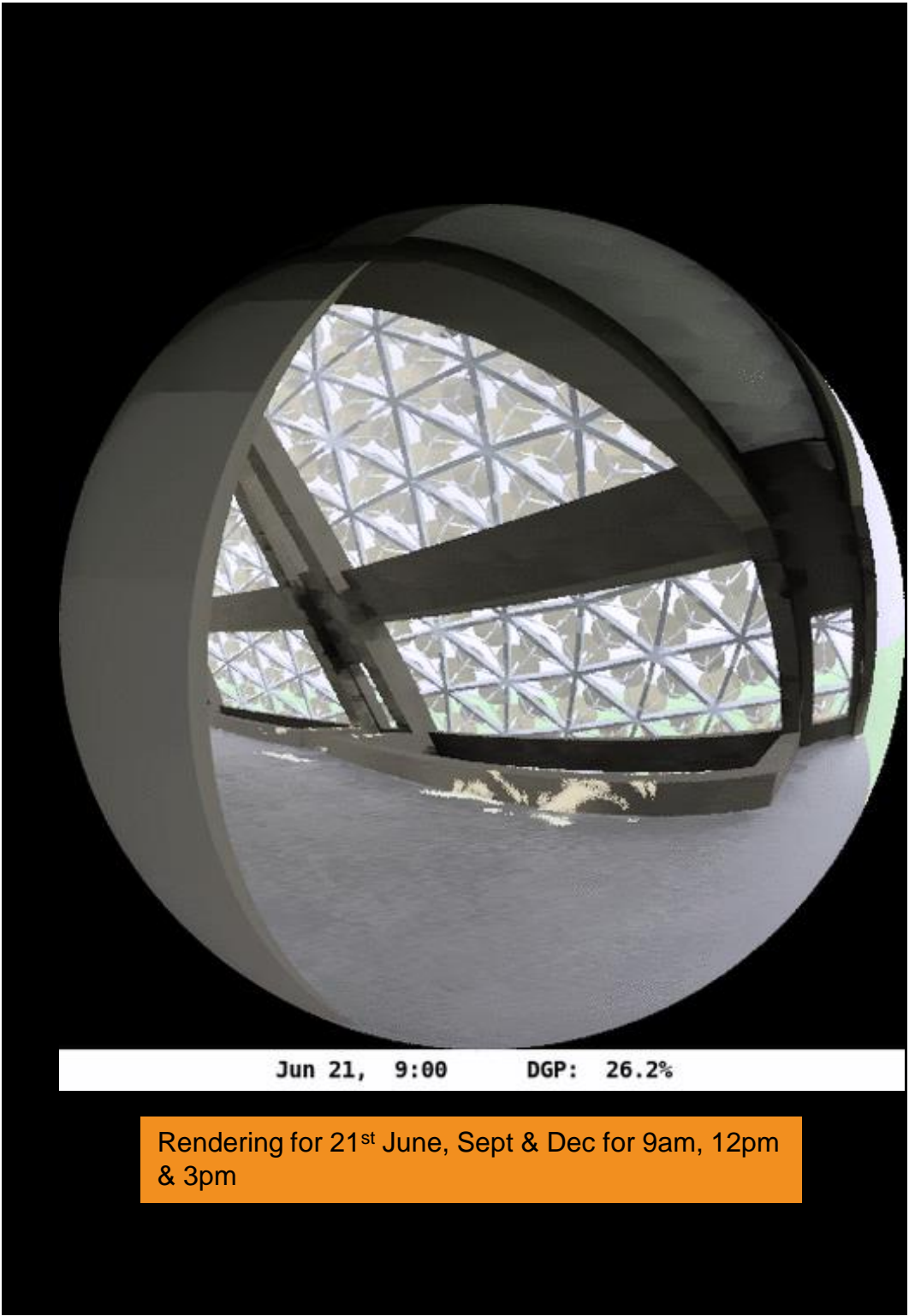


Key Plan (4th Floor)



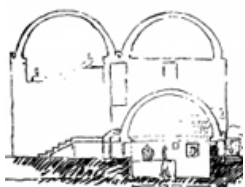
False color image for 21st Dec, 3pm

Rendering for 21st Dec, 3pm
Intolerable Glare
DGP: 50%



Rendering for 21st June, Sept & Dec for 9am, 12pm & 3pm

Inferences and Way forward for Stage 2



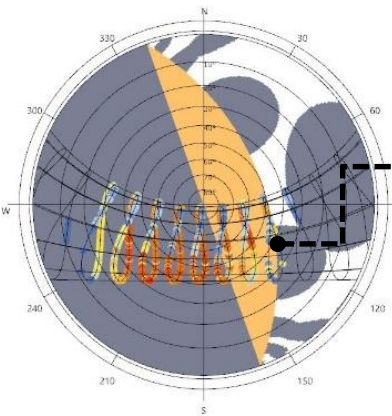
Results Summary | Probable areas of exploration

The base case results indicate that the current design is not able to meet the minimum daylight performance targets of the certification i.e. GRIHA and ECBC 2017. The main observations are as follows:-

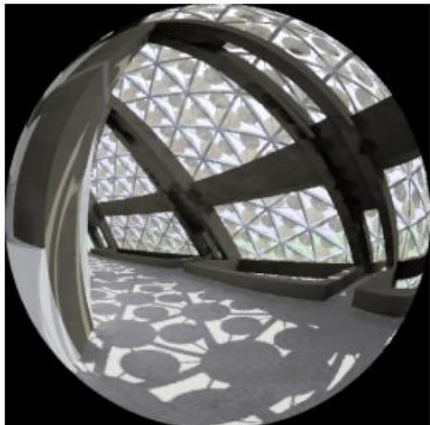
Internal finishes :- The results show that daylight is insufficient at deeper ends of the building, especially in the rectangular pedestal. The main reason is lack of internal reflections and the dark ceiling. Thus it would be required to consider white ceiling and light-colored internal finishes to enhance daylight penetration into deeper ends.



Shading from the façade / discs :- It has been observed that the disc façade is unable to cut direct sun and avoid glare into the reading spaces. The shading mask clearly shows that a major portion of the façade is exposed to sun for the harsh periods. Densification of the discs will lead to loss of daylight inside even if it shades and cuts the glare for the reading spaces



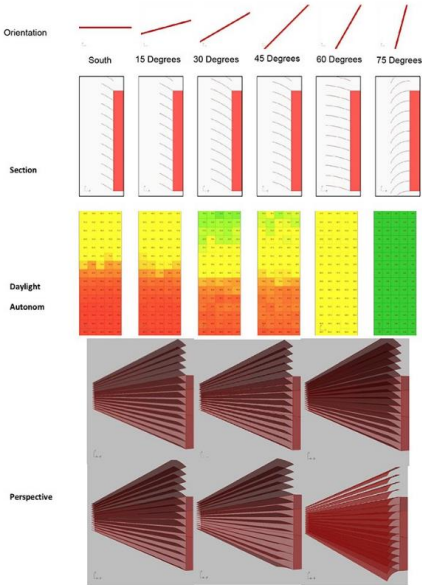
Gaps between the discs are unable to block the harsh sun for many hours and need additional shading to combat this effect



DGP: 35.6%

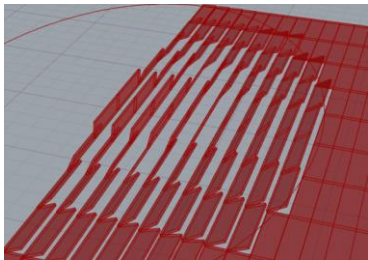
Modular Approach

For each orientation, the worst angle (i.e. maximum) vertical or horizontal shading angle can be adopted, and all the domes can have shading devices in a grid / egg create pattern behind the discs.

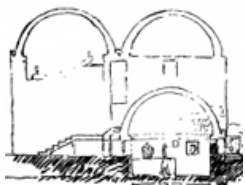


Parametric Approach

Each orientation as well as depending upon the curvature the façade will have varying shading angles and varying lengths of the overhangs and side fins. This will be challenging to execute on site but can be explored as an option

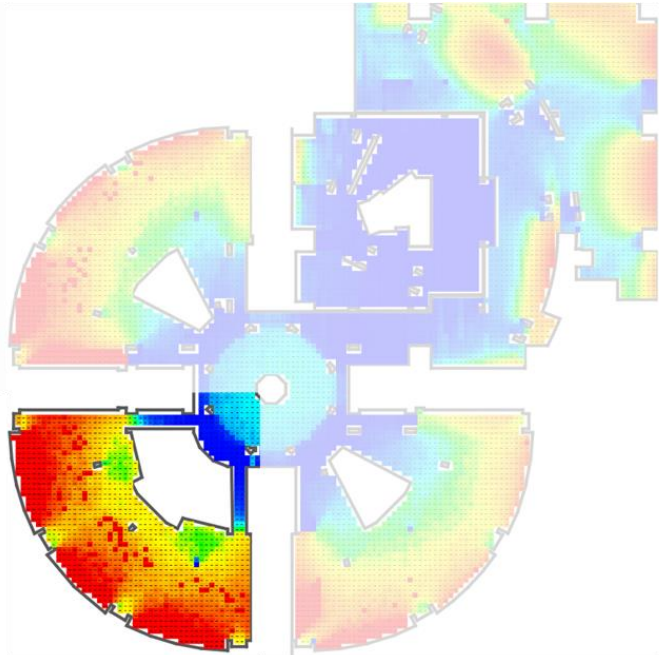


Stage 2, PART 1: Design Iterations for improving daylight performance



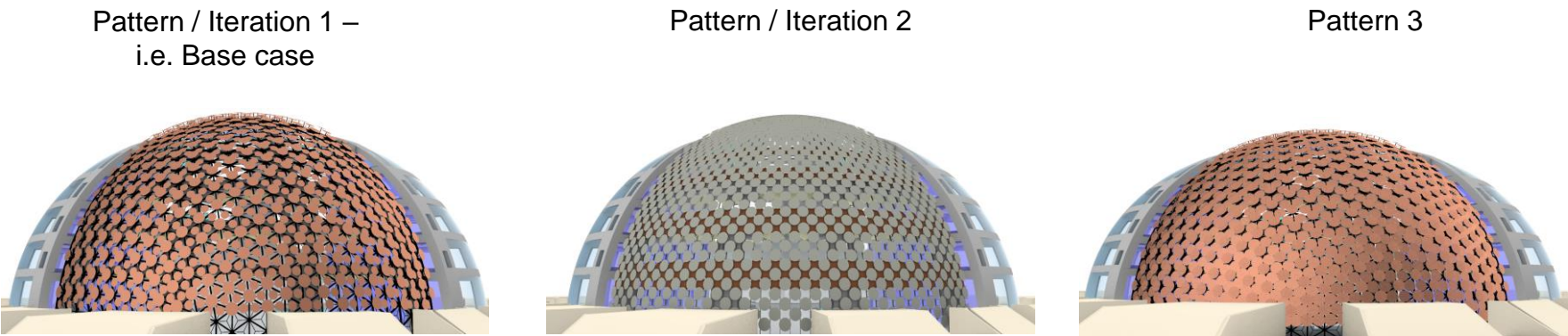
Daylight Analysis | Optimization Of Façade

In this Stage, Iterations are tested to improve the Daylight performance of the Domes only. As a worst-case scenario the south-west dome is studied in detail for different design options. The recommended strategies that work best for SW dome will then be optimized on the other domes as well. The following parameters have been selected to study:-
1. Three façade Patterns, 2. Horizontal shading devices / light shelves 3. Perforated Discs, 4. Glazing VLT (60%-base case and 30%), and Ceiling Reflectance value (40% and 75%)

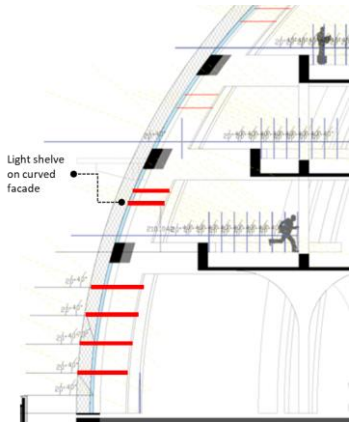


South West Dome / Quadrant performed the worst in the base case daylight performance and is the most exposed to harsh sun

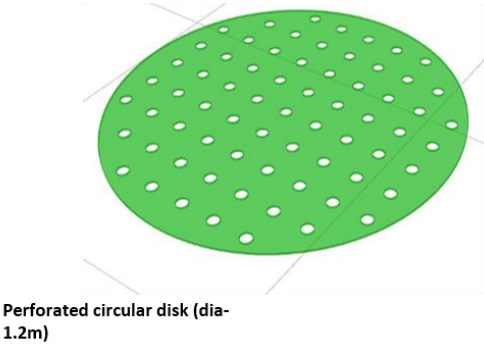
Façade Patterns



Horizontal Shading

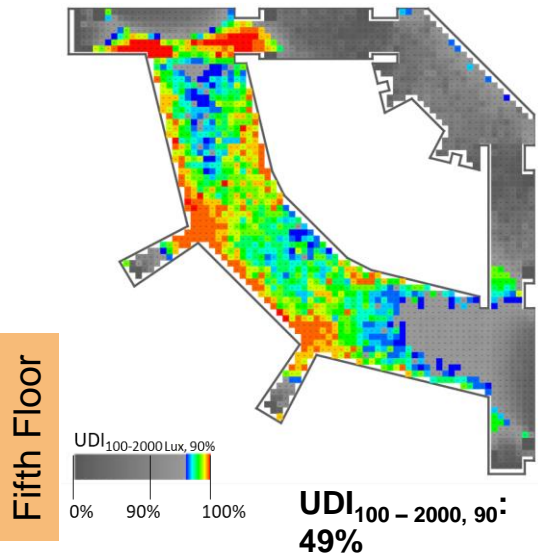
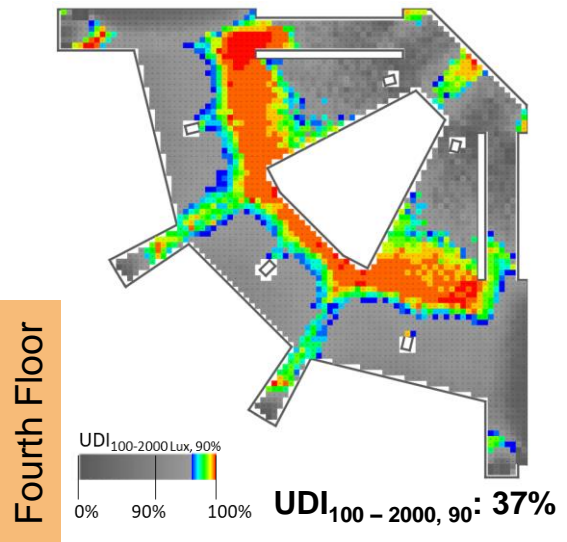
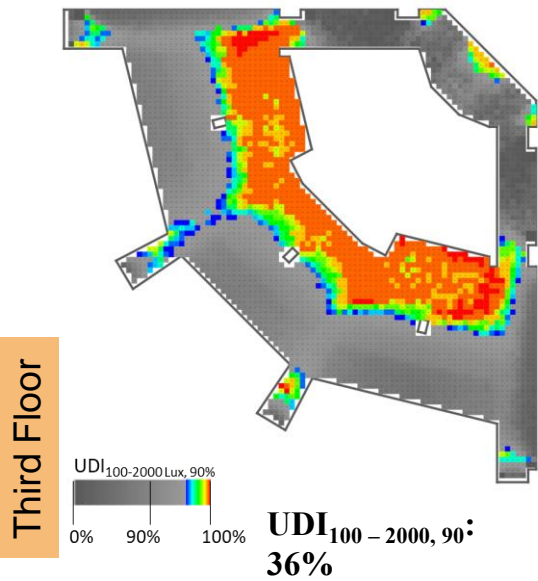
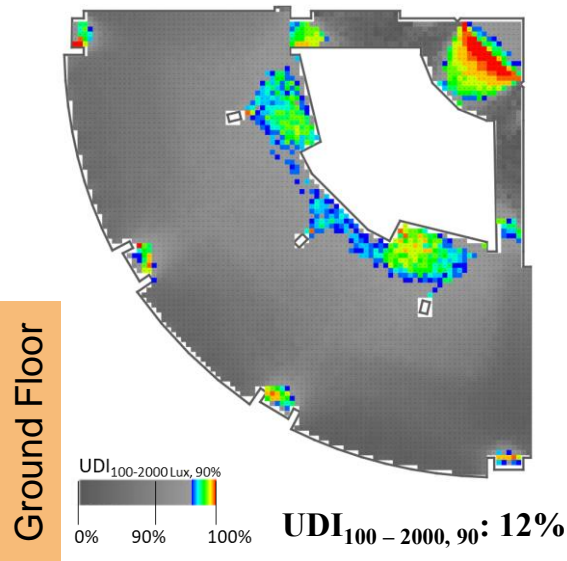


Perforated Discs (15% open)



Daylight Analysis | UDI with glazing VLT 60%

Iteration 2: 1200mm disk (initial design option before base case)



Observation

Iteration 2, the gap between the discs reduce as we go higher towards the upper part of the dome.

On the ground floor, the gap is huge and is unable to cut direct sun and avoid glare into the reading spaces and therefore, its implication can be seen with just 12% UDI.

Illuminance levels greater than 2000 lux is the majorly observed here. Similarly, the on 2nd & 3rd floors as well, the perimeter has illuminance values >2000lux for more than 10% times of the year which leads to UDI criteria not meeting in these areas.

On 5th floor due to densification of grid the general illuminance levels throughout the year remains within the threshold of 100-2000 lux.

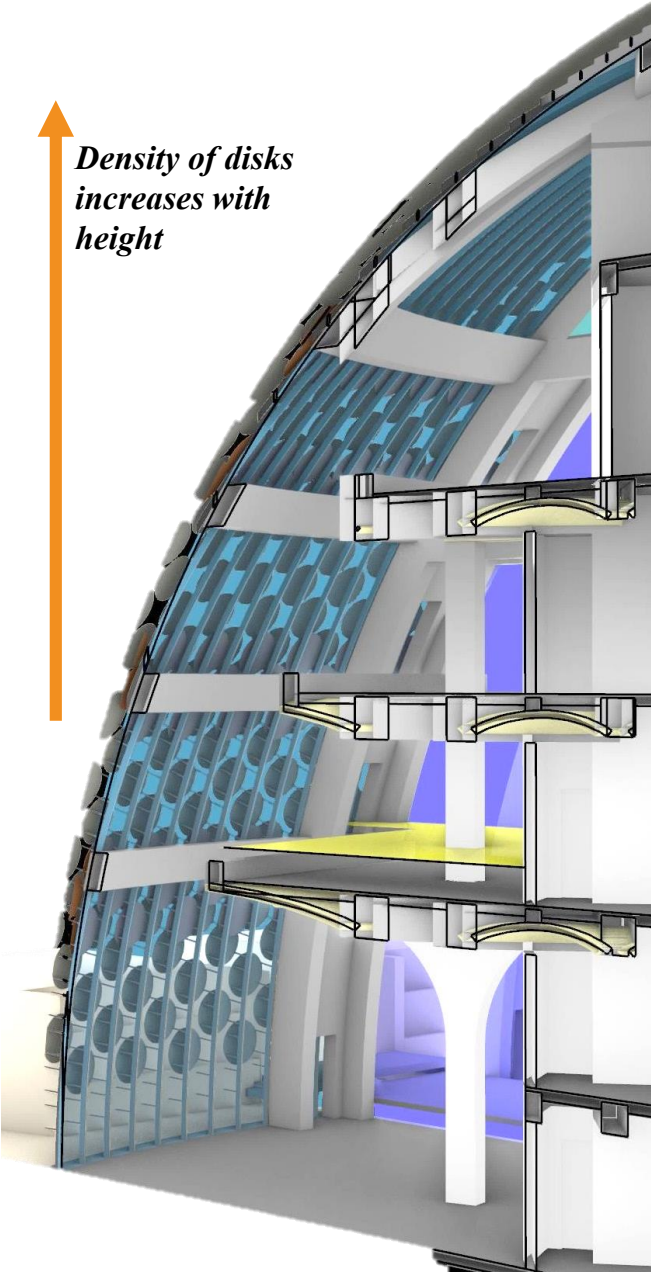
Also, the disks are blocking daylight on early morning & late evening hours when global horizontal radiation is in general low. During these times, the illuminance levels drop below 100Lux.

Inference

Densification of the discs on lower floors will lead to loss of daylight inside even if it shades and cuts the glare for the reading spaces as these floor plates are much deeper >10m.

Therefore, along with the circular disks horizontal shading devices or interior light shelves are recommended to cut the direct sun penetration on all the floors.

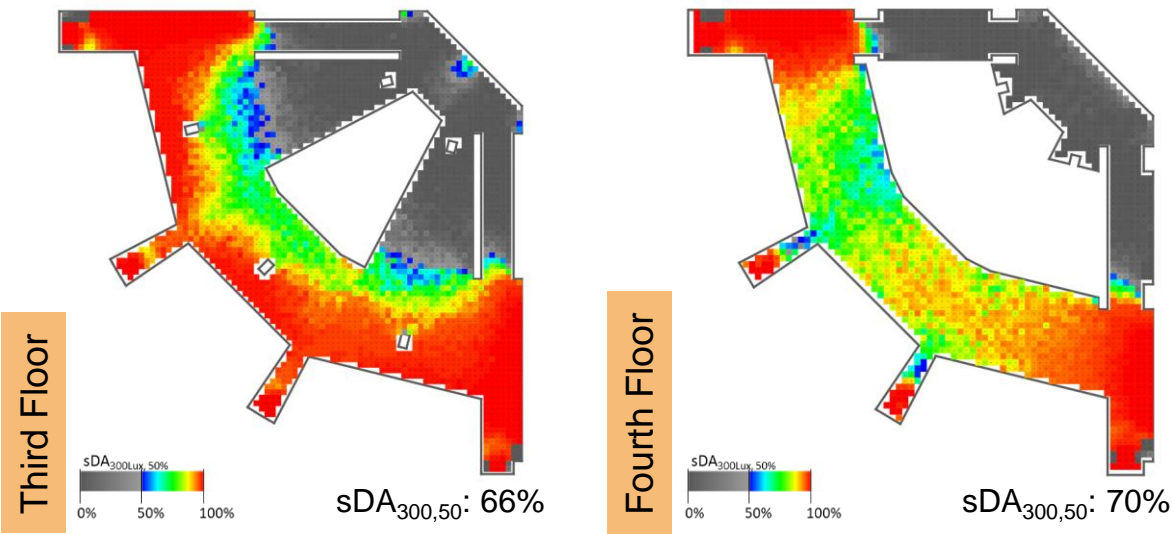
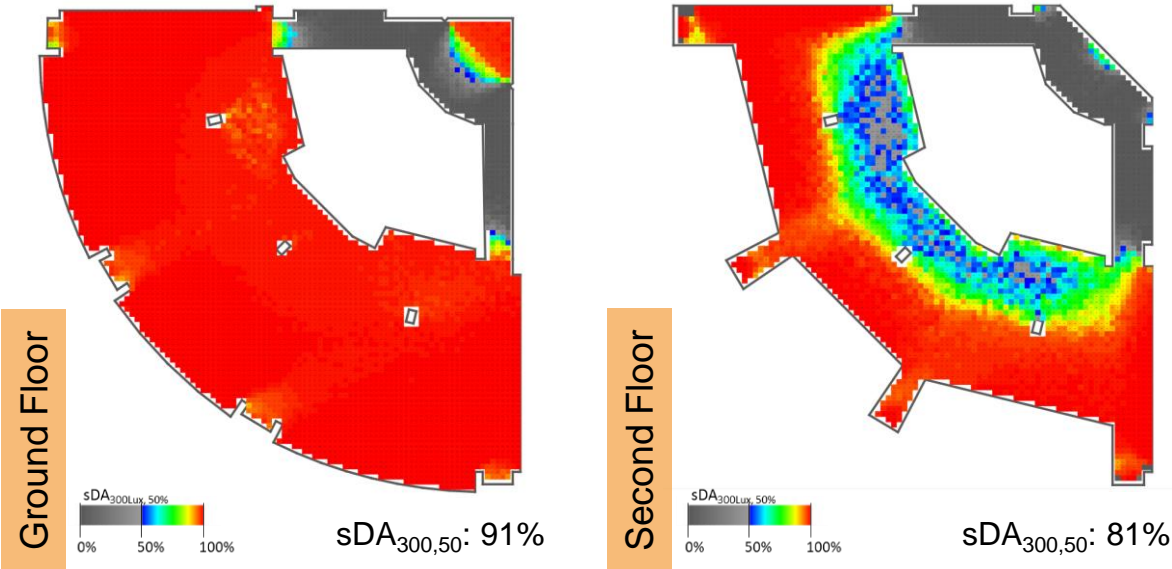
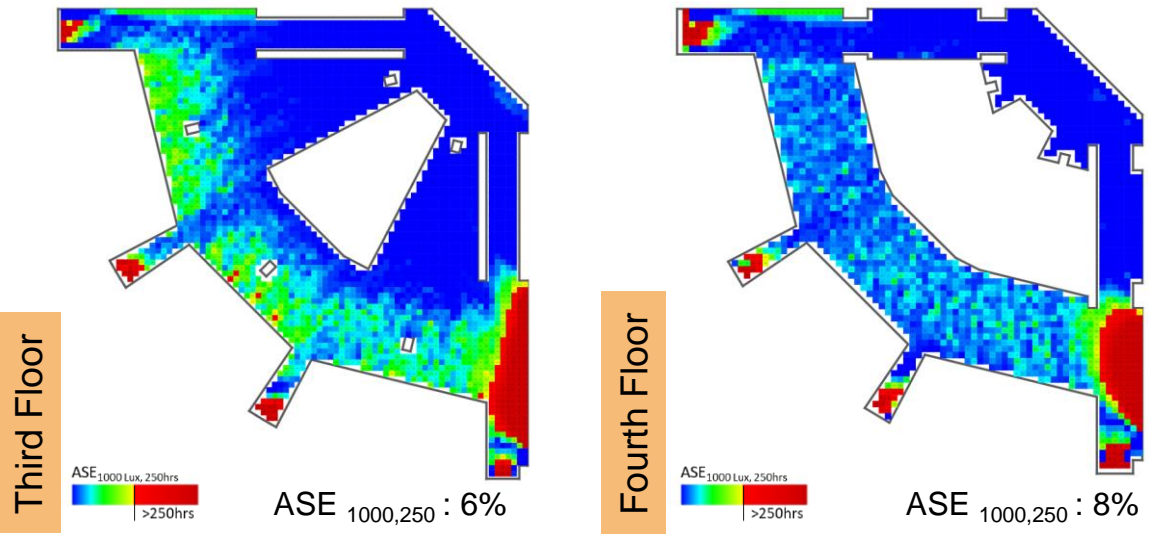
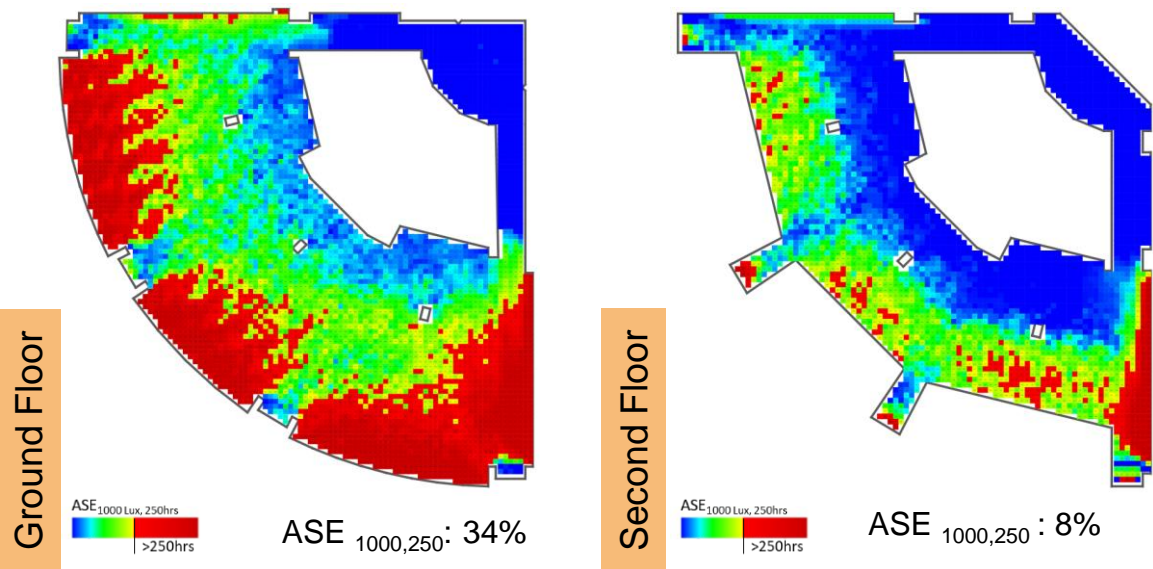
UDI time extents: 8am-5pm
Average across all floors
Iteration 2: 15%
GRIHA mandatory credits not met



Daylight Results | ASE & sDA

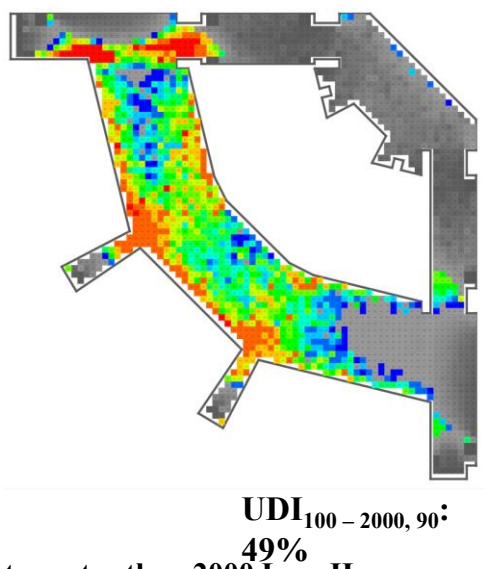
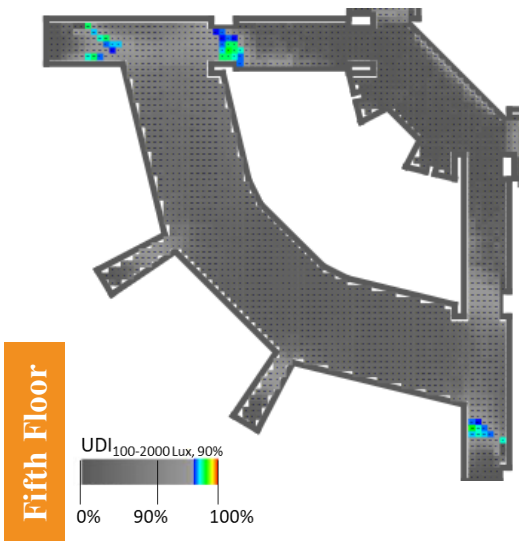
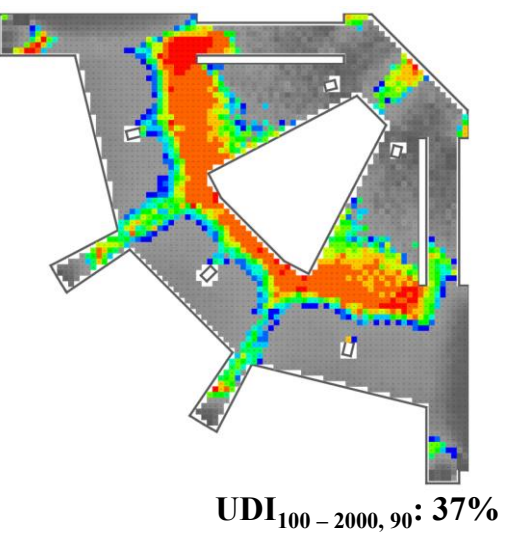
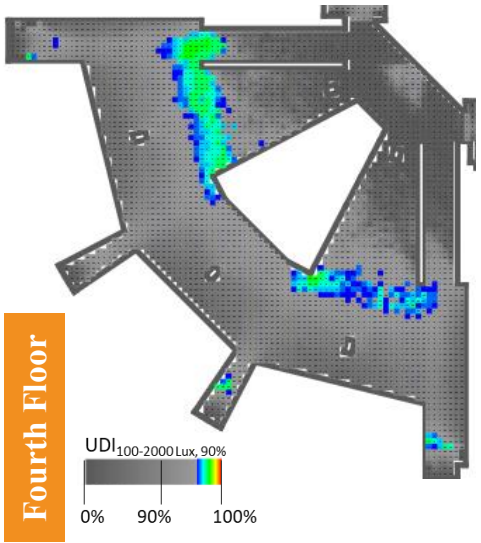
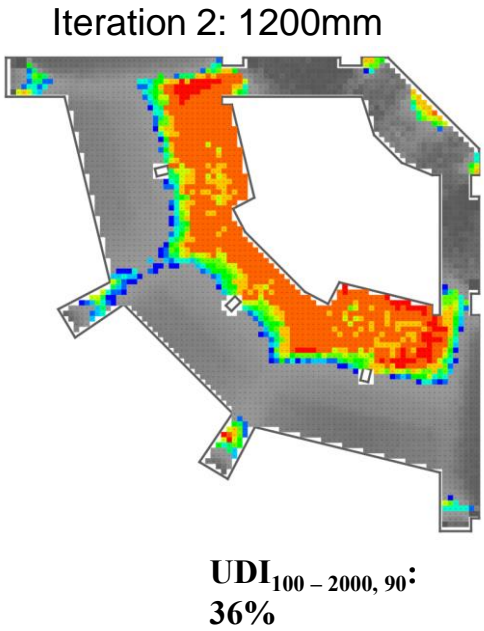
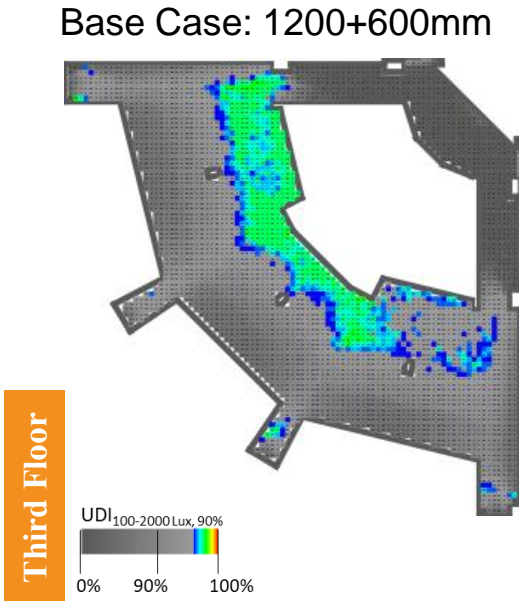
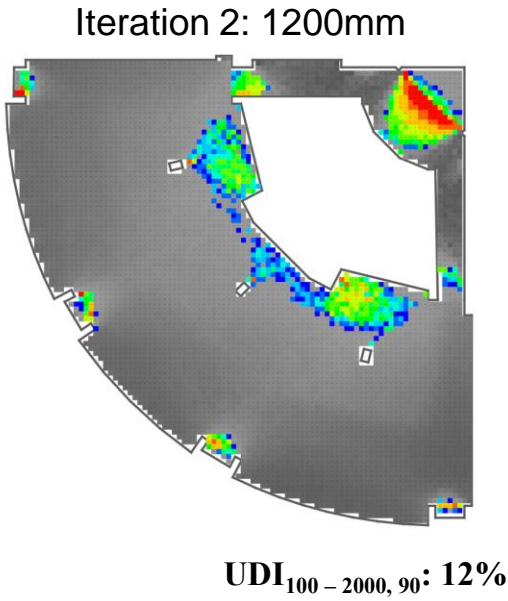
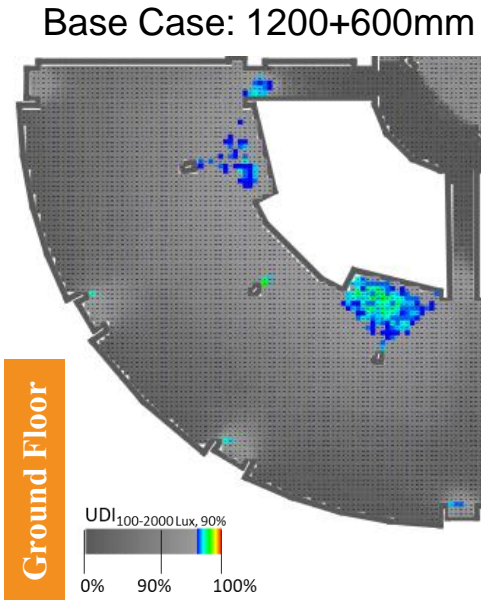
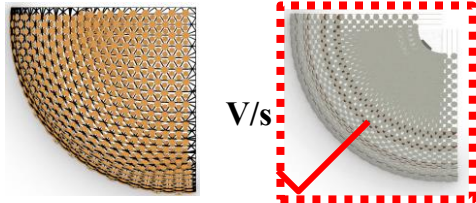
Iteration 2: 1200mm disk

SDA & ASE time extents: 8am-5pm
 Average across all floors
 Iteration 2: 78%, 17%
Not LEED compliant because ASE>10%



Daylight Results | Comparison Basecase with Iteration 2 (UDI)

Base Case: 1200mm+600mm disk V/S Iteration 2: 1200mm (Glazing VLT 60%)

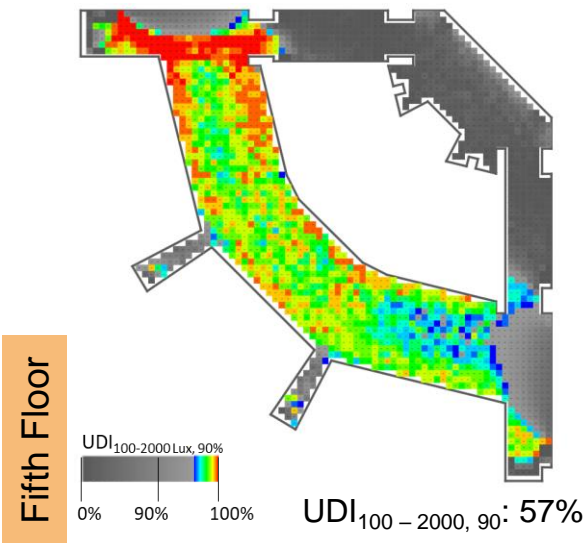
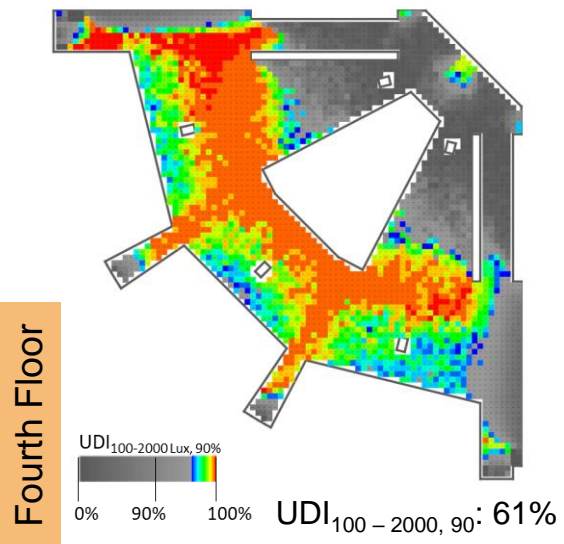
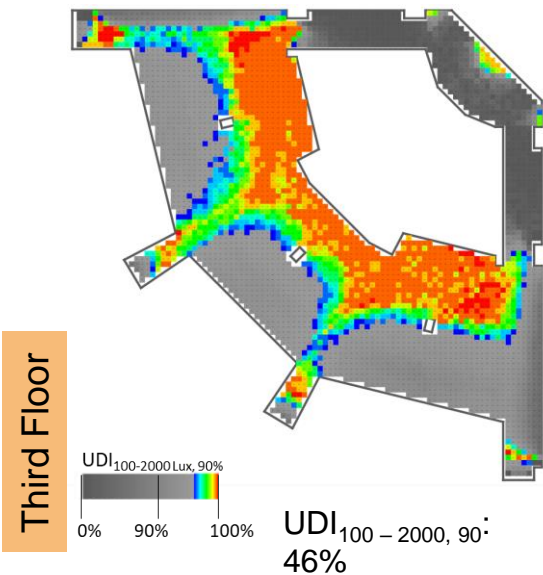
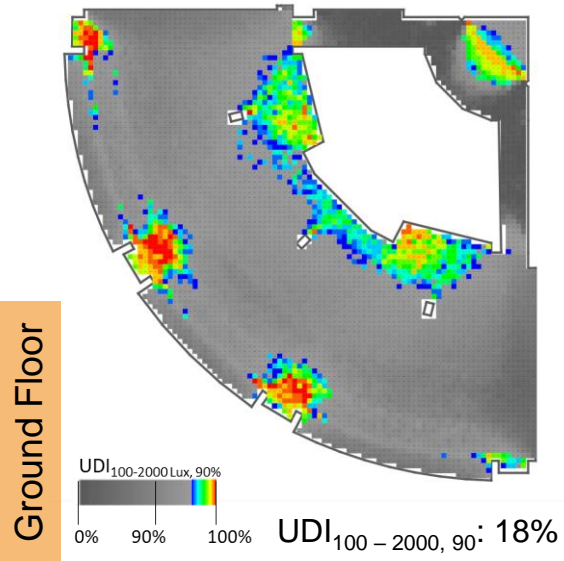
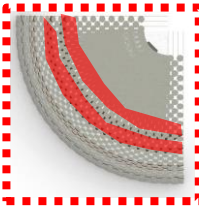


The UDI improves in Iteration 2 as compared to Base Case on 3rd 4th and 5th Floor since the increase in disc density has reduced floor area receiving light greater than 2000 Lux. However still

Daylight Results | UDI with Glazing VLT 60%

Iteration 3: 1200mm Disk + Light Shelves

UDI time extents: 8am-5pm
Average across all floors
Iteration 3: 39%
GRIHA mandatory credits not met

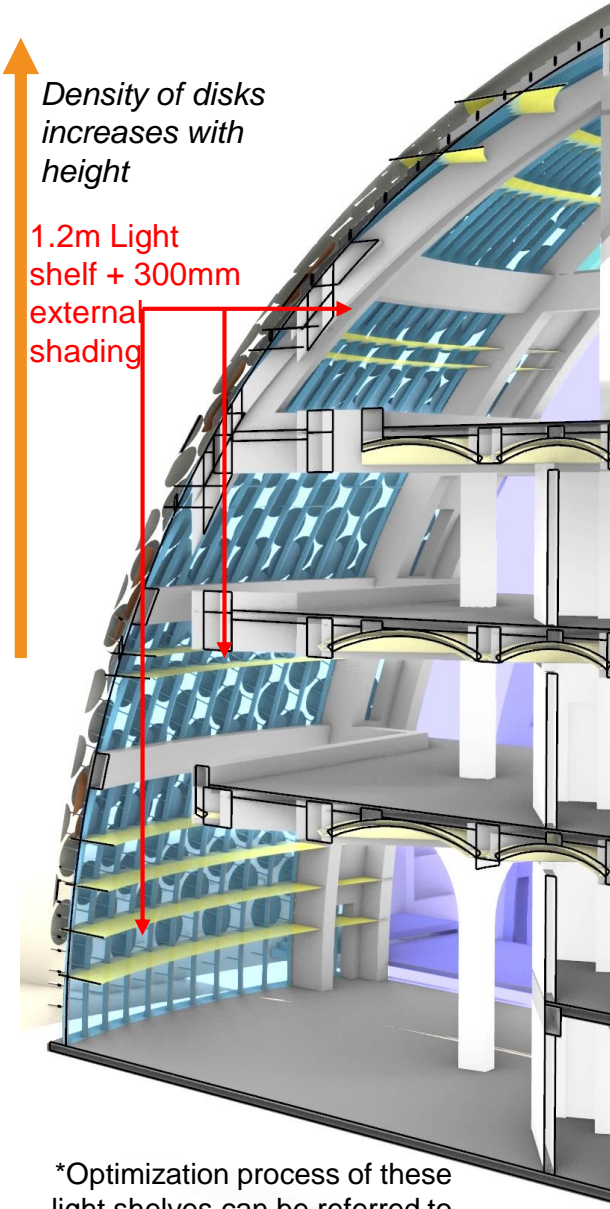


Observation
300mm external shading & 1.2m Light shelves (till RCC outer cell) have been modelled to cut the sun angle between 20-40° for the areas prone to direct solar penetration.

On the ground floor, as the density of horizontal shading devices is not enough, more sun angles need to be blocked being as being a double ht. space and low density of disks. Illuminance levels are still greater than 2000 in major parts of the reading but with a 30% improvement in UDI than previous case. 30% improvement can be seen on 3rd floor due to horizontal devices but due to similar reason as on the Gf the improvement in UDI is about 21%.

On 4th floor, UDI increased to 61% from 37% as and 10% increase on 5th floor. Direct sun on 5th floor has already been taken care by dense circular disk as seen in the previous case.

Inference
The combination of horizontal light shelf with circular disk has potential to cut the direct solar penetration and reduce points where illuminance is higher than 2000 Lux. The density & depth of these light shelf needs to be optimized for more sun angles. Further, the VLT of glass should be reduced to bring down the high illuminance levels in the perimeter along with the light shelves.

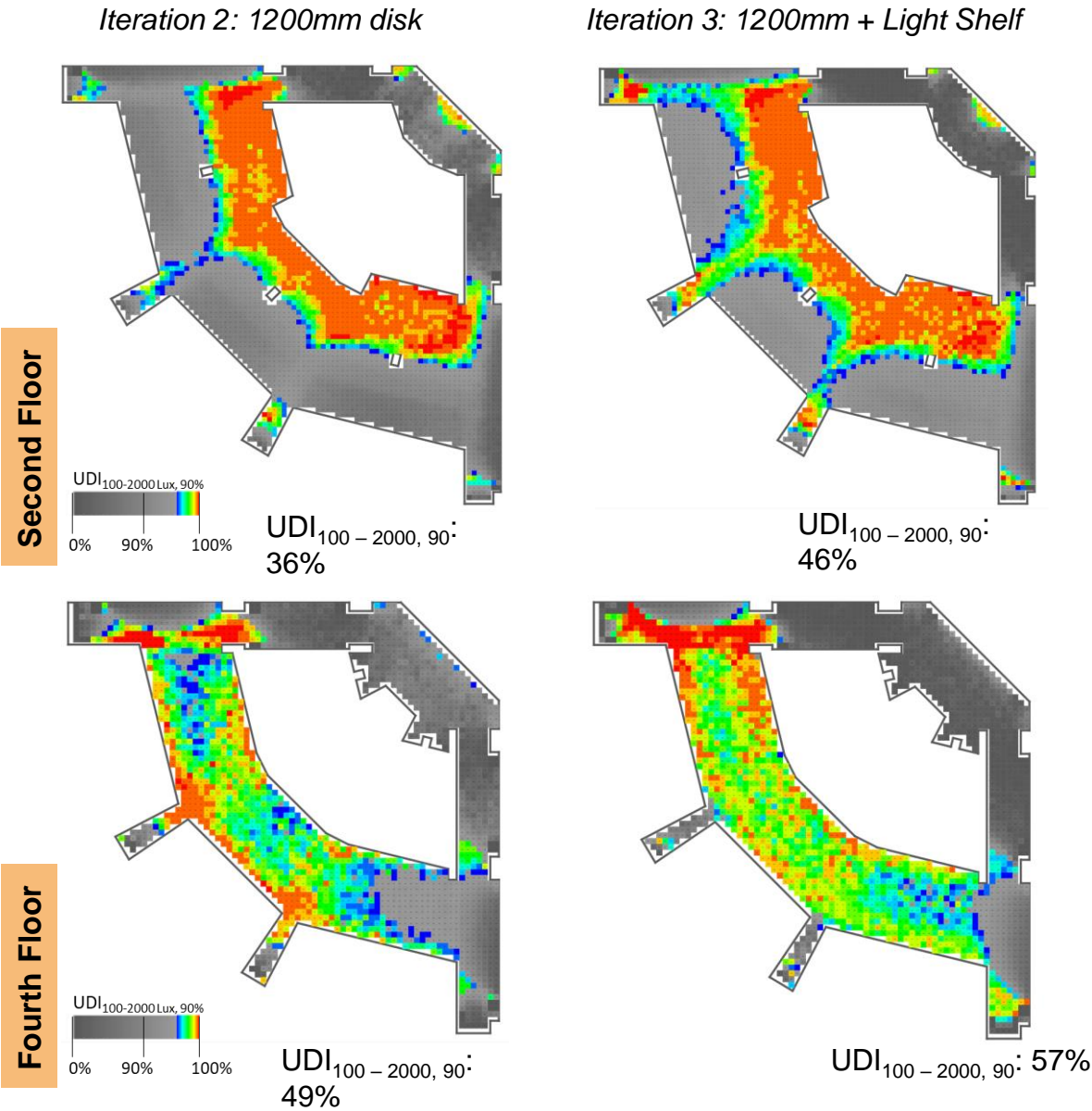
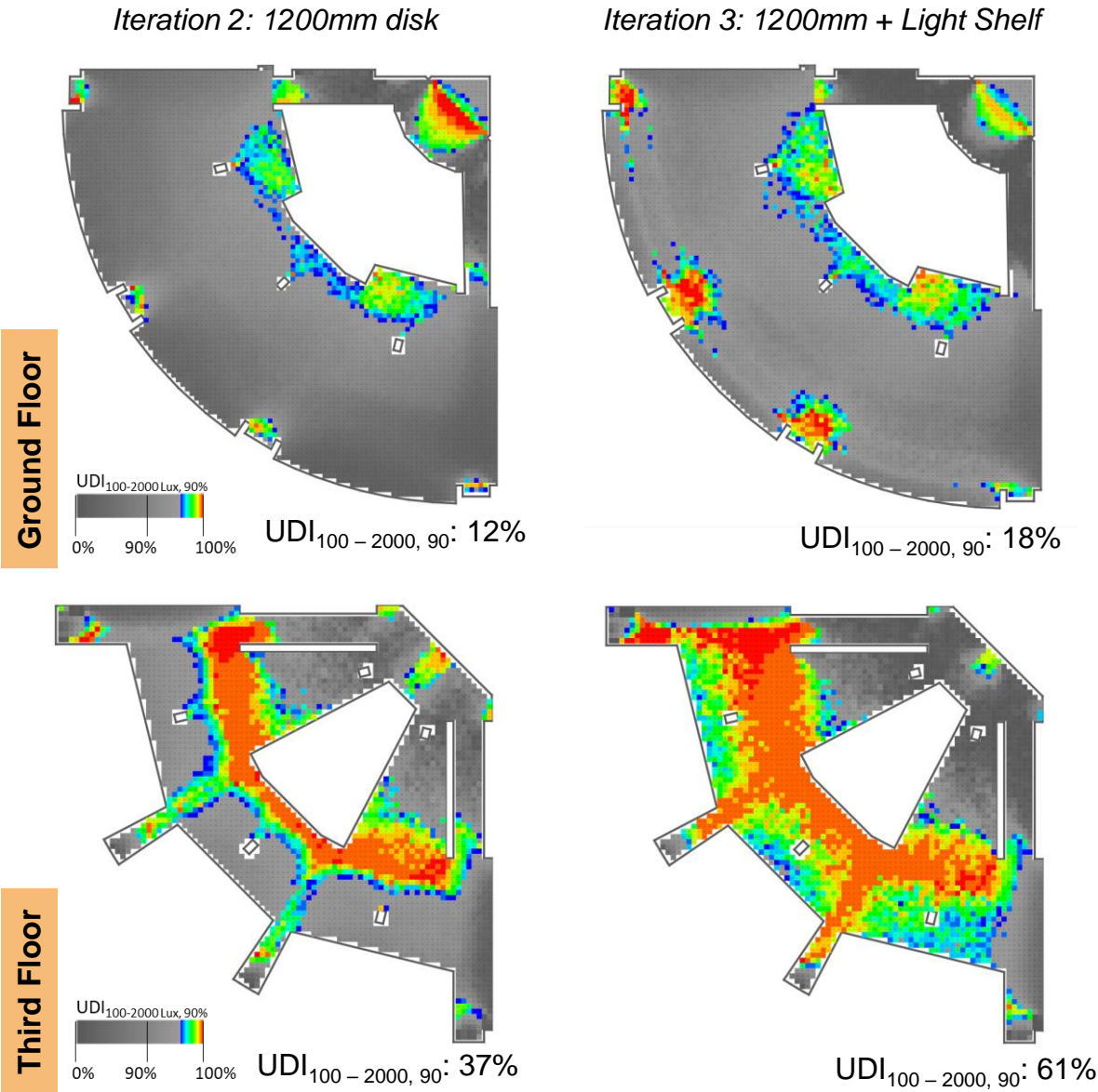
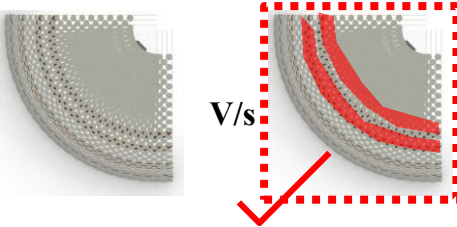


*Optimization process of these light shelves can be referred to section 1 in the appendix

Daylight Results | Comparison with glazing VLT 60%

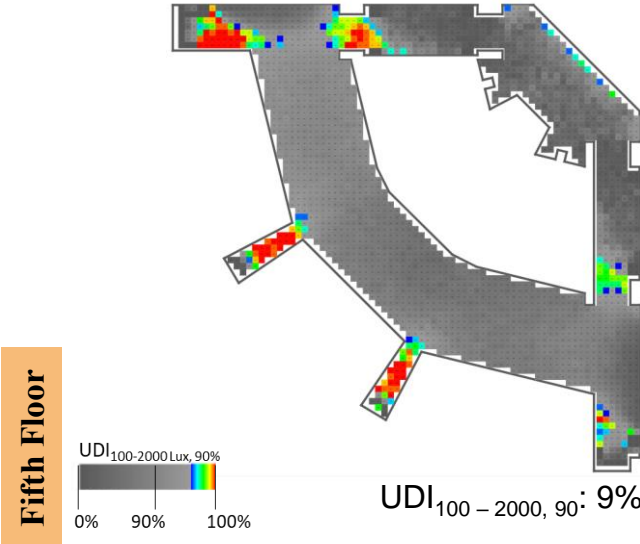
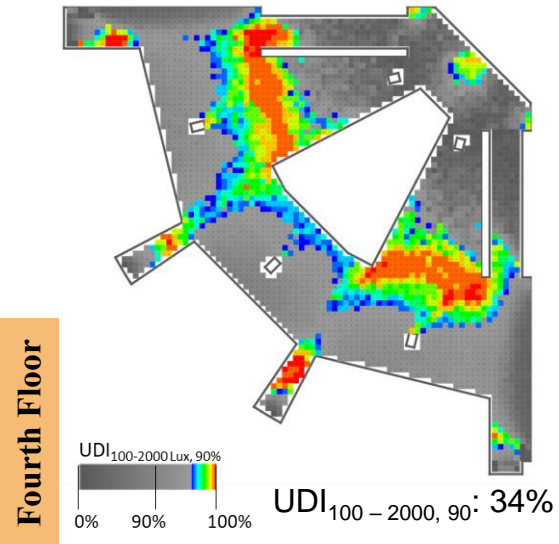
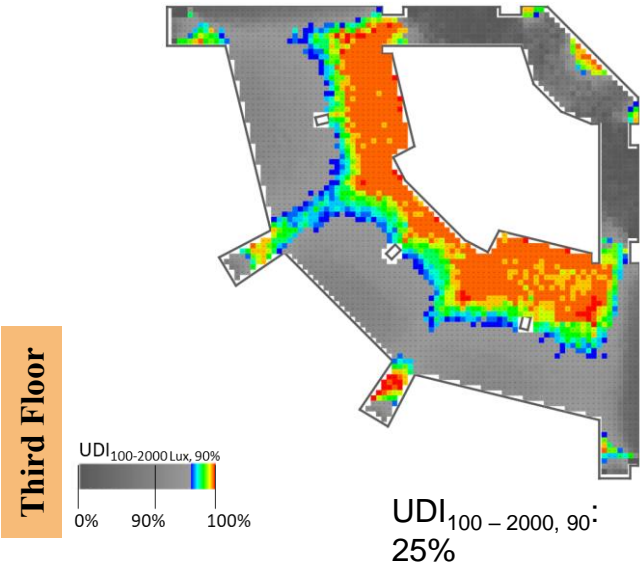
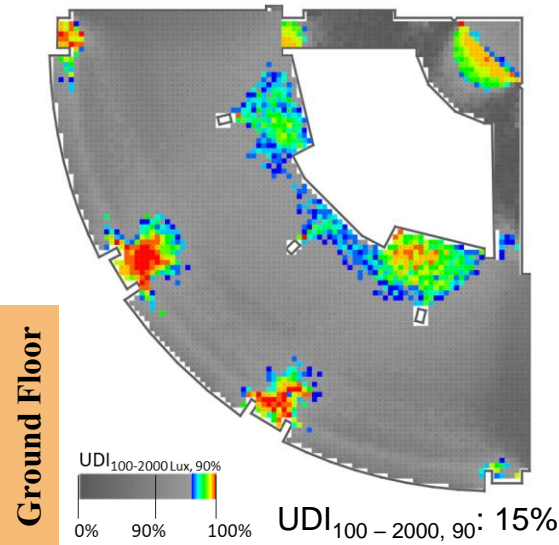
Iteration 2: 1200mm disk V/S Iteration 3: 1200mm + Light Shelf

UDI time extents: 8am-5pm
Average across all floors
Iteration 2: 29%
Iteration 3: 39%

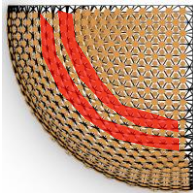


Daylight Results | UDI with glazing VLT 60%

Iteration 4: Base case (pattern 1)+ Light shelves



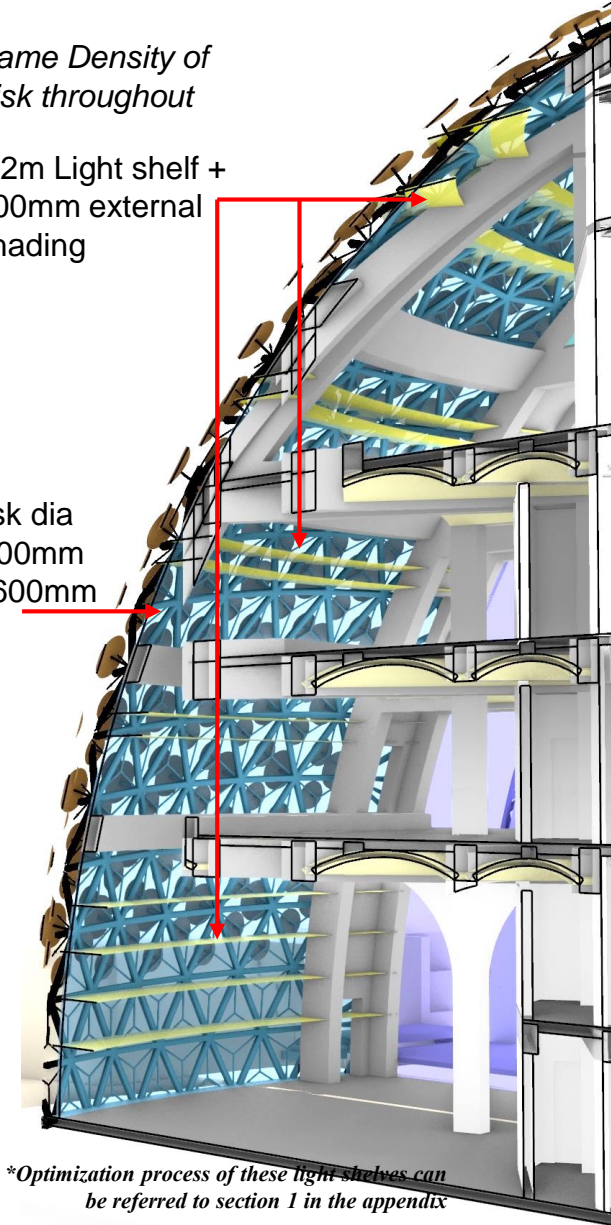
UDI time extents: 8am-5pm
Average across all floors
Iteration 4: 25%
GRIHA mandatory credits not met



Same Density of disk throughout

1.2m Light shelf +
300mm external
shading

Disk dia
1200mm
& 600mm

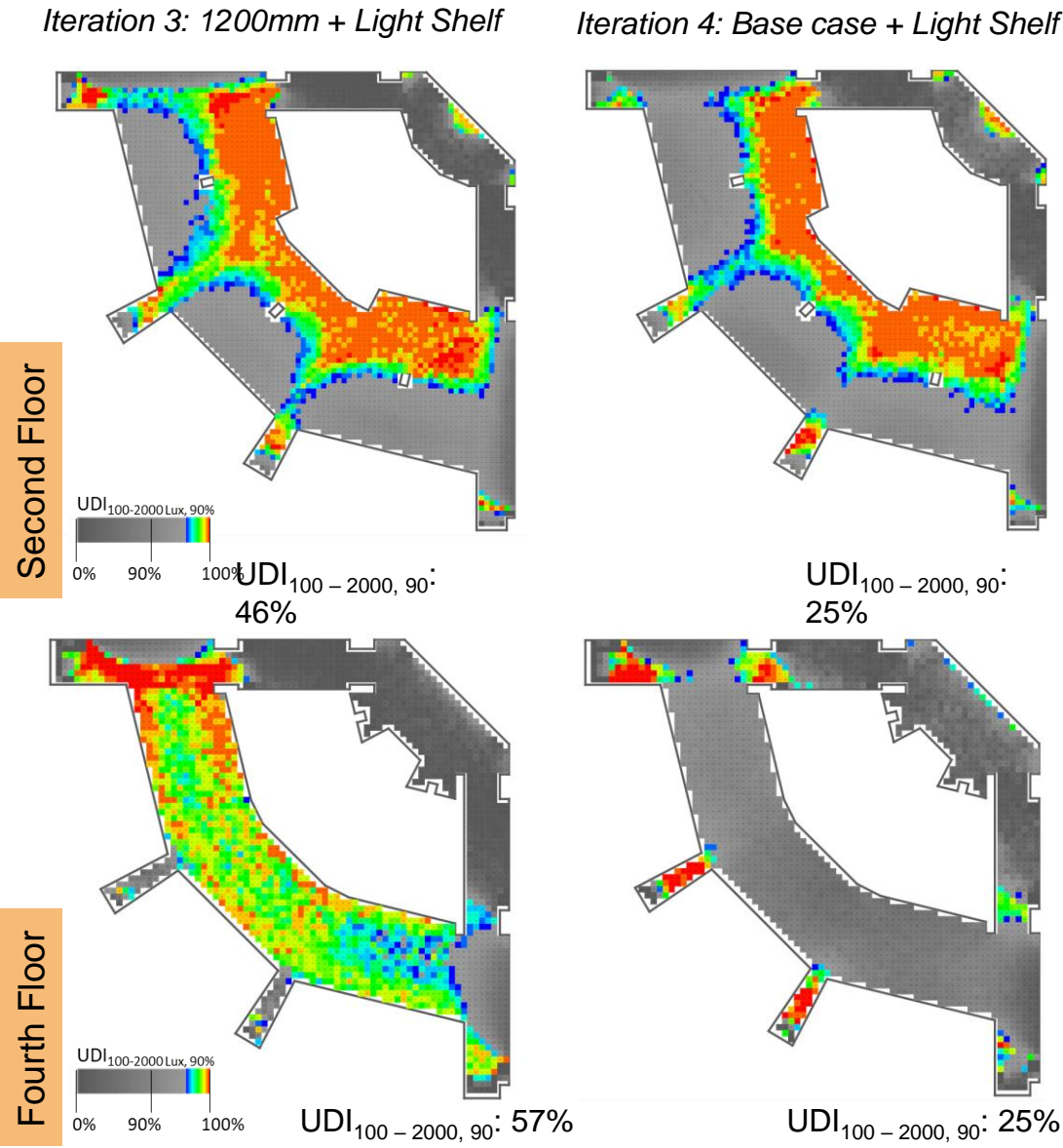
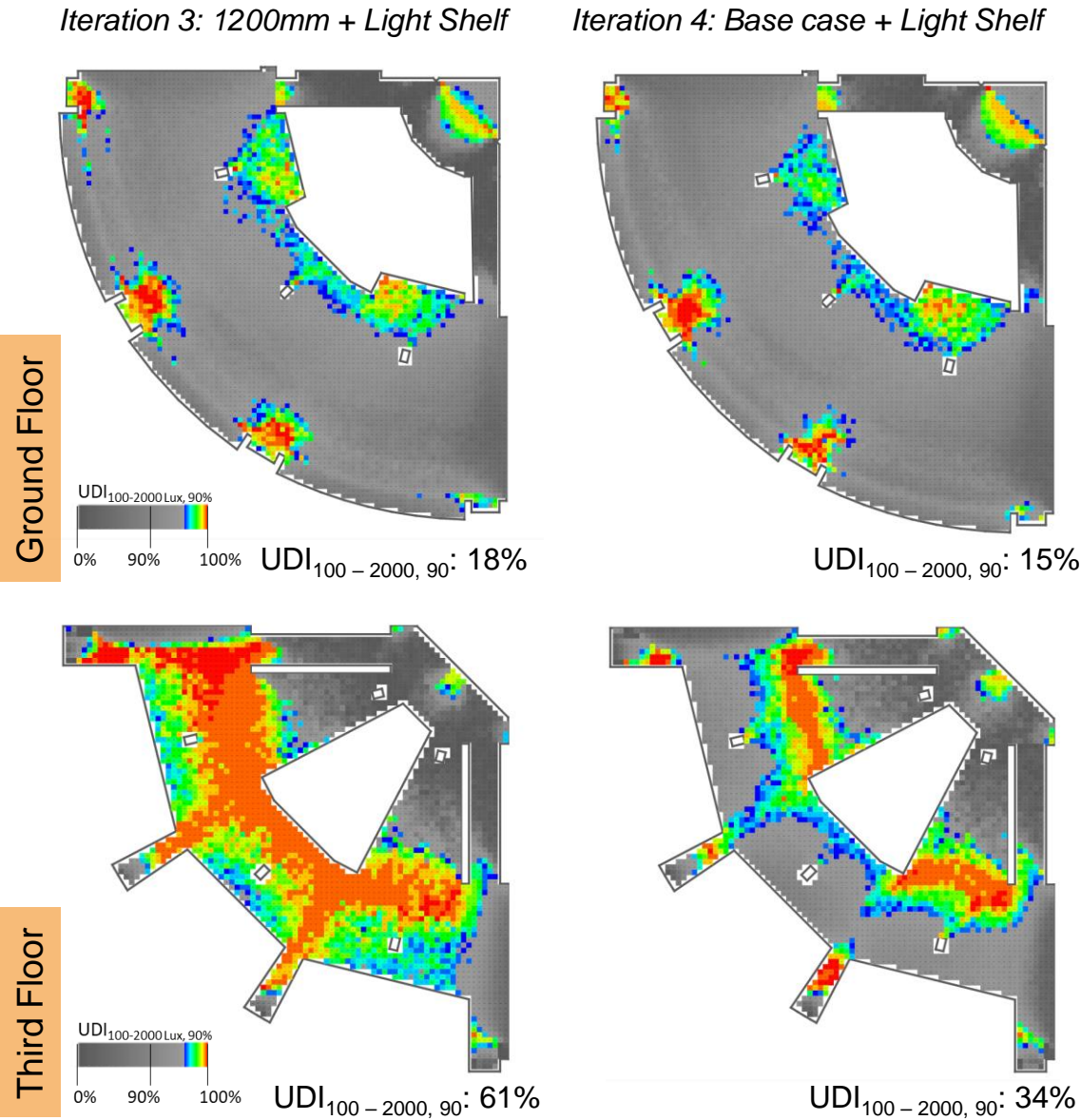
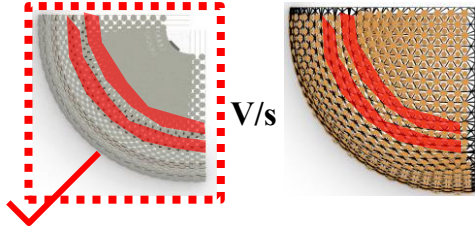


**Optimization process of these light shelves can be referred to section 1 in the appendix*

Daylight Results | Comparison (UDI) with glazing VLT 60%

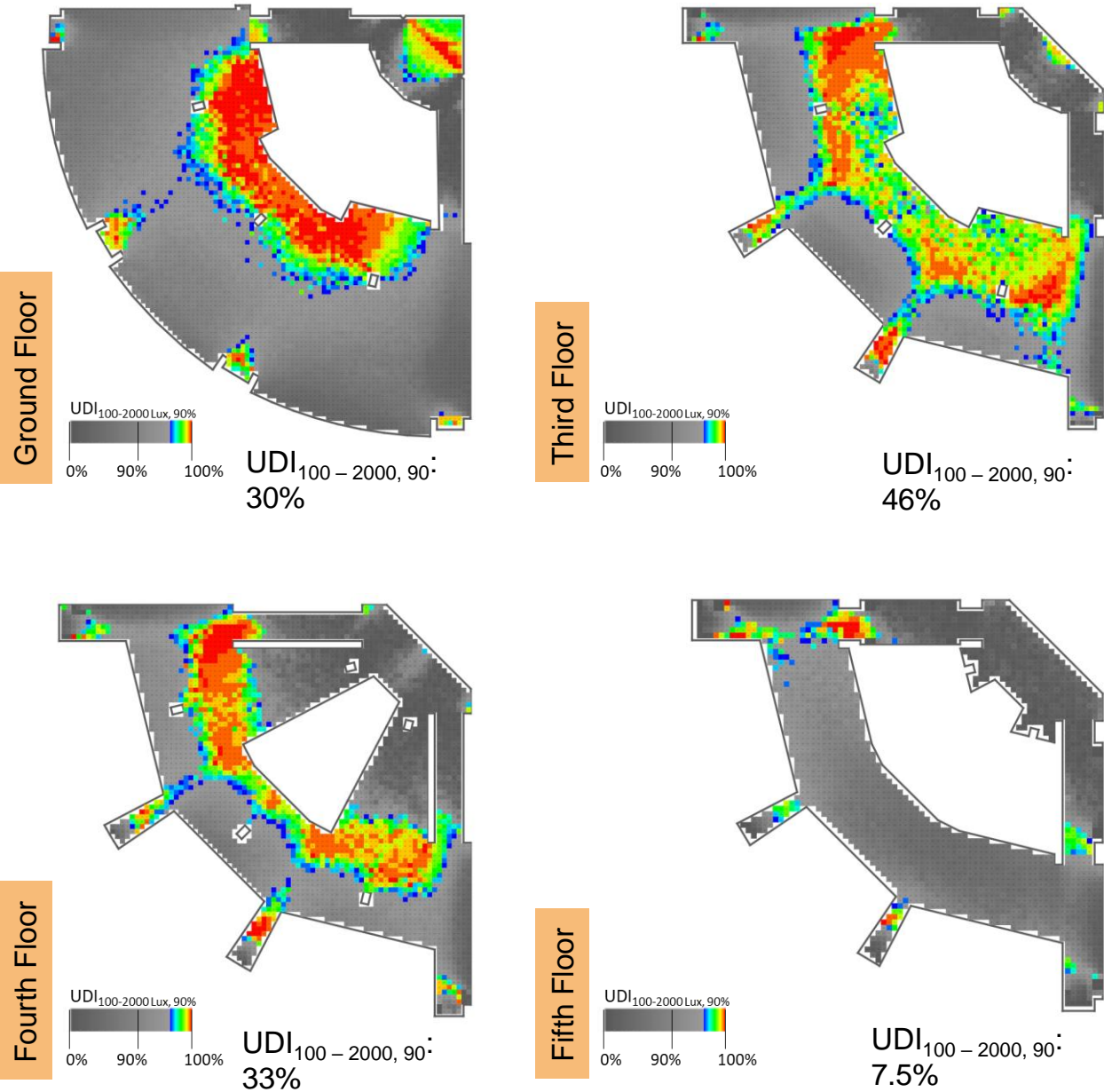
Iteration 3: 1200mm + Light Shelf V/S Iteration 4: Base Case+ Light Shelf

UDI time extents: 8am-5pm
Average across all floors
Iteration 3: 39%
Iteration 4: 25%



Daylight Results | UDI with glazing VLT 60%

Iteration 5: Pattern 3 (1200mm dia all discs) perforated

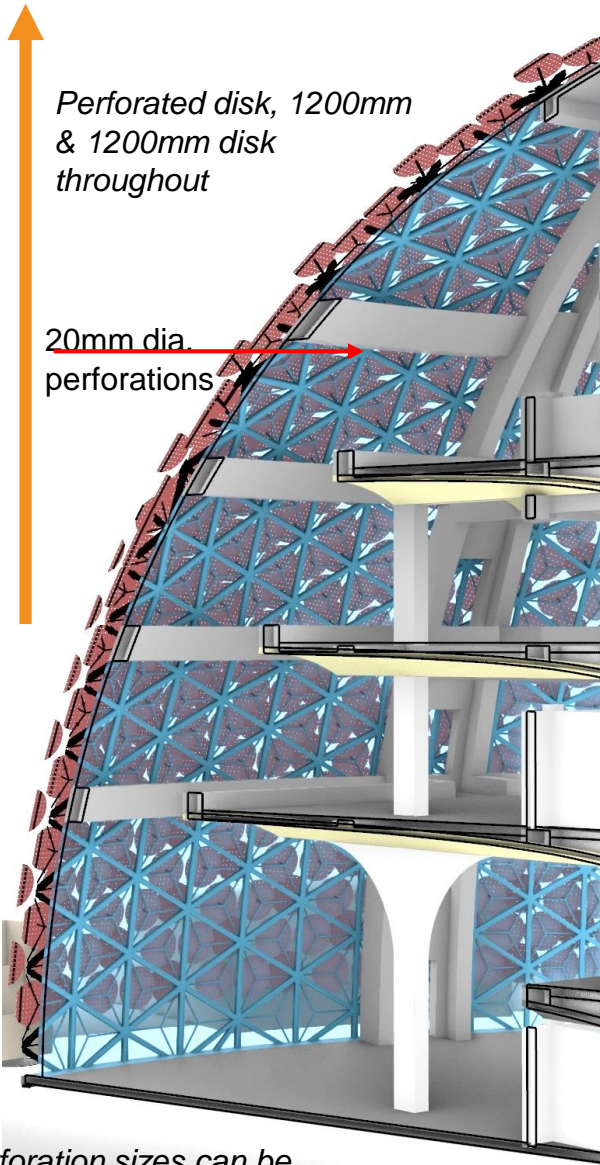


Observation
Iteration 5, the disk pattern is uniform across the dome with same disk size (1200mm) and perforation of 20mm. Perforation ratio is 15%. On the ground floor, UDI is highest so far compared to previous iterations because of larger disk size which cuts direct solar radiation. This results in UDI of 30% because of increase in useful daylight towards the perimeter area.

Similarly, on the 2nd floor the UDI increases because of lesser points near the column getting >2000 Lux during the daytime. Also, despite the perforation cutting the direct sun the daylight penetration has reduced (100lux) during the morning and evening times. On 3rd floor the perforated screen is not as effective as the horizontal light shelves in iteration 3. On 4th floor, the UDI levels strangely drops to just 7.5%. On looking at the point-time results for this floor illuminance levels >2000 Lux seems to be the reason as the disk perforations are perpendicular to the sun.

Inference
Perforations in the disk shows a positive result but this can be further improved by reducing the VLT of the glass.

UDI time extents: 8am-5pm
Average across all floors
Iteration 5: 30%
GRIHA mandatory credits not met



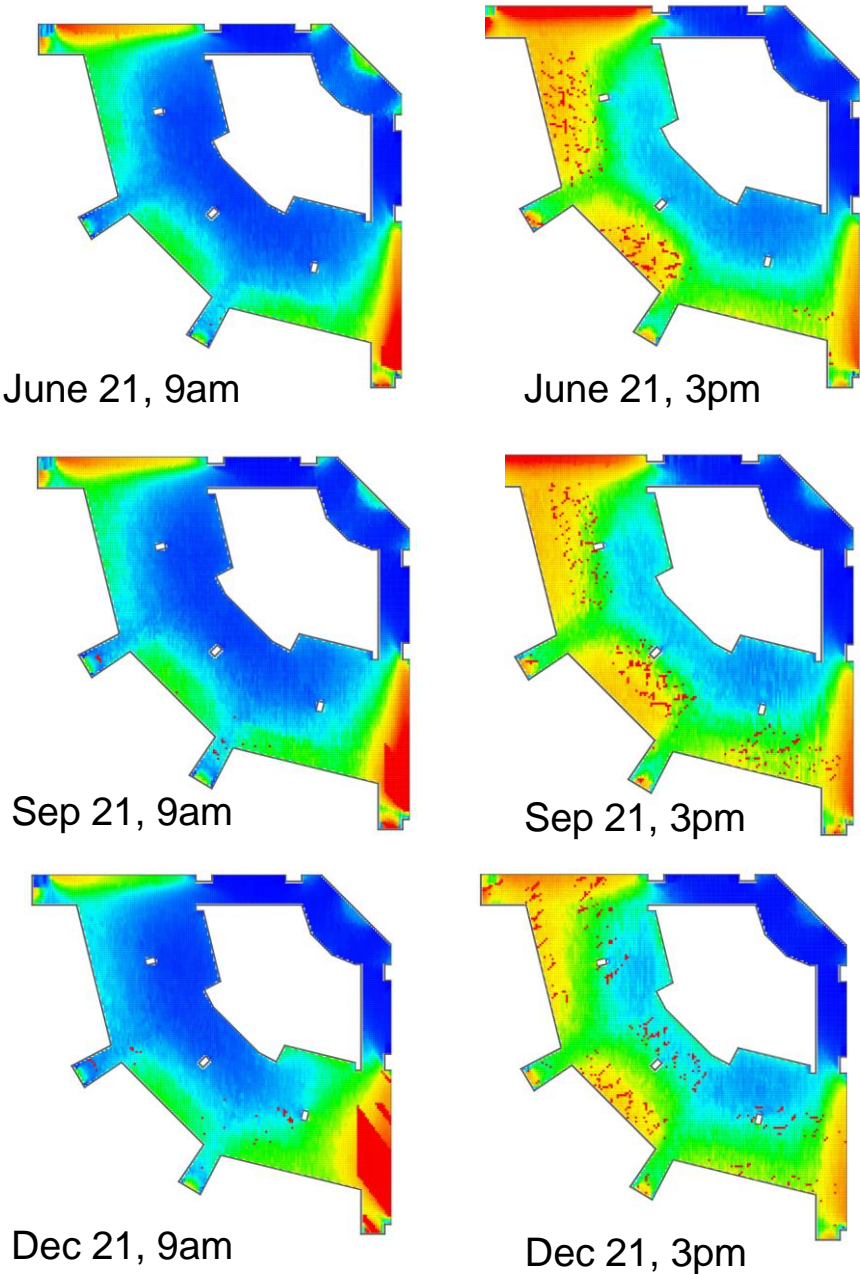
*Perforation sizes can be referred in the appendix

Daylight Results | Point-in-time analysis

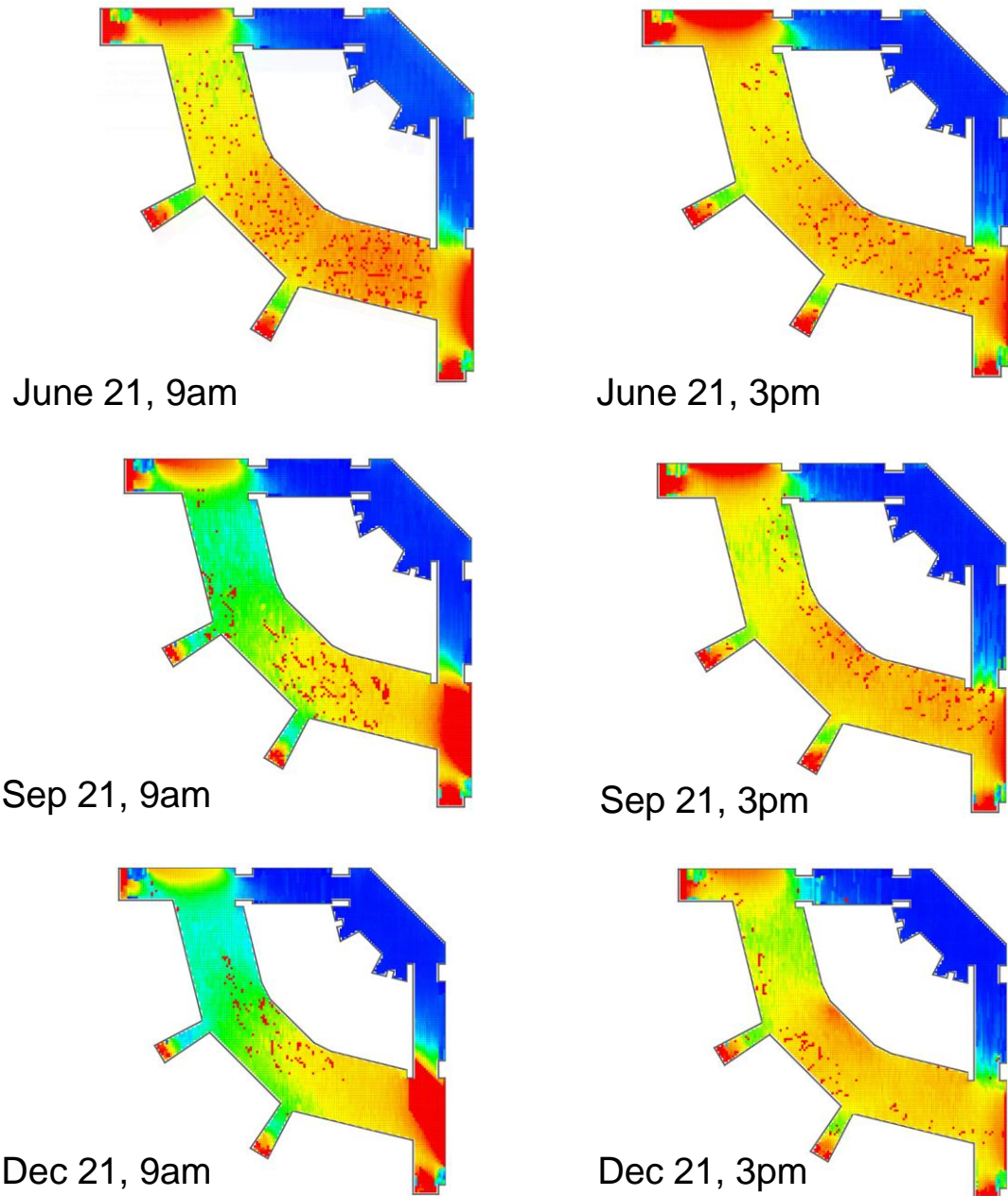
Iteration 5: 1200 & 1200mm perforated disk



Second Floor



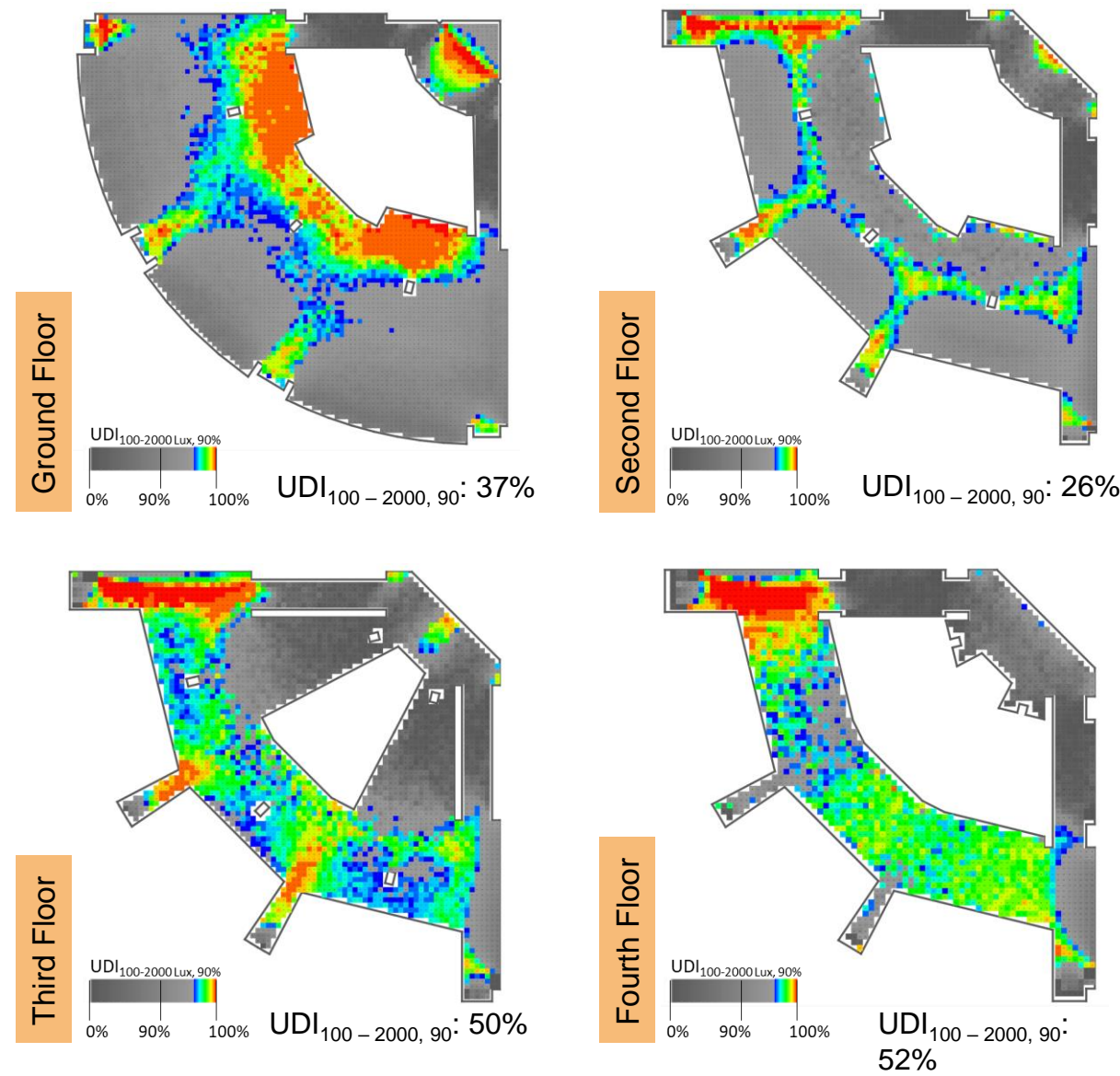
Fourth Floor



Daylight Results | UDI with glazing VLT 30%

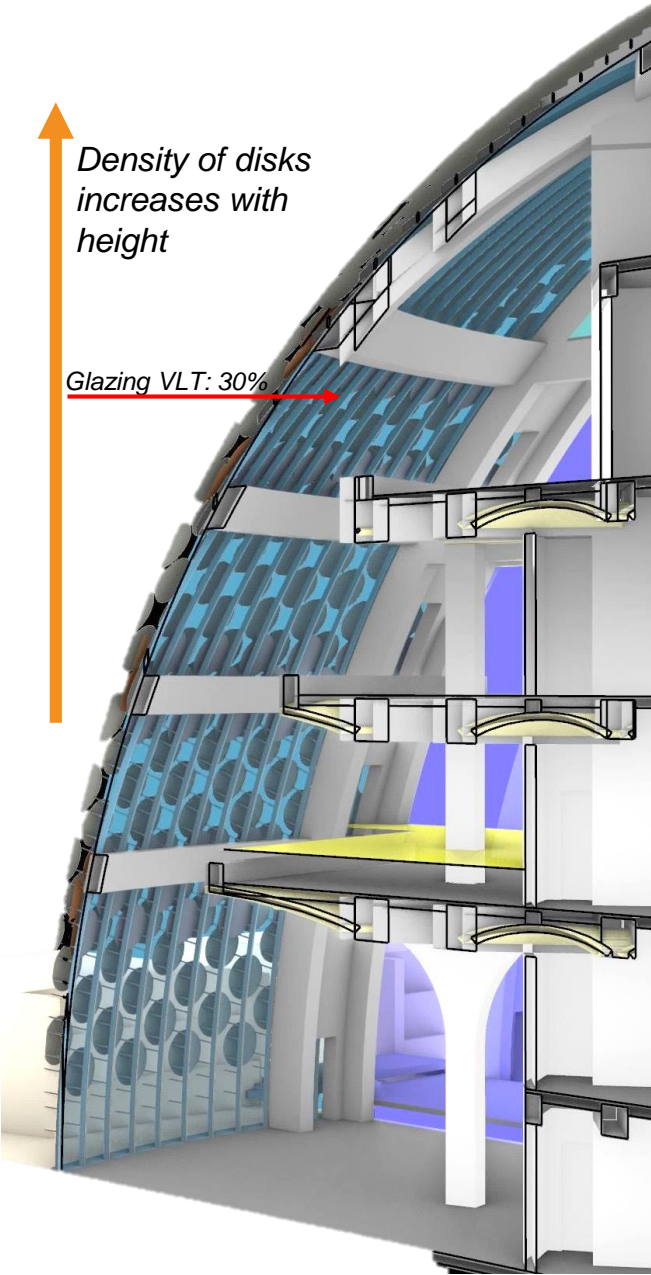
Iteration 6: Pattern 2(1200mm disc) , VLT 30%

UDI time extents: 8am-5pm
Average across all floors
Iteration 6: 39%
GRIHA mandatory credits not met



Observation
Iteration 5, the sizes of the disk increases as we go higher as the circular disks have been placed on the vertical grid lines thereby, decreasing the distance between the disk towards the upper part of the dome. The VLT of the glazing was reduced to 30%.
On the ground floor, 3X more useful daylight can be observed. On the 2nd floor the illuminance there is a drop in illuminance levels on the rear part of the floor plate due to which the UDI levels have dropped down to 26% compared 36% when VLT was 60%.
On 4th & 5th floor there is an improvement in UDI due to reduction in direct illuminance levels. Compared to iteration 2, which had VLT of 60%, the overall average UDI was 18% which has now increased to 39%.

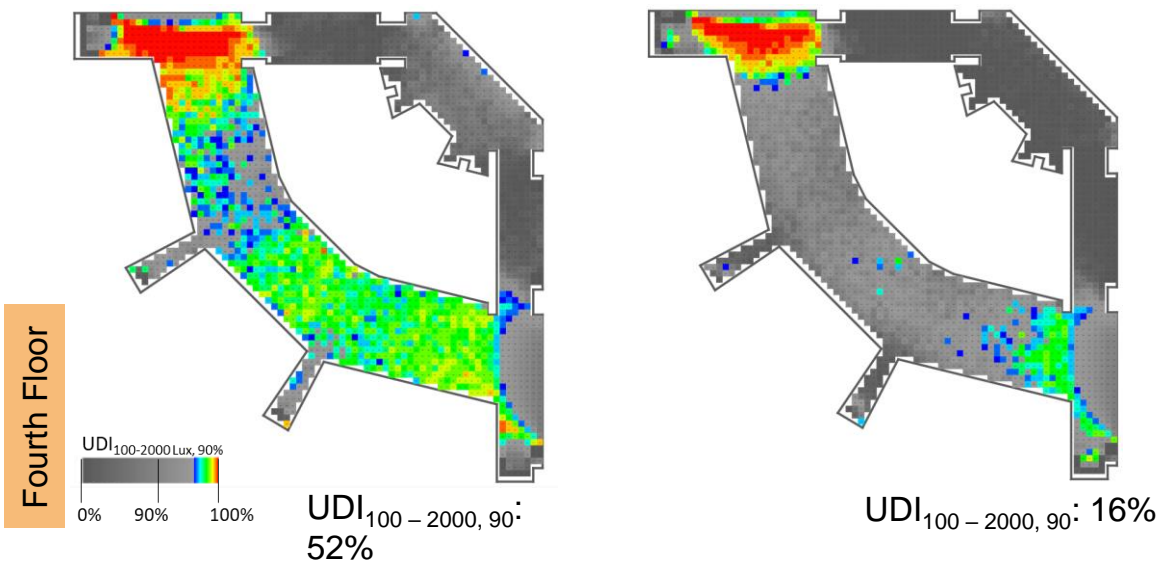
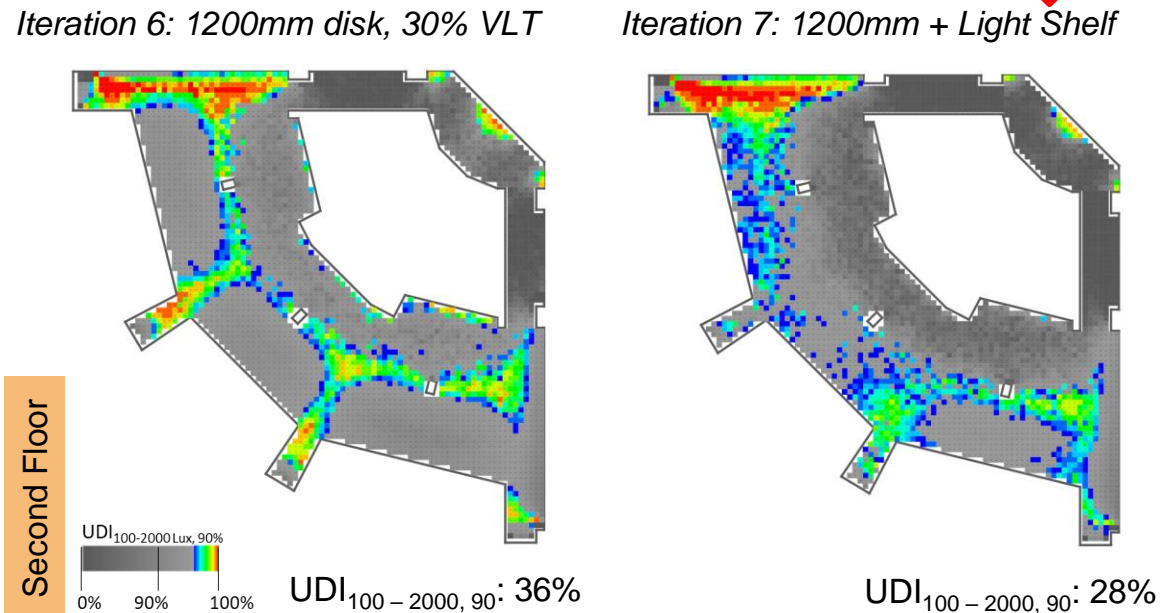
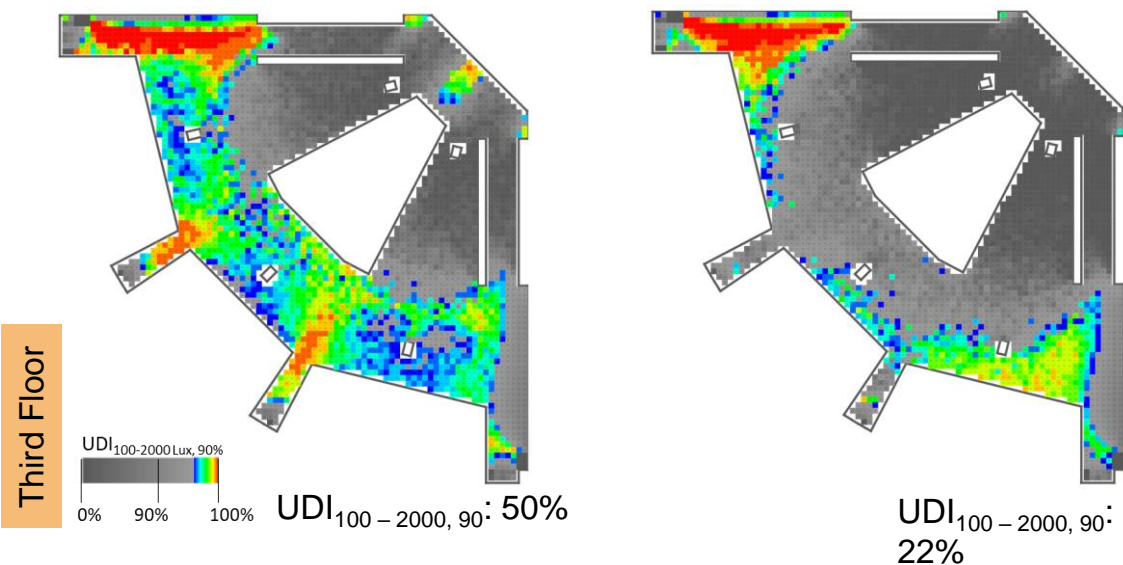
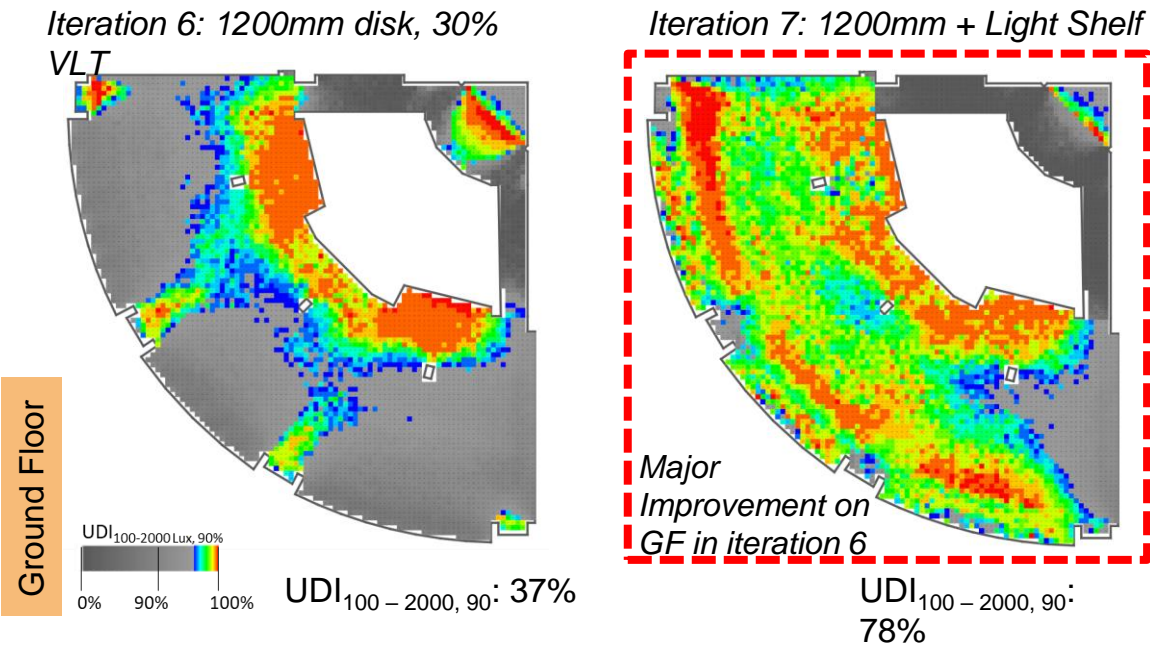
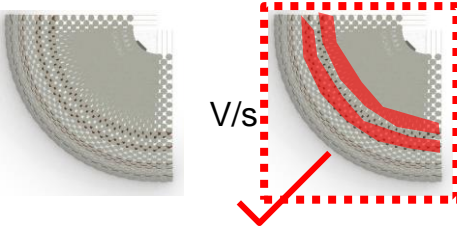
Inference
The VLT of the glass should be reduced to 30% for controlled daylight penetration which will bring more uniformity in daylight levels.
Further, light shelves with 30% VLT should be tested.



Daylight Results | Comparison UDI with glazing VLT 30%

Iteration 6: 1200mm disc V/S Iteration 7: 1200mm + Light Shelf

UDI time extents: 8am-5pm
Average across all floors
Iteration 6: 39%
Iteration 7: 43%

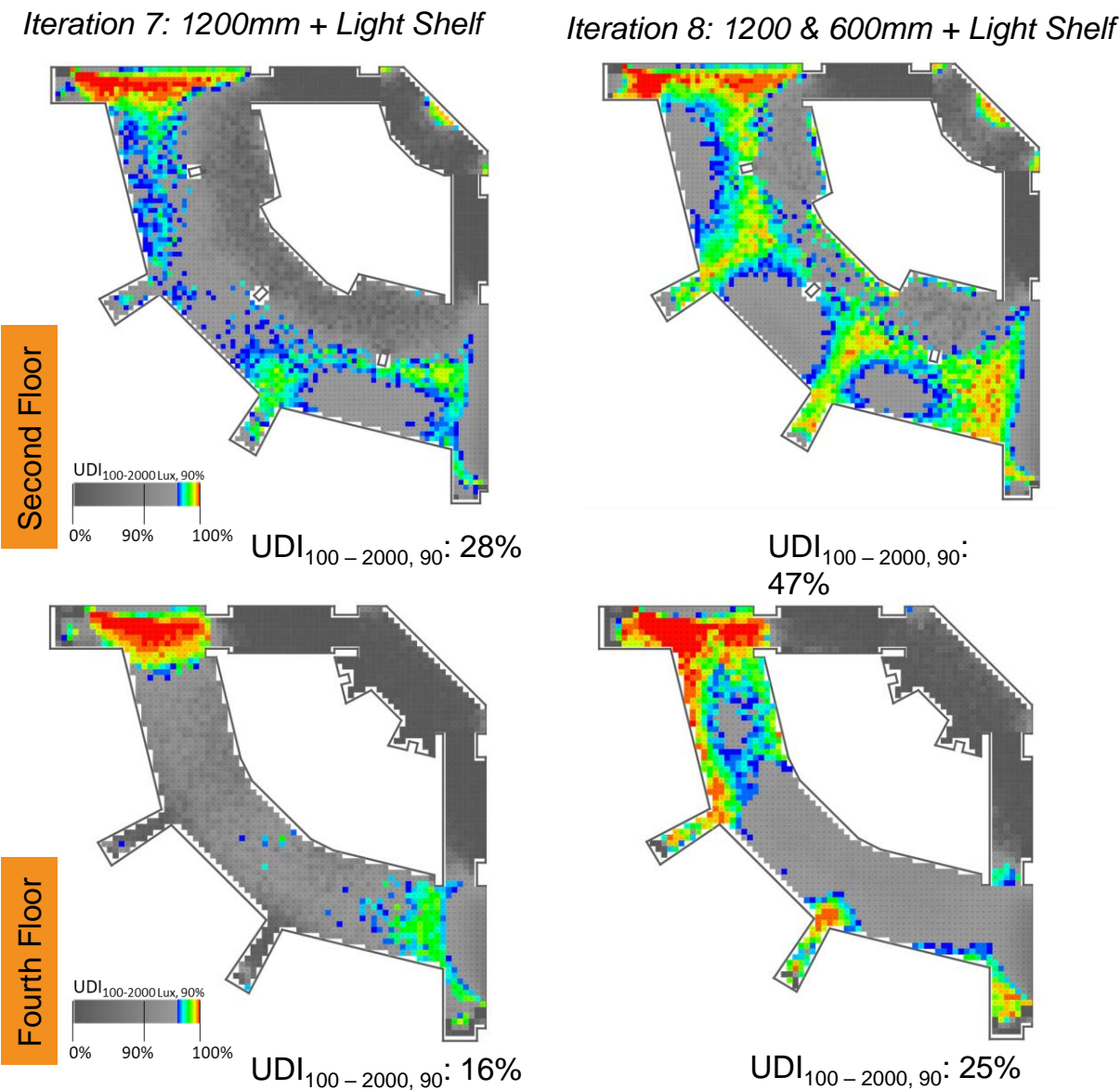
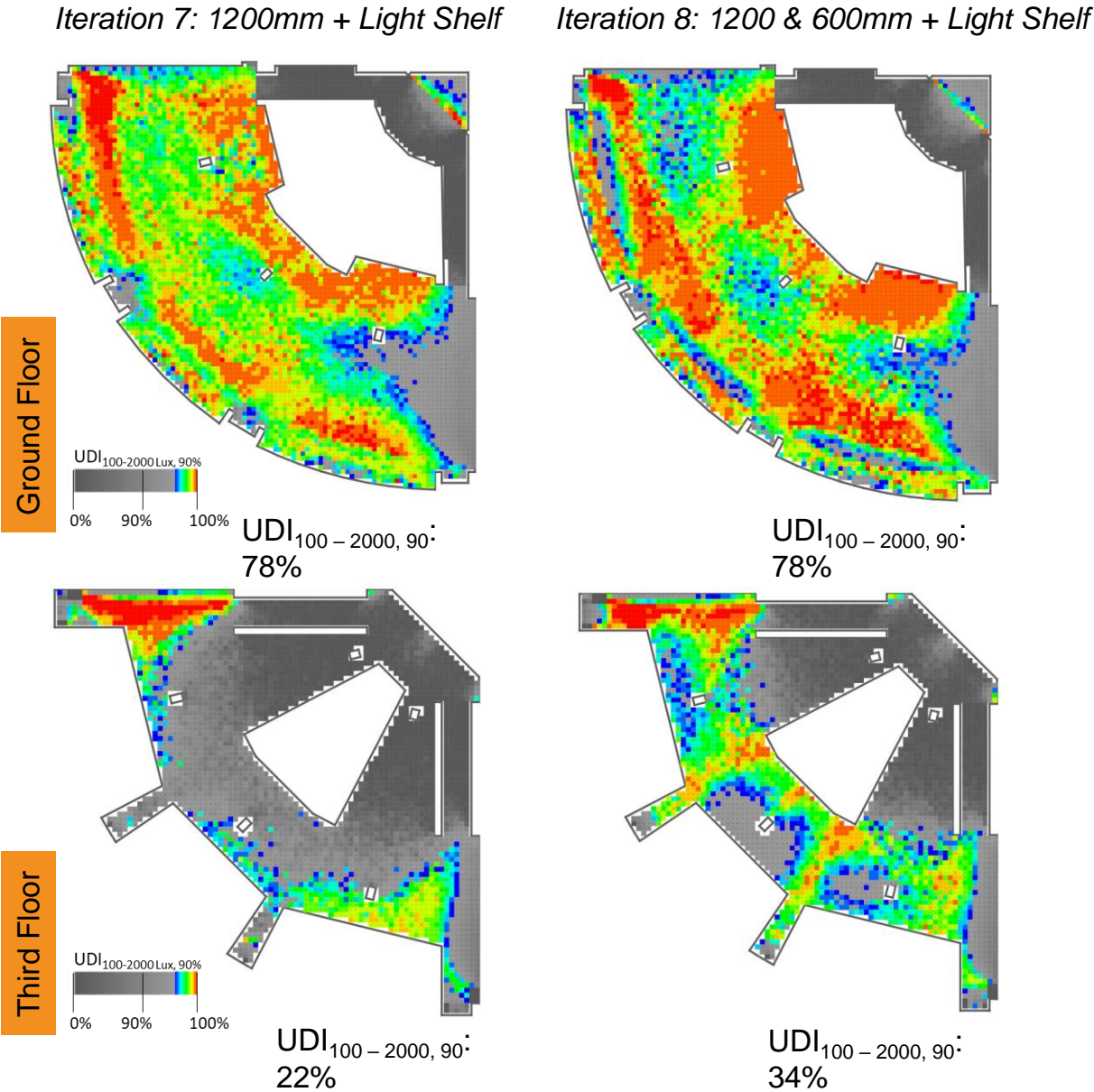
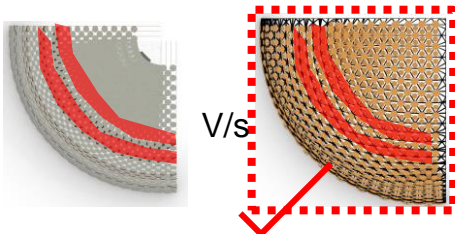


Major Improvement can be seen in iteration 6, specifically on the GF as the horizontal elements cut the direct sun for the angles between 20°-40°. But on the upper floors the combination of light shelves with 30% VLT glass reduces the illuminance levels below 100 Lux thereby, reducing the overall UDI.

Daylight Results | Comparison (UDI) with glazing VLT 30%

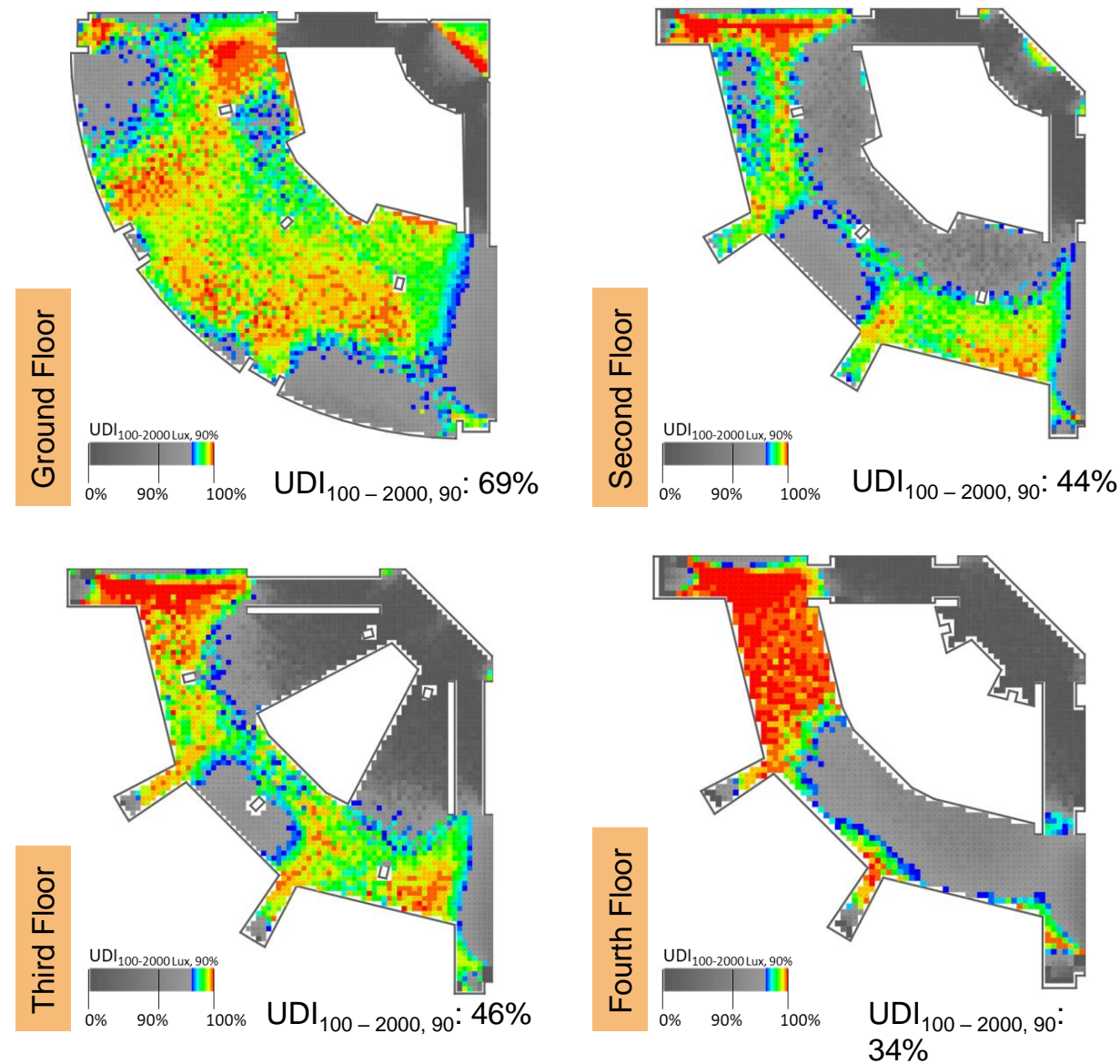
Iteration 7: 1200mm + Light Shelf V/S Iteration 8: 1200mm & 600mm disk (Base Case) + Light Shelf

UDI time extents: 8am-5pm
Average across all floors
Iteration 7: 43%
Iteration 8: 55.9%
(GRIHA compliant)

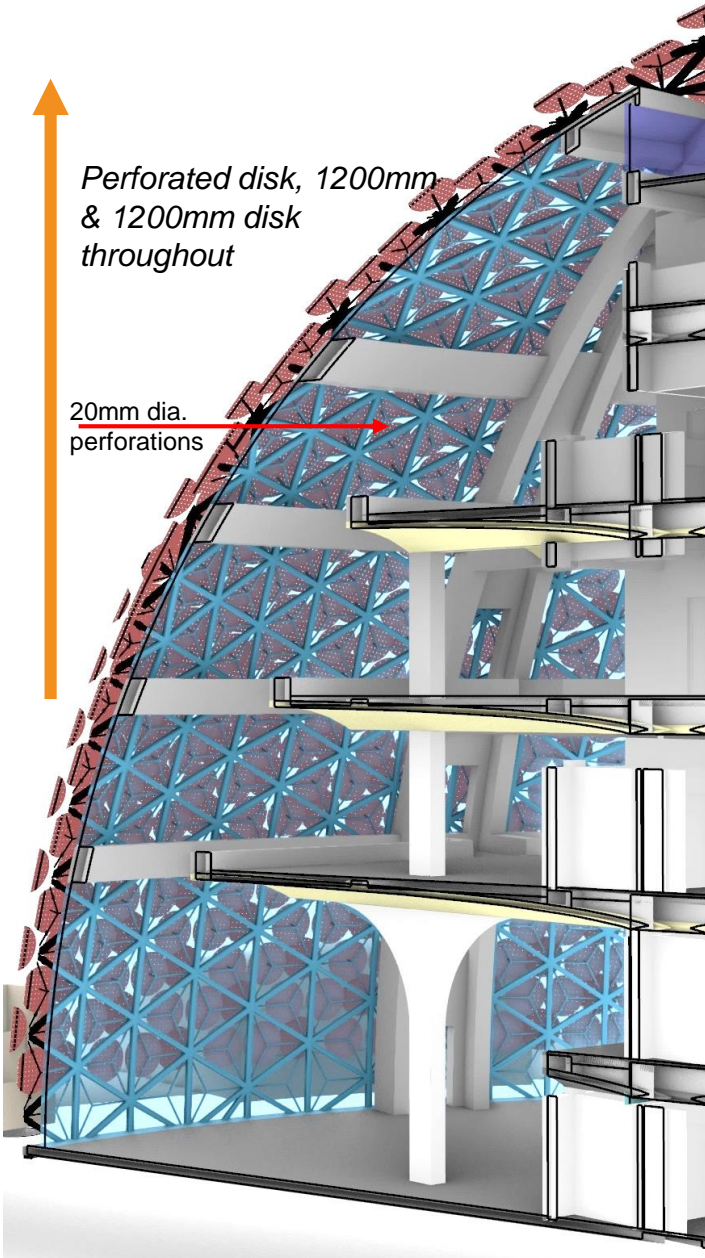


Daylight Results | UDI with glazing VLT 30%

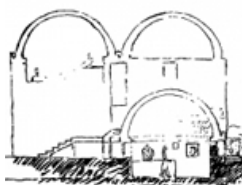
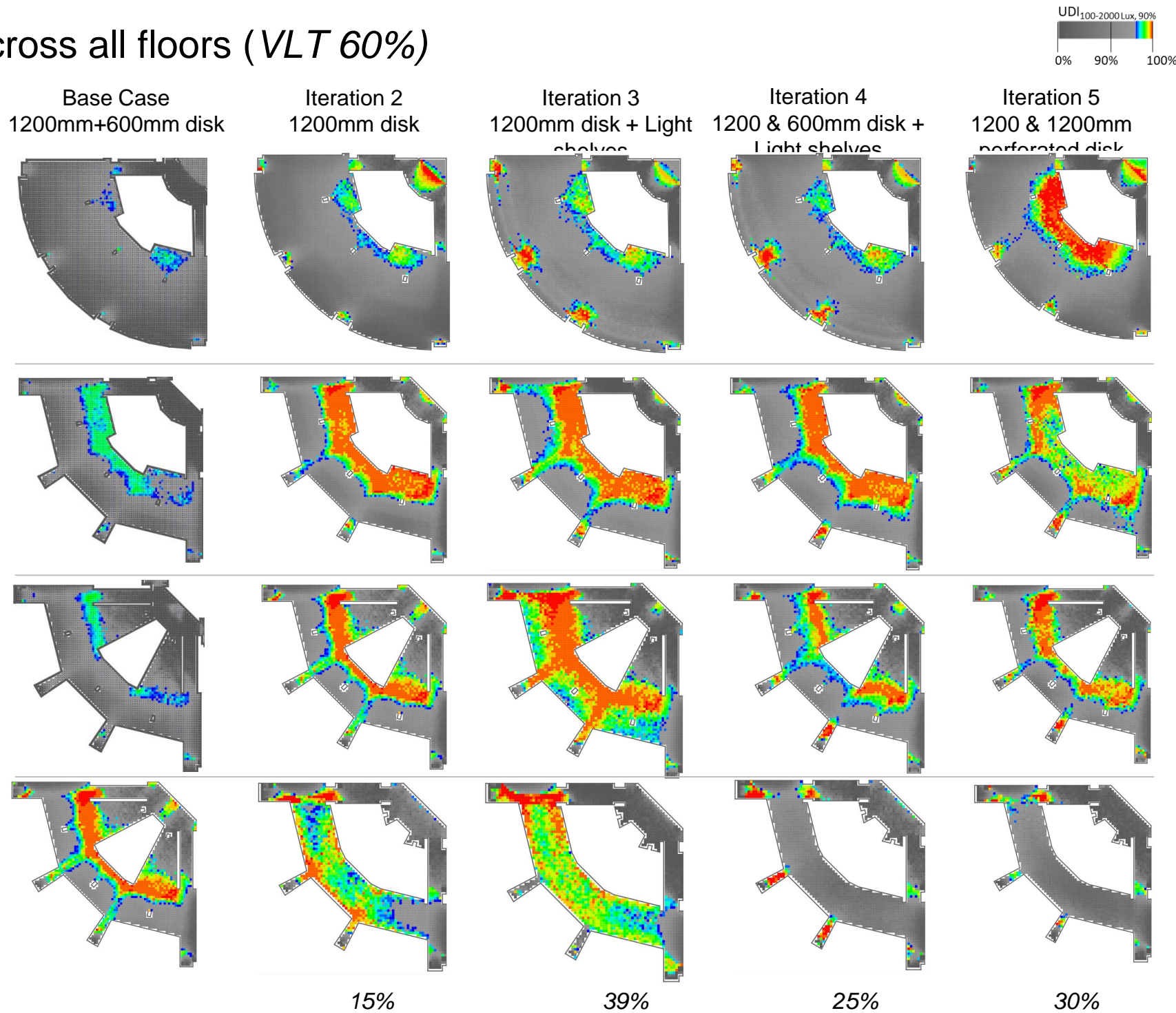
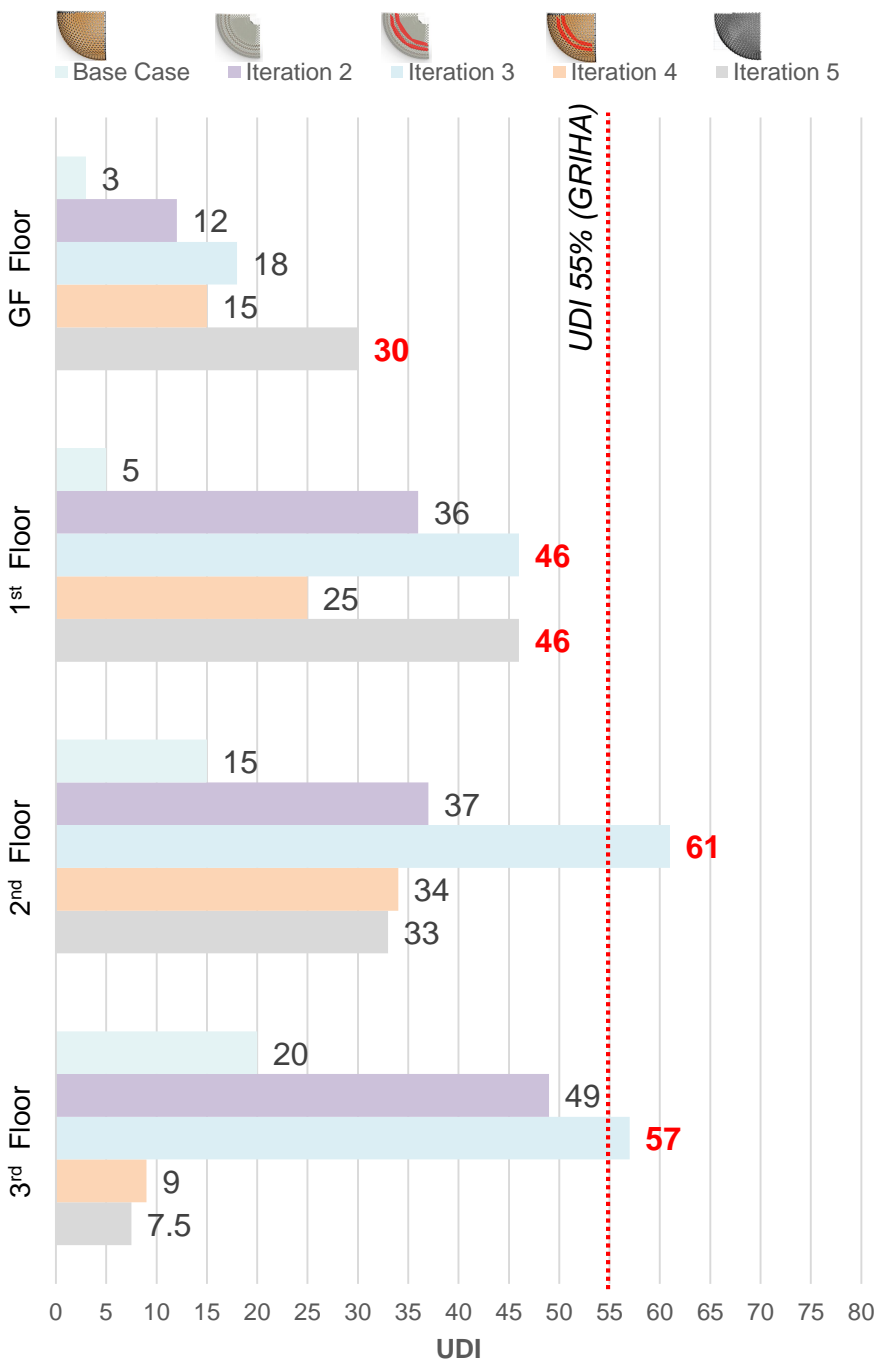
Iteration 9: 1200 & 1200mm perforated disk



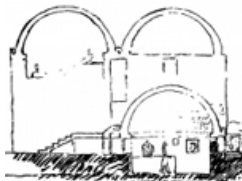
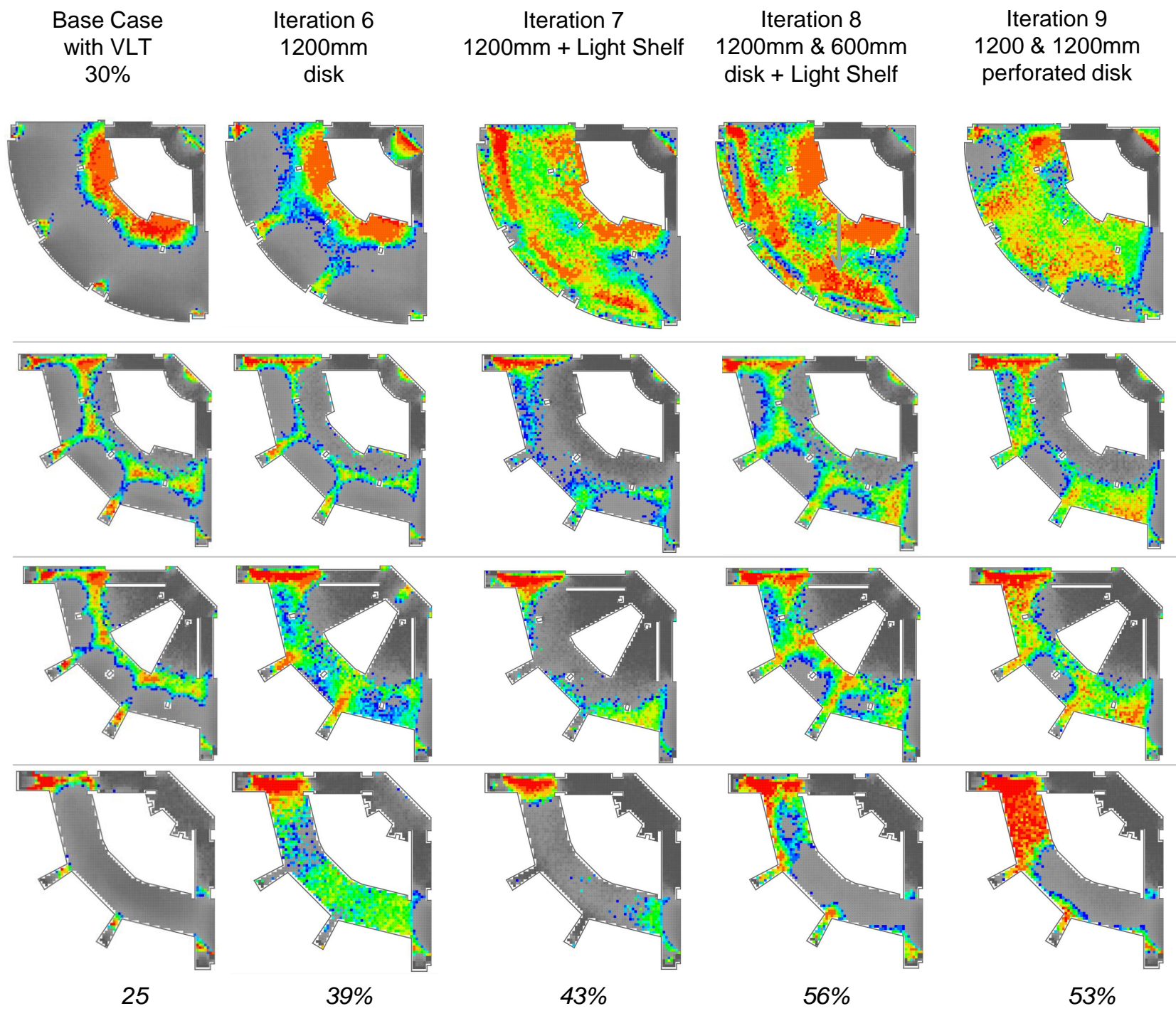
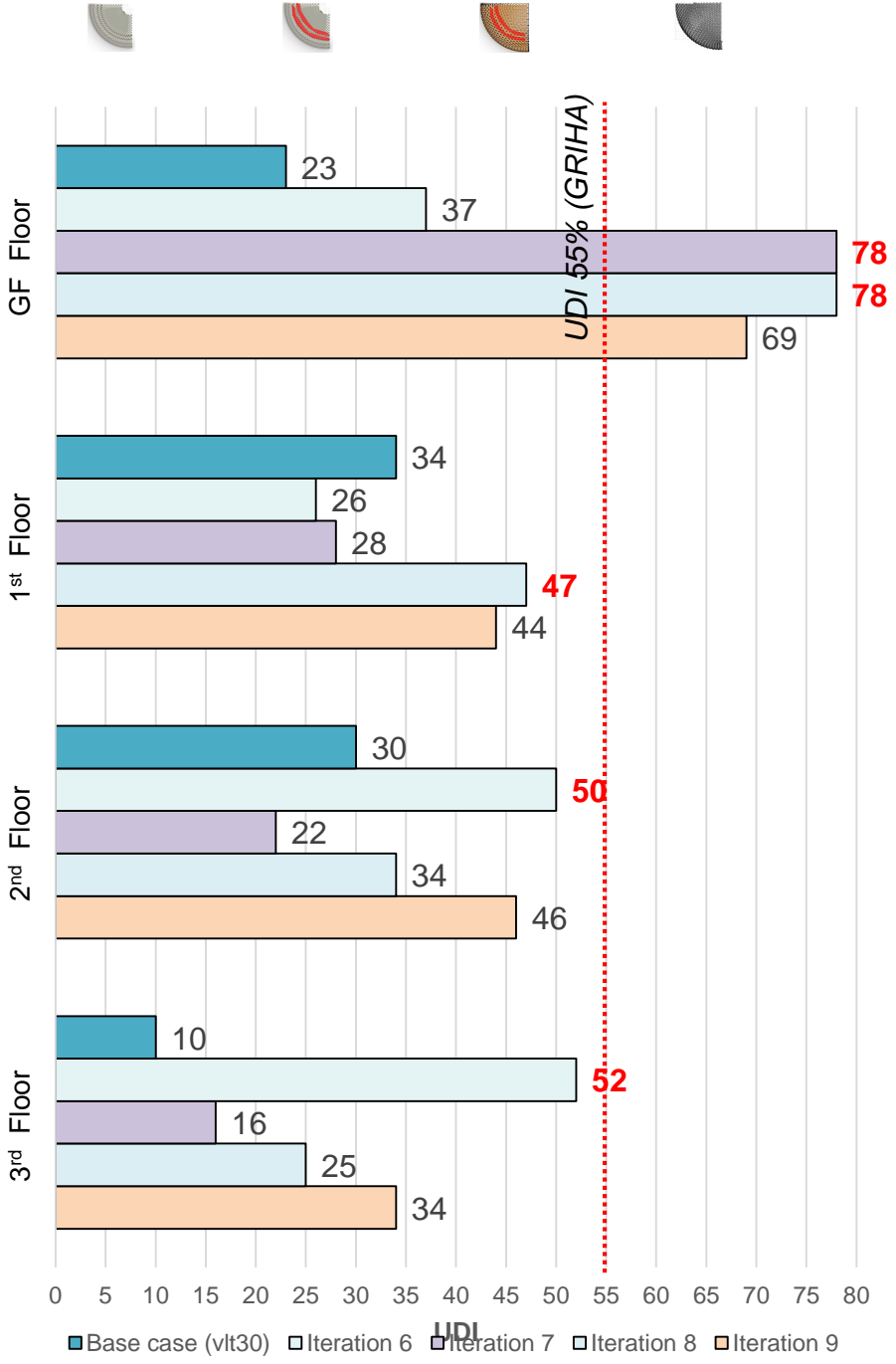
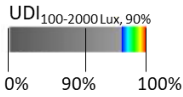
UDI time extents: 8am-5pm
Average across all floors
Iteration 5: 52.8%
GRIHA mandatory credits not met



Daylight Results | Comparison across all floors (VLT 60%)



Daylight Results | Comparison across all floors (VLT 30%)

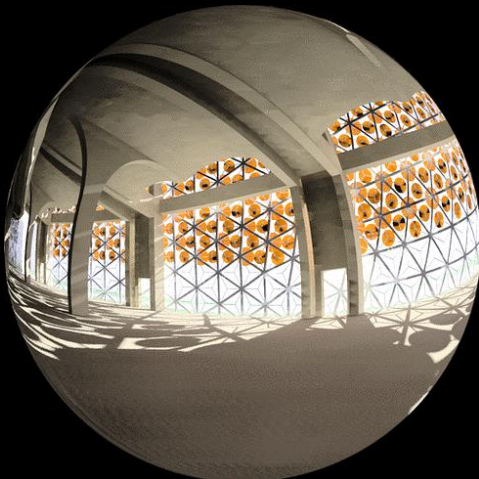


Daylight Results | Luminance Based Simulations

DGP Renderings

DGP Renderings

Iteration
DGP



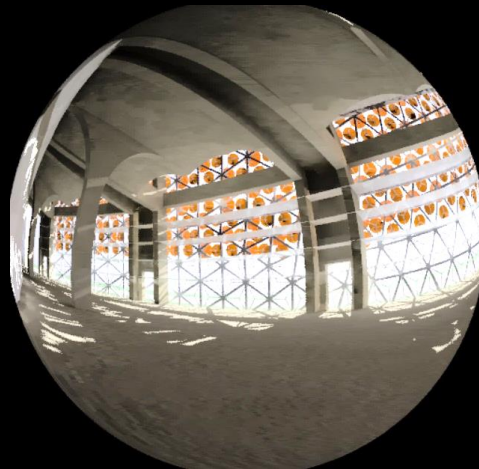
Base Case with VLT
30%
28.8



Iteration 6
1200mm disk
28.5



Iteration 7
1200mm + Light Shelf
27.6

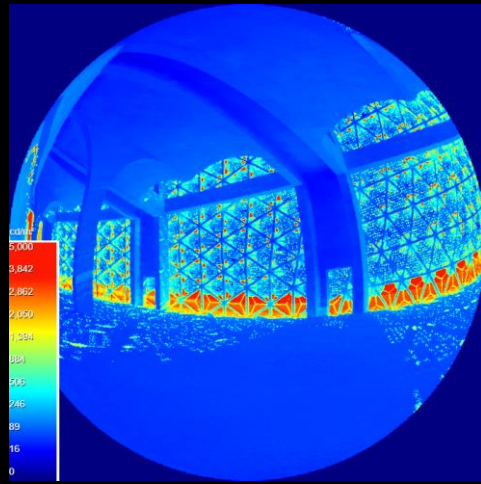
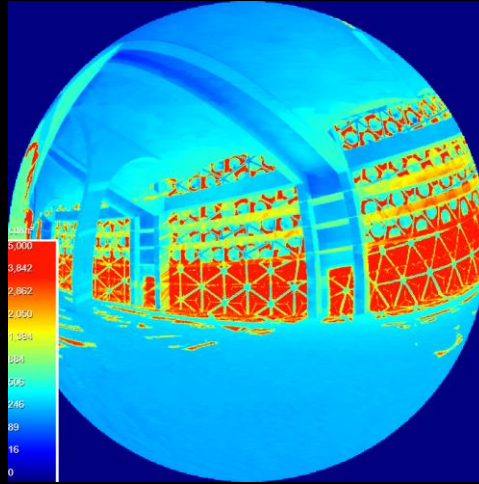
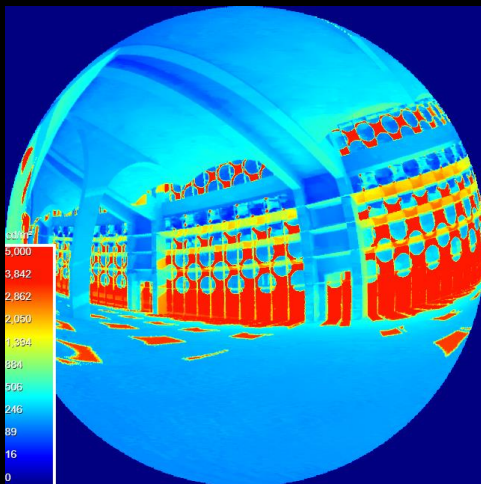
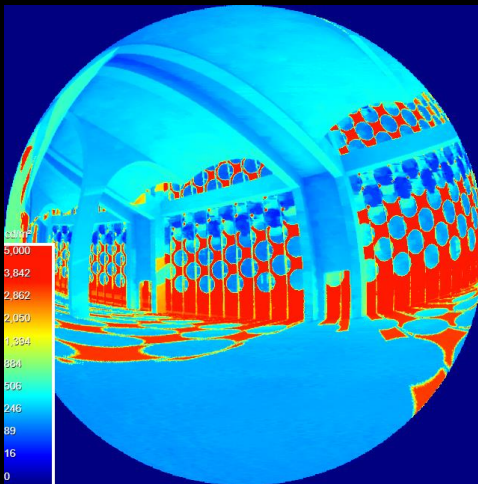
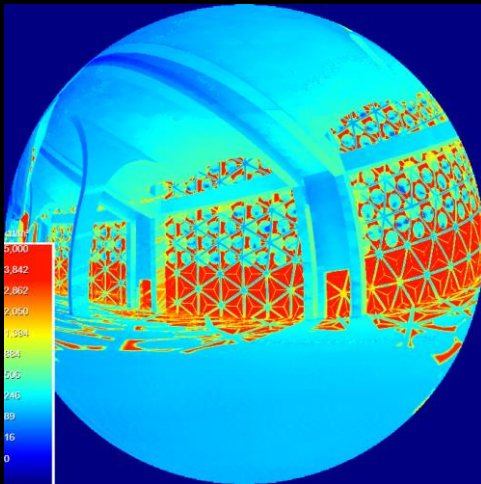


Iteration 8
1200mm & 600mm disk + Light Shelf
28

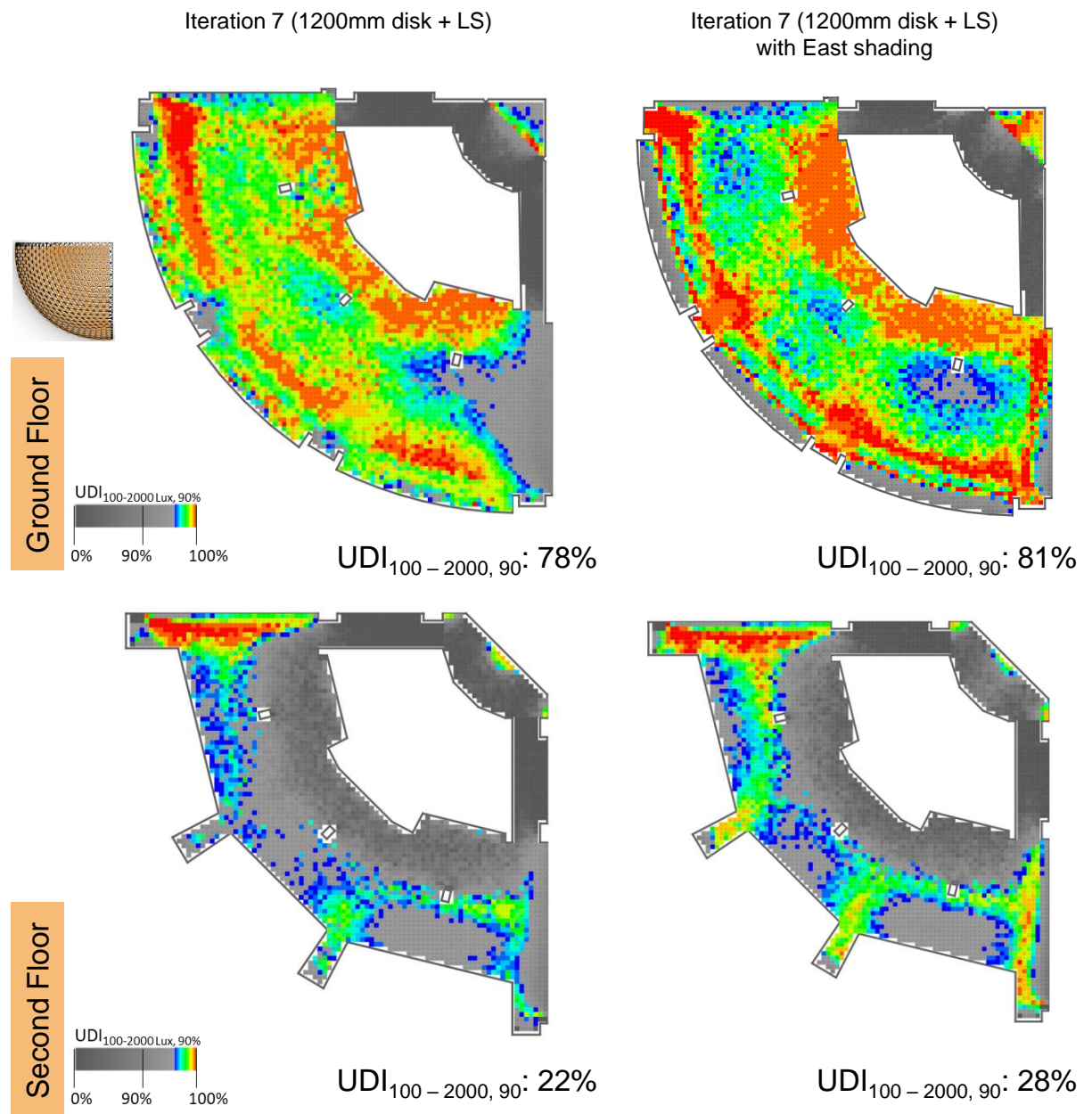


Iteration 9
1200 & 1200mm perforated disk
23.7

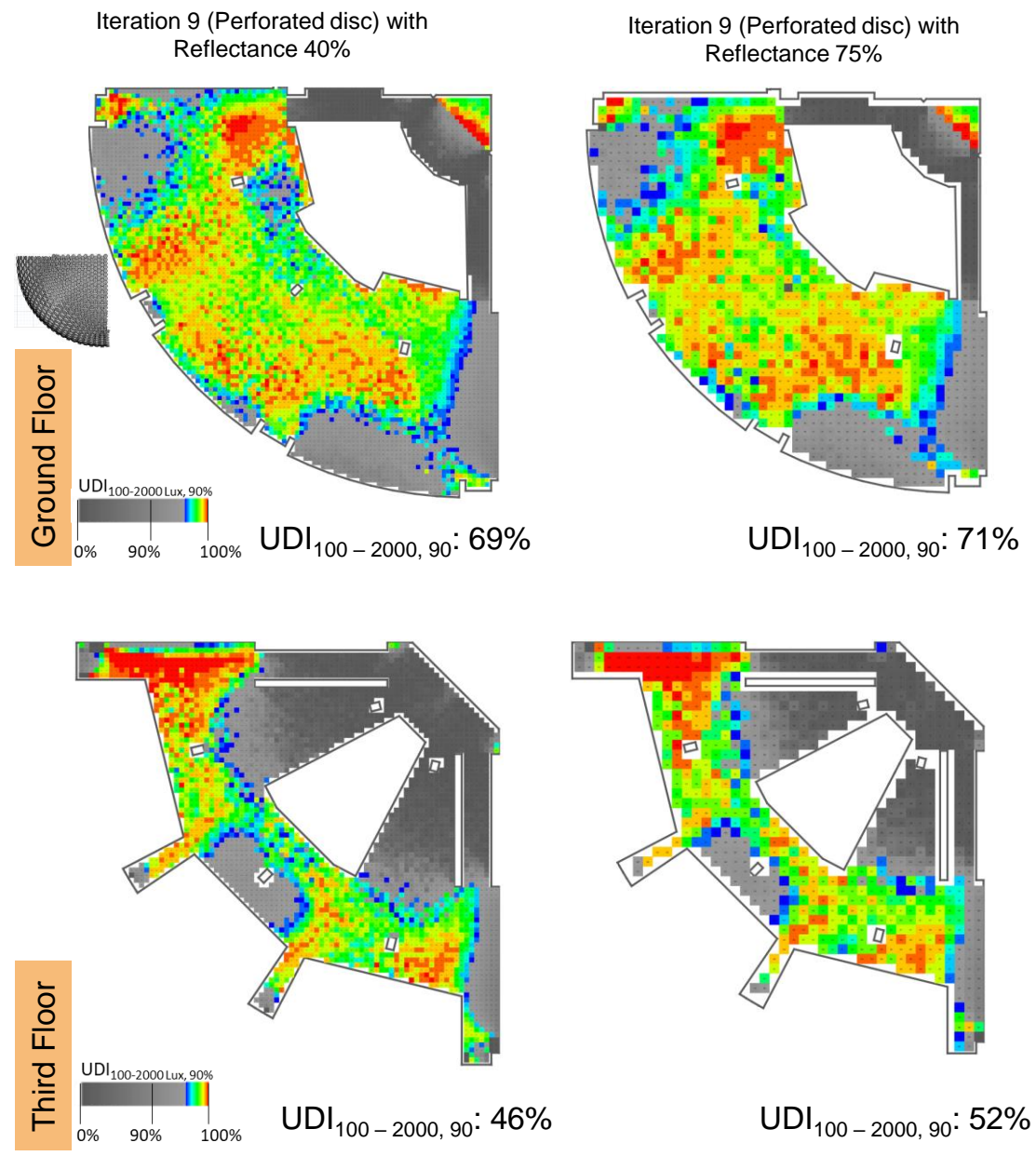
False Color Images



Daylight Results | Implication of East shading and Ceiling Reflectance



Adding the horizontal shading in the Eastern glazing has the potential to increase the overall UDI by 5-10%.

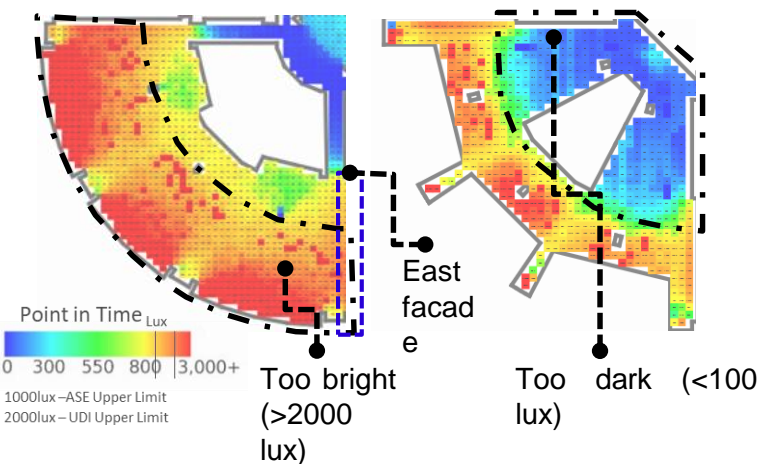


Increasing the ceiling reflectance leads to an overall improvement in the UDI by 5-6%.

Results summary| Observations & design recommendations

Base case results indicated two problems

- 1. High illuminance on the periphery
- 2. Low illuminance behind



Specific observations:-

- 1. Ground floor is too bright and needs shading till the work plane (i.e. 0.9m) level, or appropriate shading above to cut the direct light at the work plane.
- 2. East façade (Marked above) with flat glass needs shading on all floors- source of direct light from 9am -11 am.
- 3. Upper floors get too dark behind the columns line. Sudden non uniformity in lux levels is observed.

Solutions explored in the iterative process

Glazing VLT

BASE CASE GLAZING VLT 60%

- 1. U value - Double Glazed Glass - 1.4 W/m2K
- 2. SHGC - Double Glazed Glass - 0.34
- 3. Reference : Saint Gobain DGU SKN16511 Lumina (VLT 60%)

PROPOSED CASE GLAZING VLT – 30%

Reference1- SKN 444 II – VLT 34%, SHGC Double glazing- 0.2, U value – 1.6 W/m2K

Implication:-

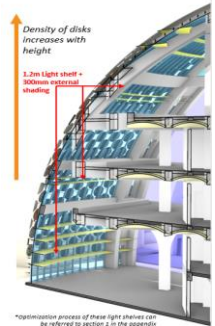
- 1. High improvement (20-25%) in the Daylight performance
- 2. No Architectural implication – design and detail can remain same
- 3. Moderate increase in Capital cost of the glazing.
- 4. Indirect cost benefits- Low SHGC will help reduce HVAC loads and thereby extra cost will offset

Horizontal Shading

RECOMMENDATION – Horizontal light shelves with high reflective / white finish to block the harsh Solar angles and reflect light on the ceiling for deeper daylight penetratio

Implication:-

- High improvement (25%) in the Daylight performance
- 1. Additional element- Moderate design & cost implication



With shading

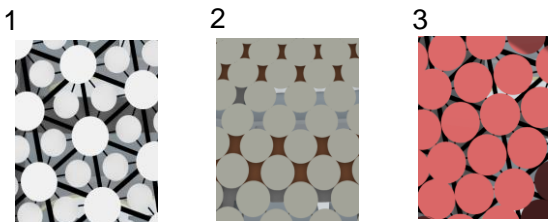
Ceiling Reflectance

RECOMMENDATION – Minimum 40% reflectance is required.

- 1. 70% reflectance improves daylight performance by 5-7% with current design.
- 2. Limited cost implication. Architecturally this will mean an additional finish
- 3. Reflectance is difficult to control and depends on the construction quality



Façade Patterns



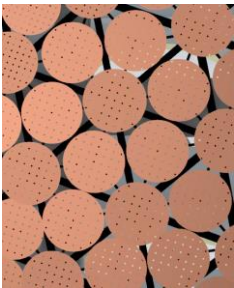
RECOMMENDATION – Pattern 1 i.e. base case is more balanced and uniformly spaced thus this pattern works well in total.

Pattern 2- Works well for top floors due to high density but doesn't work for lower floors.

Pattern 3- Same size discs on pattern 1 works with perforated discs

Perforated discs

RECOMMENDATION – Discs with 15% perforation works well with pattern 3 and VLT 30%. This option can be optimized further to improve daylight performance



Implication:-

- 1. Cost needs to be enquired.
- 2. Thickness and available perforations need to be retested

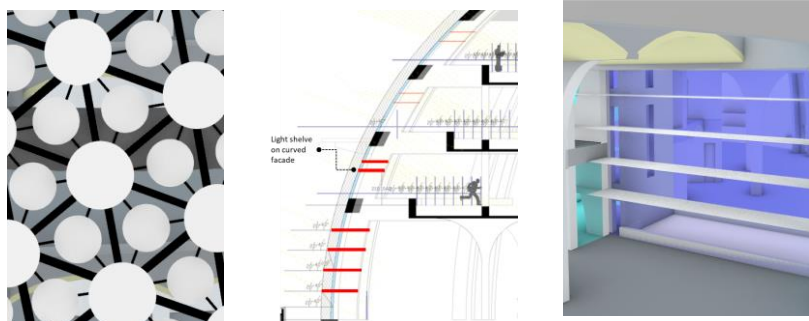
Results summary| Way forward

Design Options with Corten steel discs

Pattern 1 i.e. base case (1.2m and 0.8m dia discs)

- This has a uniform geometry (triangulations) and works equitably for all the floors if they are supported with horizontal light shelves to cut glare. The gaps between the discs allow daylight penetration and the light shelves are designed to cut excess daylight and direct sun.
- Pattern 1 can be optimized by adding light shelves only till 3rd floor. After that the density of discs is good enough to increase daylight.

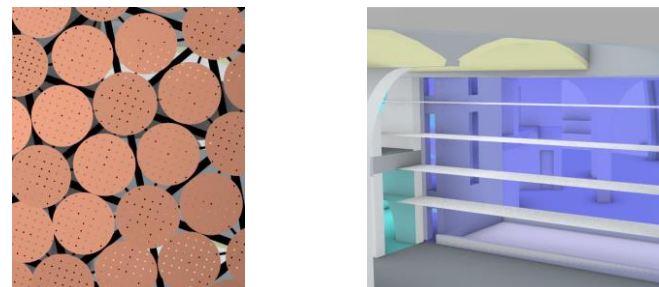
Recommendations for Pattern 1



- Pattern 1 – 1.2m & 0.8m discs in two layers
- VLT of glass = 30%
- Concrete reflectance = 40% (min) recommended 75%
- Horizontal light shelves till floor 3 on the curved facade.
- Horizontal light shelves on East façade on all 3 floors

Pattern 3 i.e. base case perforated (all discs 1.2m dia)

- Increasing disc size to 1.2m for both the layers reduces the gaps between the discs and cuts the excessive glare causing direct light
 - Perforations help diffuse incident light and compensate for the increased density
 - Pattern 3 can be optimized with Light shelves on the East façade to cut the direct morning sun.
 - Pattern 3 will improve by increasing the reflectance of internal finishes, especially ceiling.
- Recommendations for Pattern 3



- Pattern 1 – 1.2m perforated discs in both layers
- VLT of glass = 30%
- Concrete reflectance = 40% (min) recommended 75%
- Horizontal light shelves on East façade on all 3 floors

Expected Average UDI with these measures = 70%

New Design Options

If horizontal and vertical louvers are designed well with a low VLT glazing, then Discs can be eliminated. A new design option can be worked out incase the cost and architectural implication of the Pattern 1 and Pattern 3 option do not work in favor of the client.

New design options can be explored with lighter materials like Polycarbonate sheets or ETFE screens.



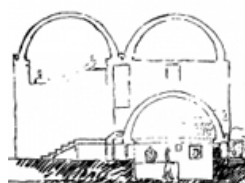
Horizontal & Vertical shading with low VLT glass or Polycarbonate sheets (translucent materials)
(ref- Apple office Singapore)



Horizontal & Vertical shading through ETFE fins or panels
(ref- Esplanade Singapore)

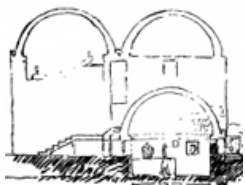


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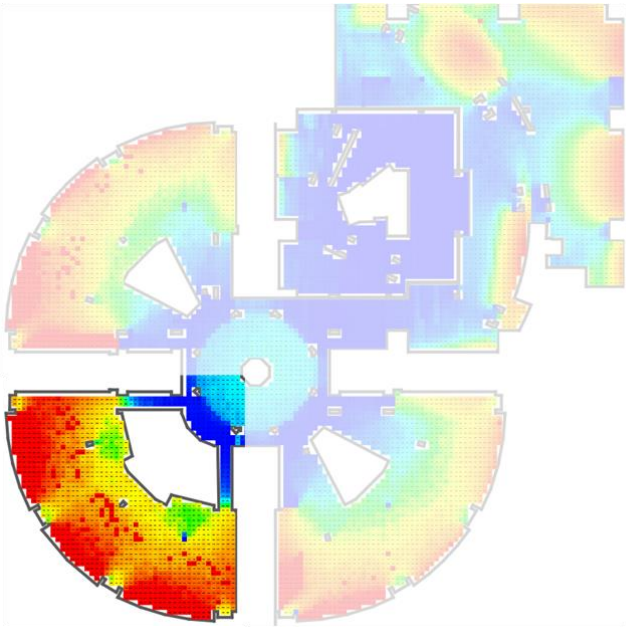
Library Preliminary Architecture Report
Nalanda University , Rajgir

Stage 2, PART 2: New Design Iterations for improving daylight performance



Daylight Analysis | Optimization of façade

- In the previous stage of Design Iterations for the Discs Façade the following points were observed:-
1. The density of discs was insufficient to shade the gaps between them and required horizontal shading to support the Pattern 1 (Base case)
 2. East façade of the S-W dome also needs shading and adding horizontal louvers to cut the sun of altitude angle 40deg was designed from the shading mask.
 3. Perforated discs had to be made even more dense to minimize Glare and ASE above 250 hours.
 4. These design iterations have significantly reduced the building's view to the outside and needs re-imagination to develop a new design
 5. This stage explores a new façade design option devised from parametrically varying triangular fins optimized according to the shading angles derived from the sun path



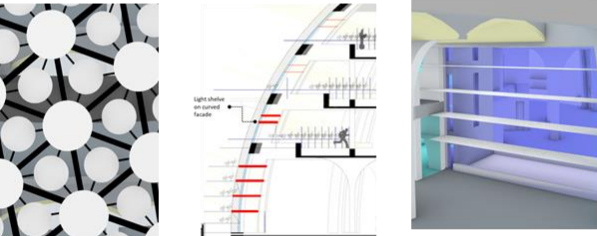
South West Dome / Quadrant performed the worst in the base case daylight performance and is the most exposed to harsh sun

Design Options with Corten steel discs

Pattern 1 i.e. base case (1.2m and 0.8m dia discs)

- This has a uniform geometry (triangulations) and works equitably for all the floors if they are supported with horizontal light shelves to cut glare. The gaps between the discs allow daylight penetration and the light shelves are designed to cut excess daylight and direct sun.
- Pattern 1 can be optimized by adding light shelves only till 3rd floor. After that the density of discs is good enough to increase daylight.

Recommendations for Pattern 1



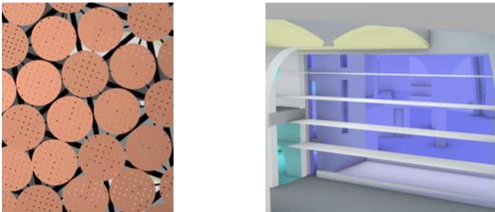
- **Pattern 1 – 1.2m & 0.8m discs in two layers**
- **VLT of glass = 30%**
- **Concrete reflectance = 40% (min) recommended 75%**
- **Horizontal light shelves till floor 3 on the curved facade.**
- **Horizontal light shelves on East façade on all 3 floors**

Expected Average UDI with these measures = 70%

Pattern 3 i.e. base case perforated (all discs 1.2m dia)

- Increasing disc size to 1.2m for both the layers reduces the gaps between the discs and cuts the excessive glare causing direct light
- Perforations help diffuse incident light and compensate for the increased density
- Pattern 3 can be optimized with Light shelves on the East façade to cut the direct morning sun.
- Pattern 3 will improve by increasing the reflectance of internal finishes, especially ceiling.

Recommendations for Pattern 3



- **Pattern 1 – 1.2m perforated discs in both layers**
- **VLT of glass = 30%**
- **Concrete reflectance = 40% (min) recommended 75%**
- **Horizontal light shelves on East façade on all 3 floors**



New Design Options

If horizontal and vertical louvers are designed well with a low VLT glazing, then Discs can be eliminated. A new design option can be worked out incase the cost and architectural implication of the Pattern 1 and Pattern 3 option do not work in favor of the client. New design options can be explored with lighter materials like Polycarbonate sheets or ETFE screens.



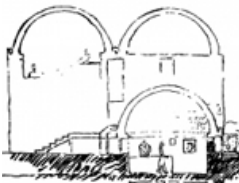
Horizontal & Vertical shading with low VLT glass or Polycarbonate sheets (translucent materials)
(ref- Apple office Singapore)



Horizontal & Vertical shading through ETFE fins or panels
(ref- Esplanade Singapore)



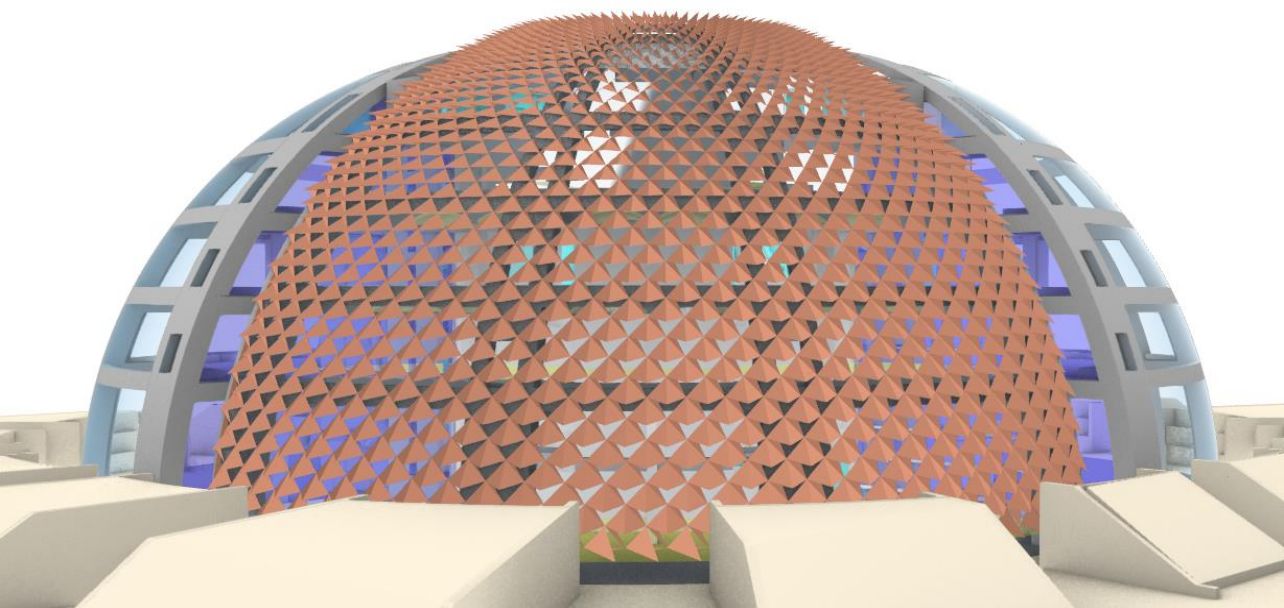
NALANDA
University



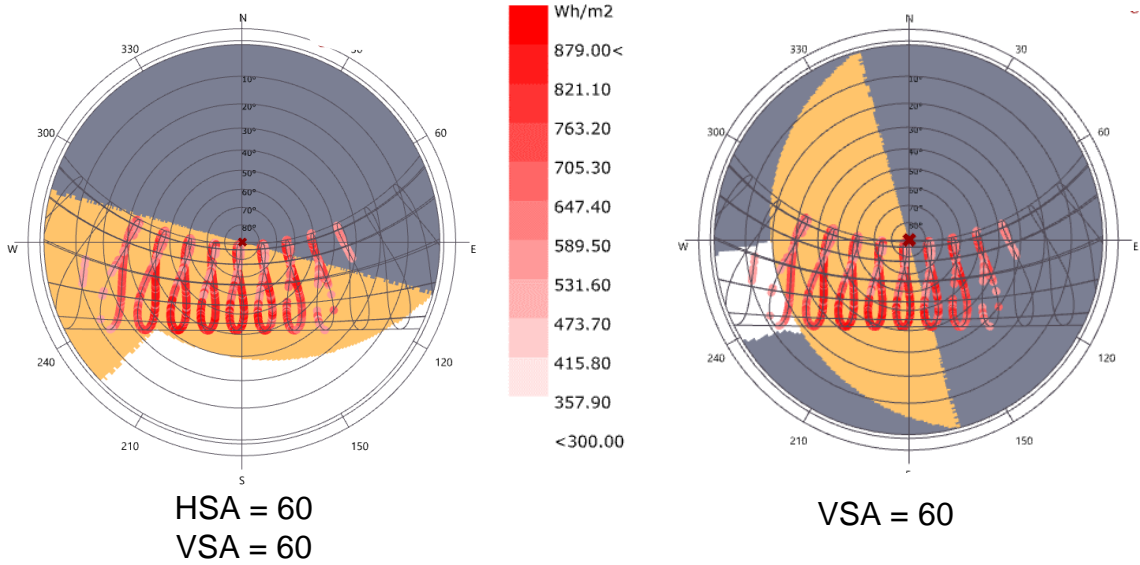
Library Preliminary Architecture Report
Nalanda University , Rajgir

Daylight Analysis | New Façade

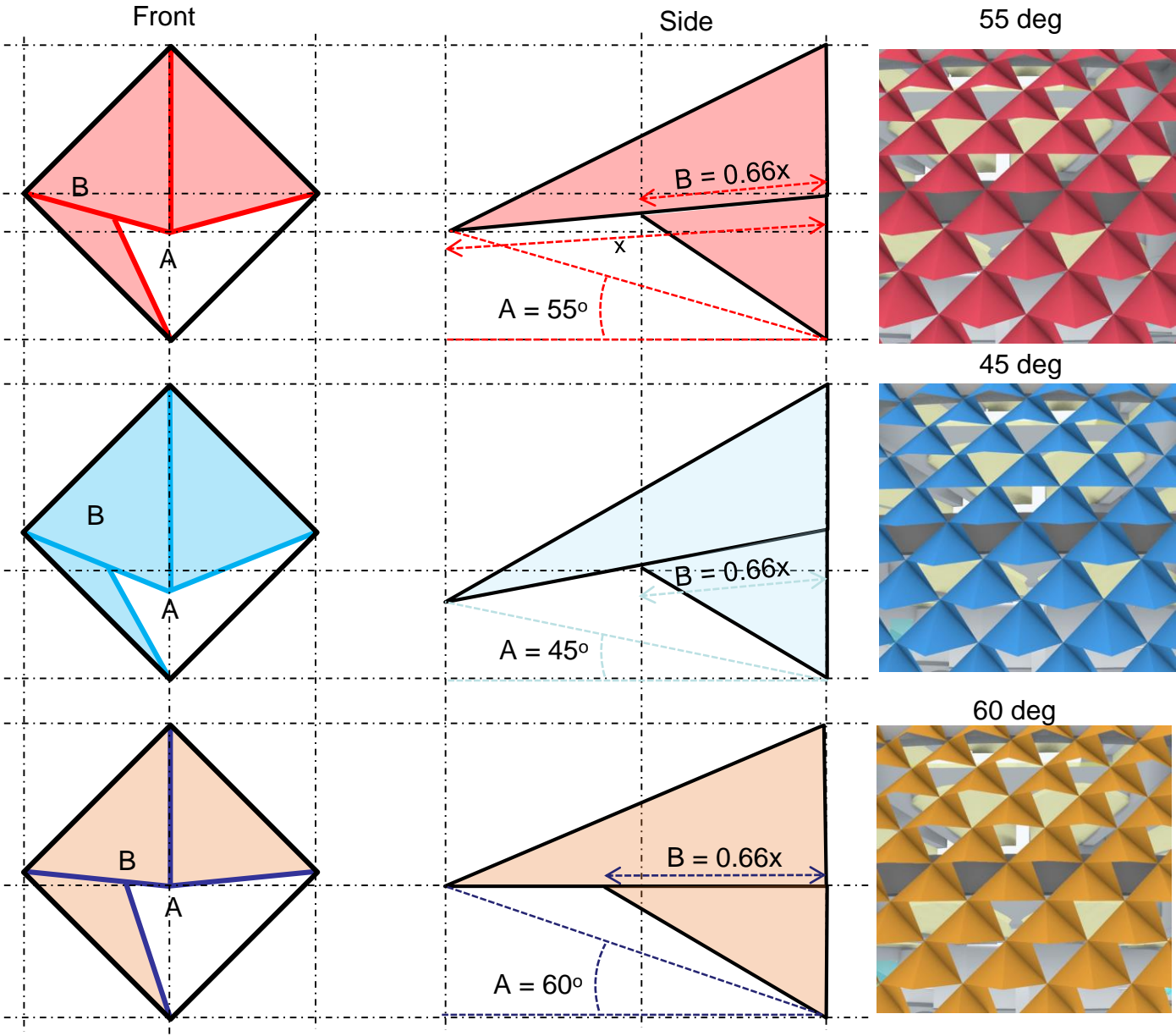
New Façade Iteration with Triangular Fins for horizontal and vertical shading



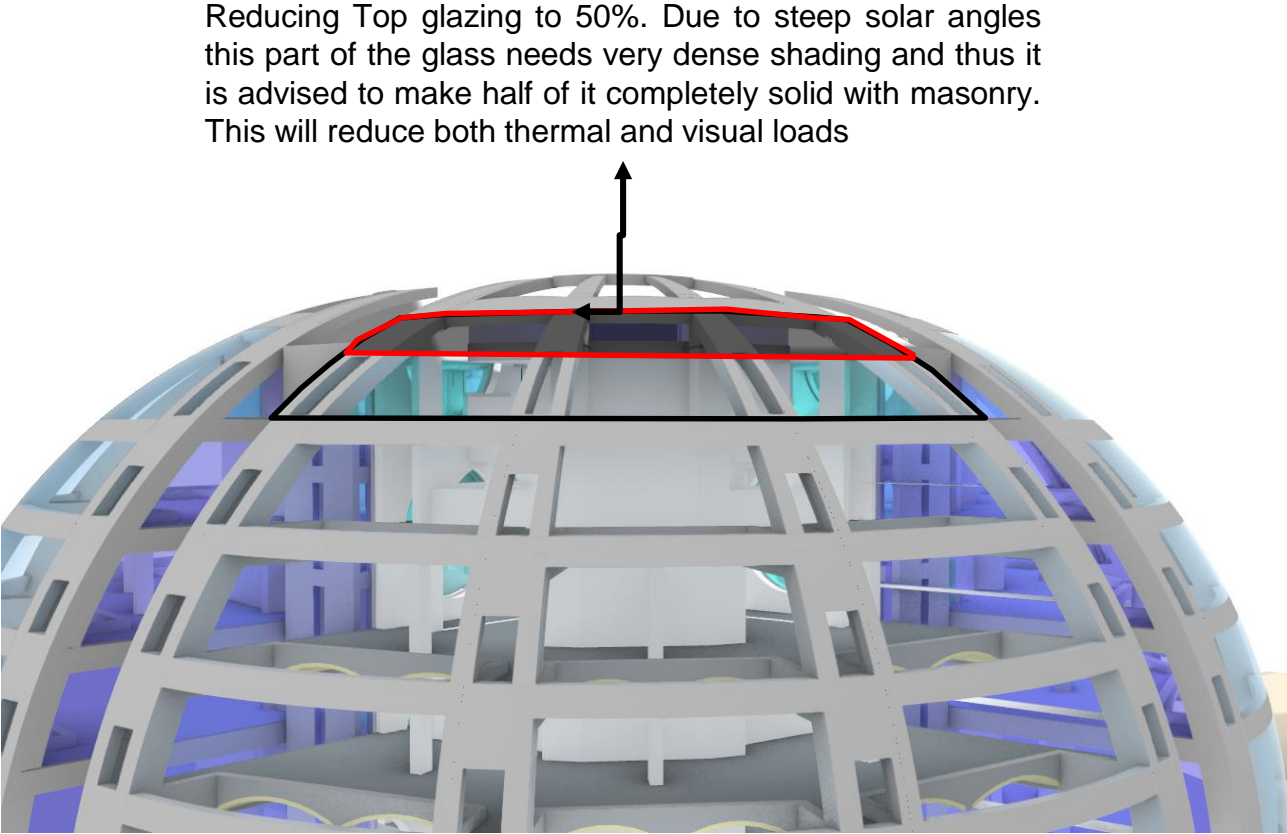
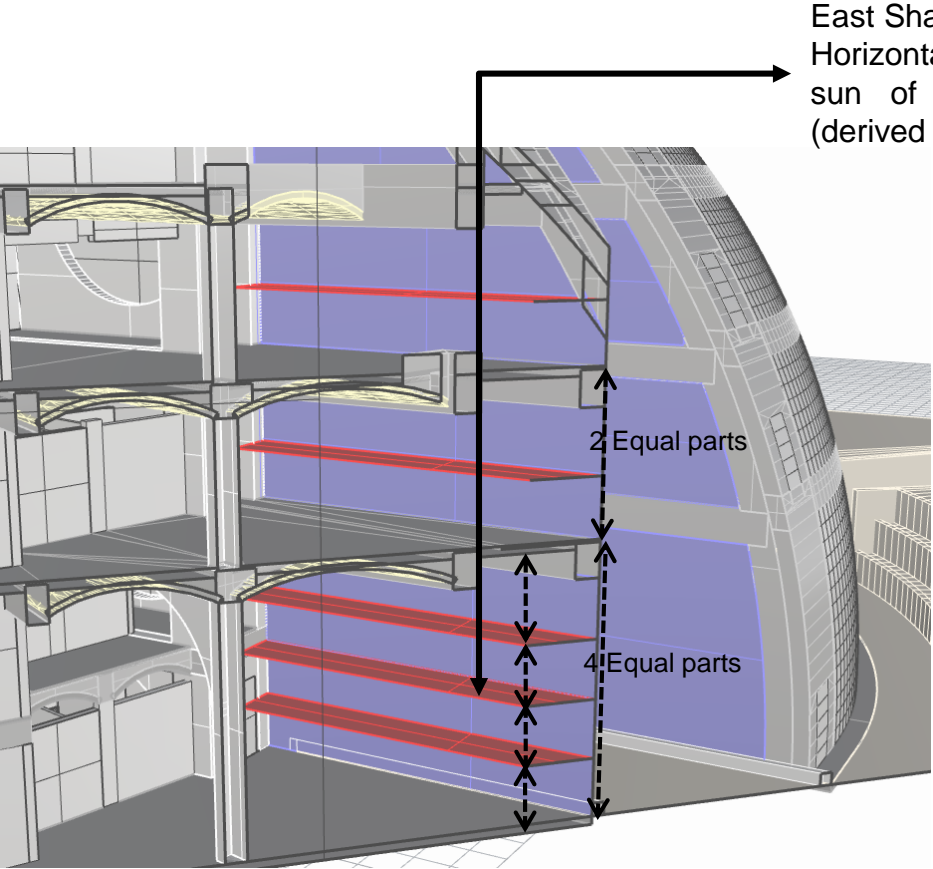
Shading Mask



Three combinations of shading angles were tested



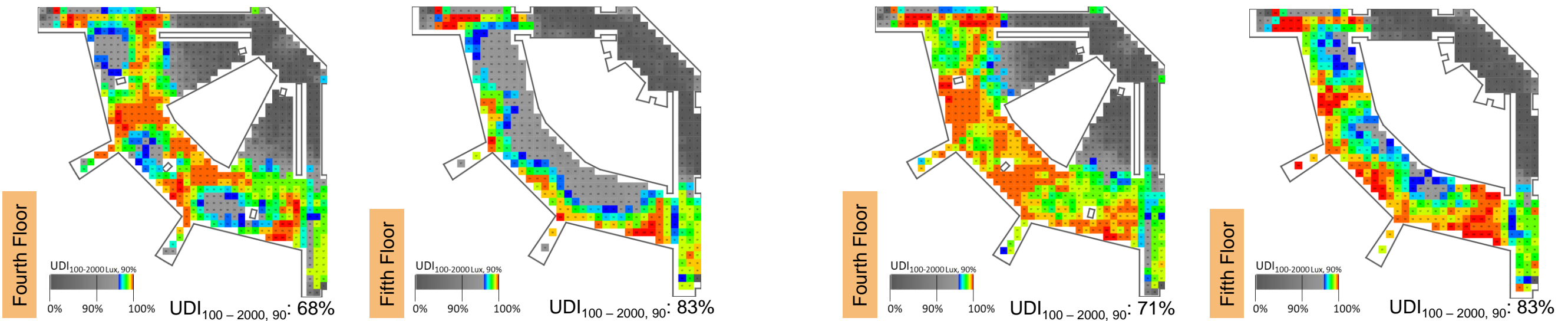
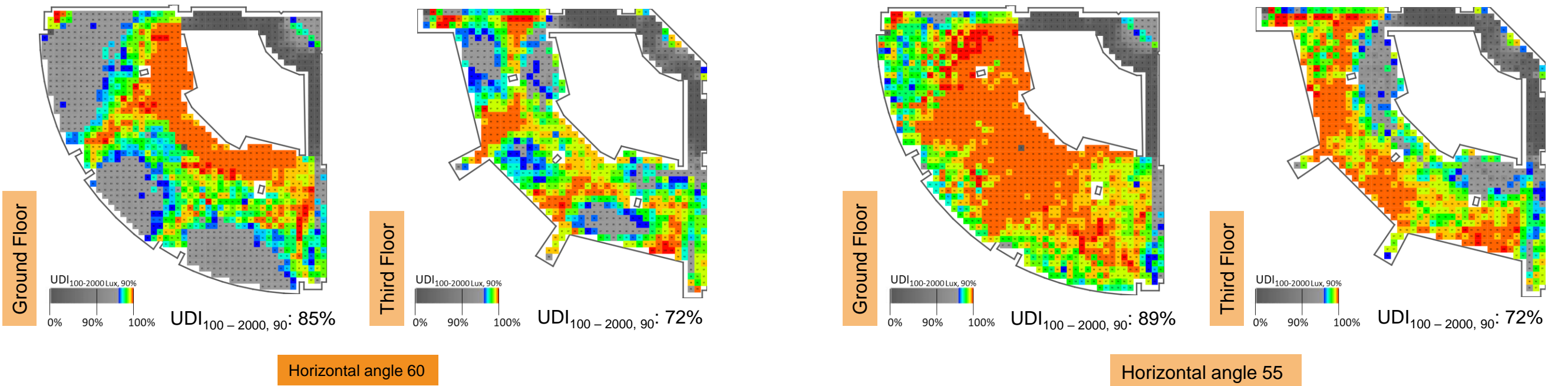
Daylight Analysis | New Façade – additional modifications



The new design iterations of three shading angles with East shading and top glazing reduced to half are simulated for UDI performance with various Glazing VLTs (40,34,30%) and with 80% ceiling reflectance in the following slides.

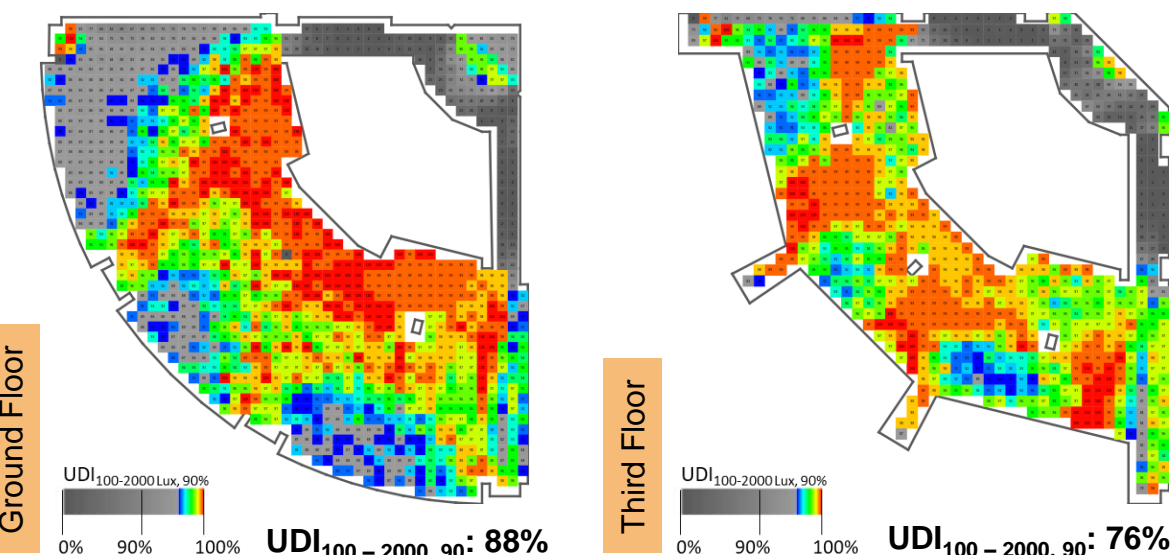
Daylight Results | UDI with Horizontal angle 60° vs Horizontal angle 55°

Pattern 4: Triangular shape : VLT 30

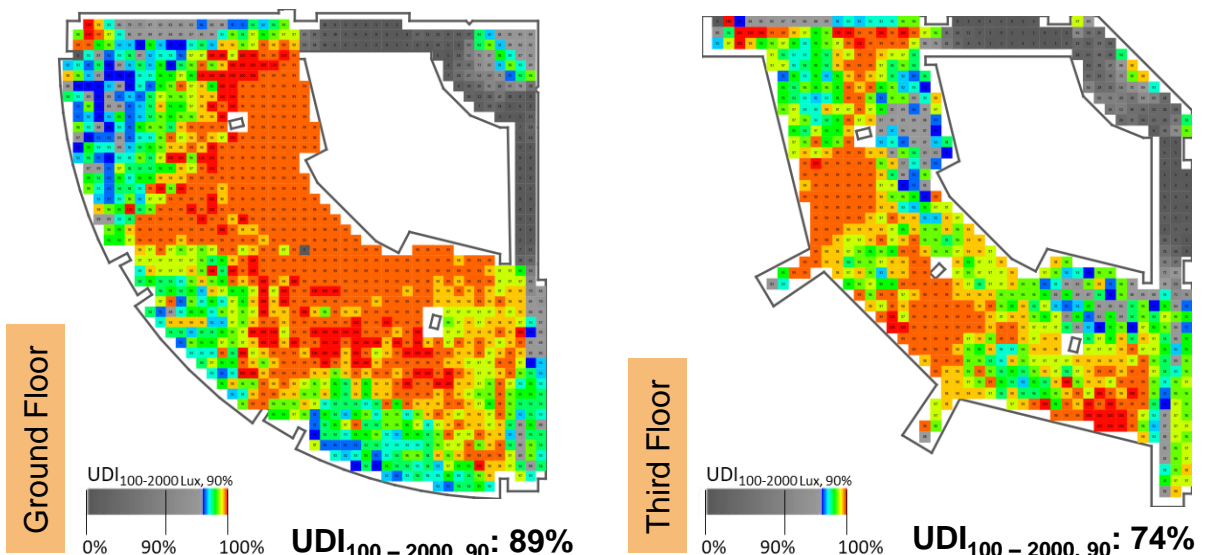


Daylight Results | UDI with Horizontal angle 55°

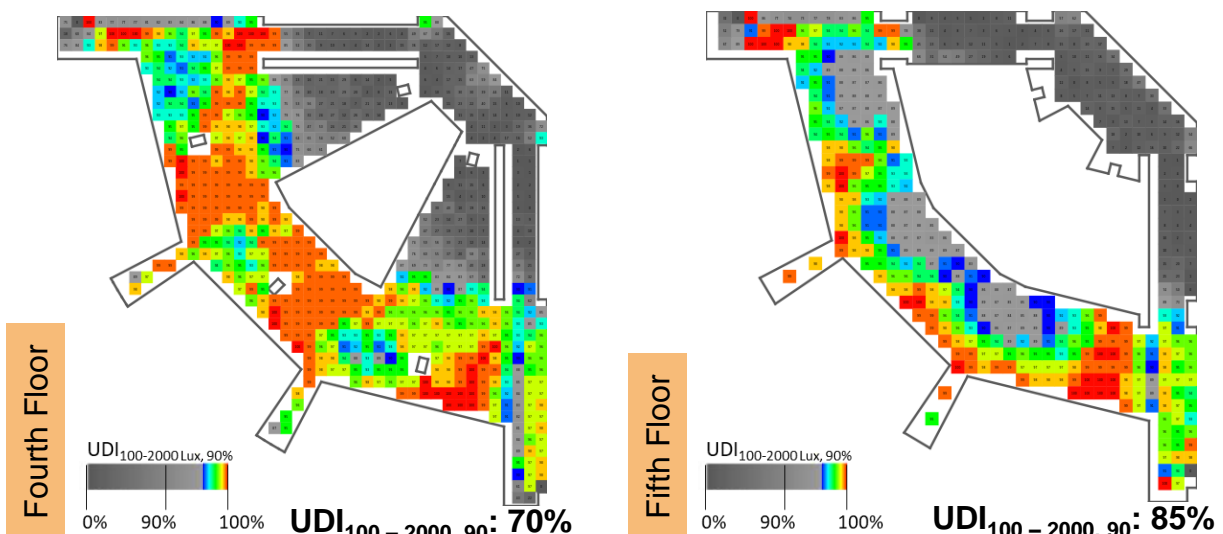
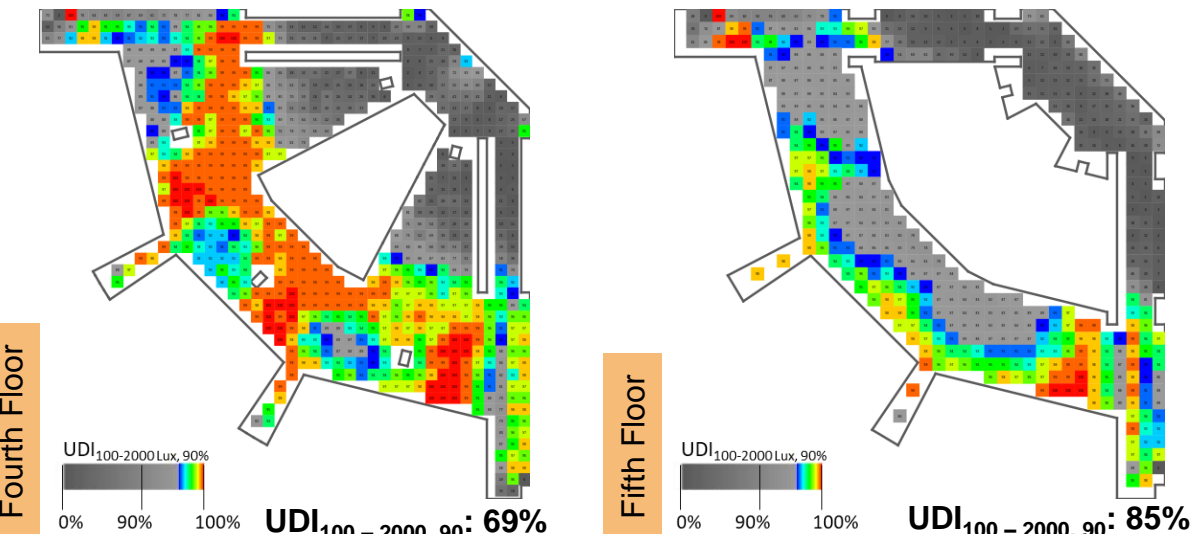
Pattern 4: Triangular shape : VLT 40 vs VLT 34



VLT 40



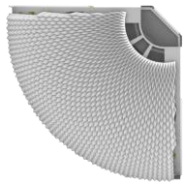
VLT 34



Daylight Results | UDI with glazing VLT 34% Ceiling 80%

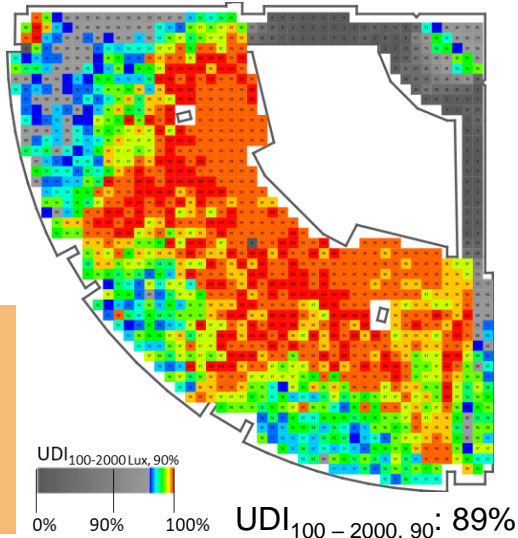
Pattern 4: Triangular shape

UDI time extents: 8am-5pm
Average across all floors
Pattern 4: 76.61%
GRIHA mandatory credits met

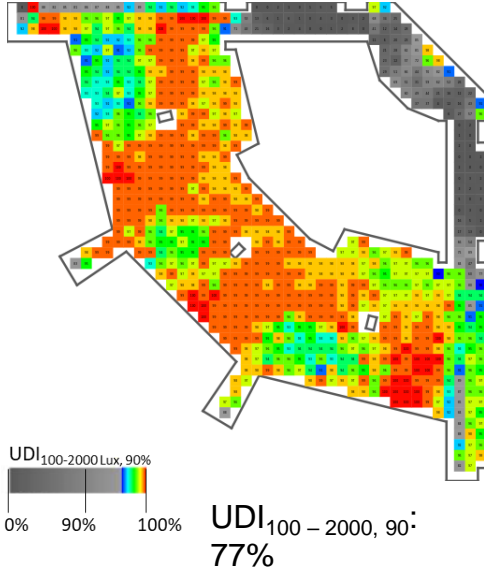


Average UDI_{100 – 2000, 90°}: 76.6%

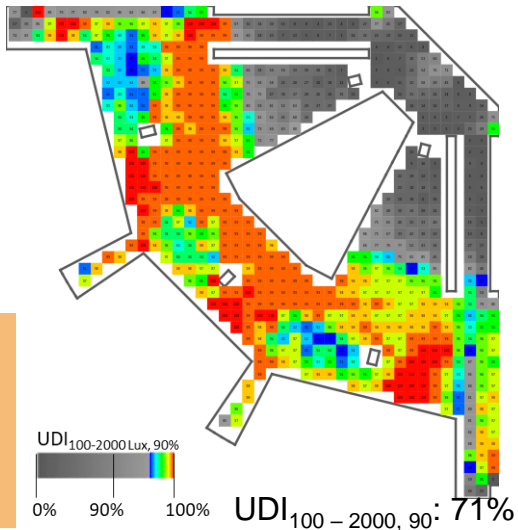
Ground Floor



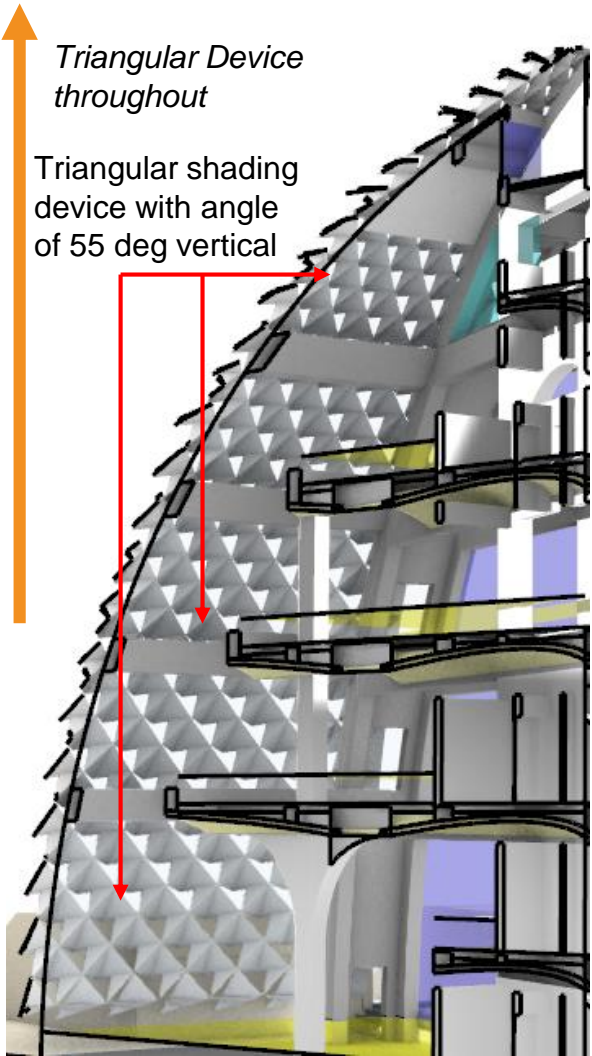
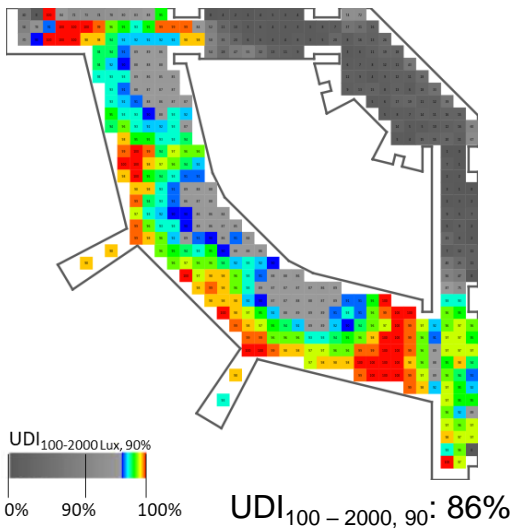
Third Floor



Fourth Floor



Fifth Floor



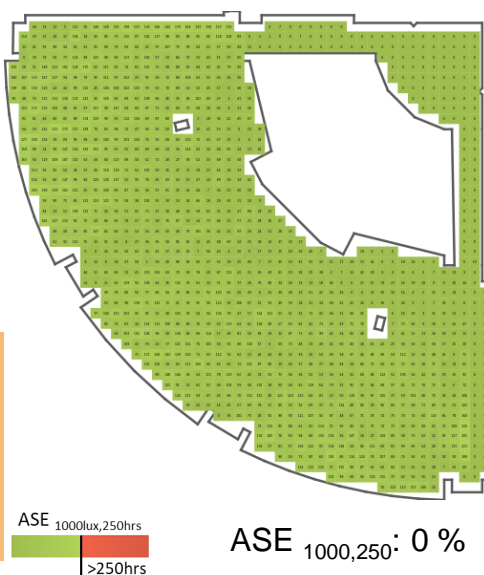
*Optimization process of these light shelves can be referred to section 1 in the appendix

Daylight Results | ASE & sDA with glazing VLT 34% Ceiling 80%

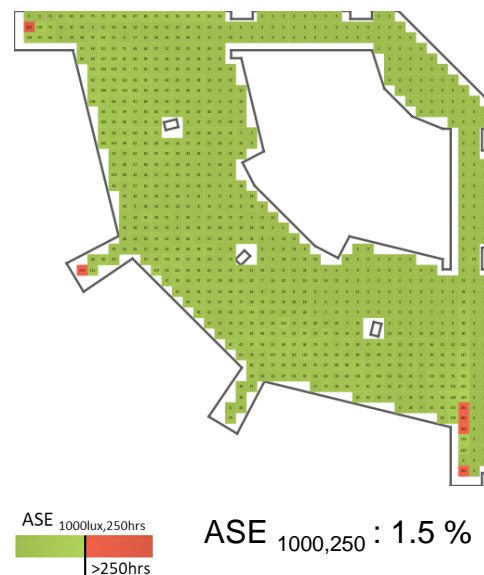
Pattern 4: Triangular shape

SDA & ASE time extents: 8am-5pm
Average across all floors
Pattern 4: 71.86%, 0.5%
LEED compliant ASE<10%

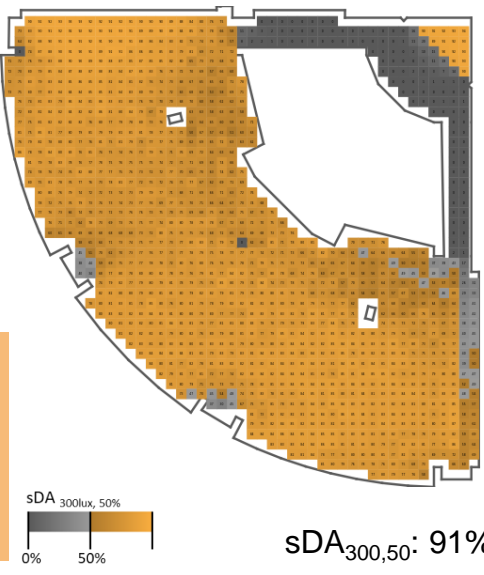
Ground Floor



Second Floor



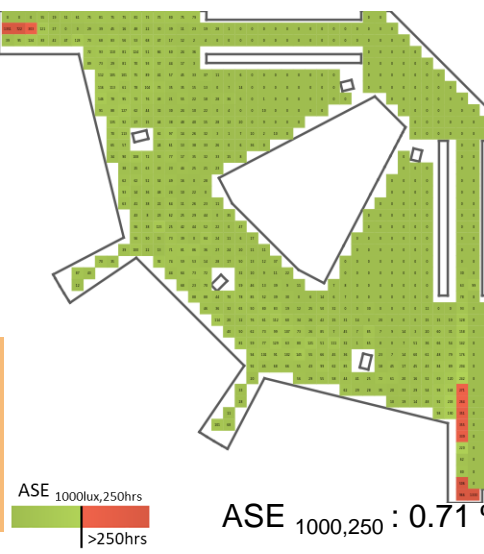
Ground Floor



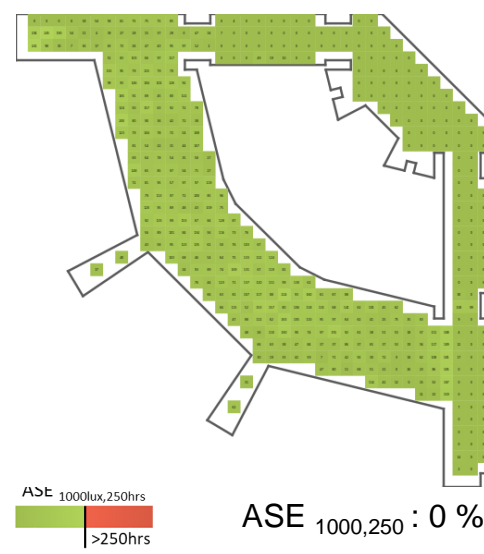
Second Floor



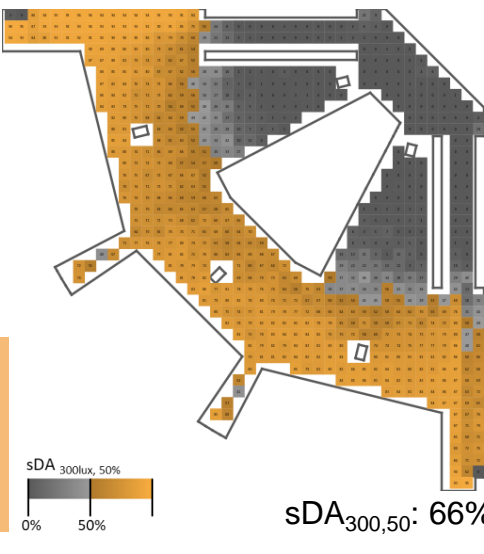
Third Floor



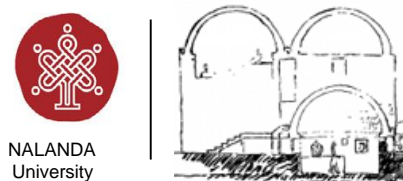
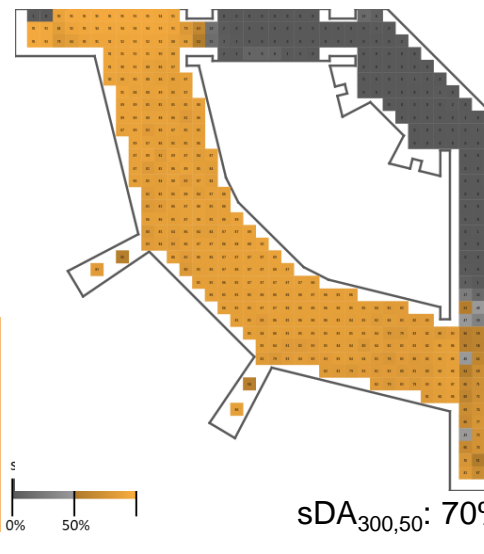
Fourth Floor



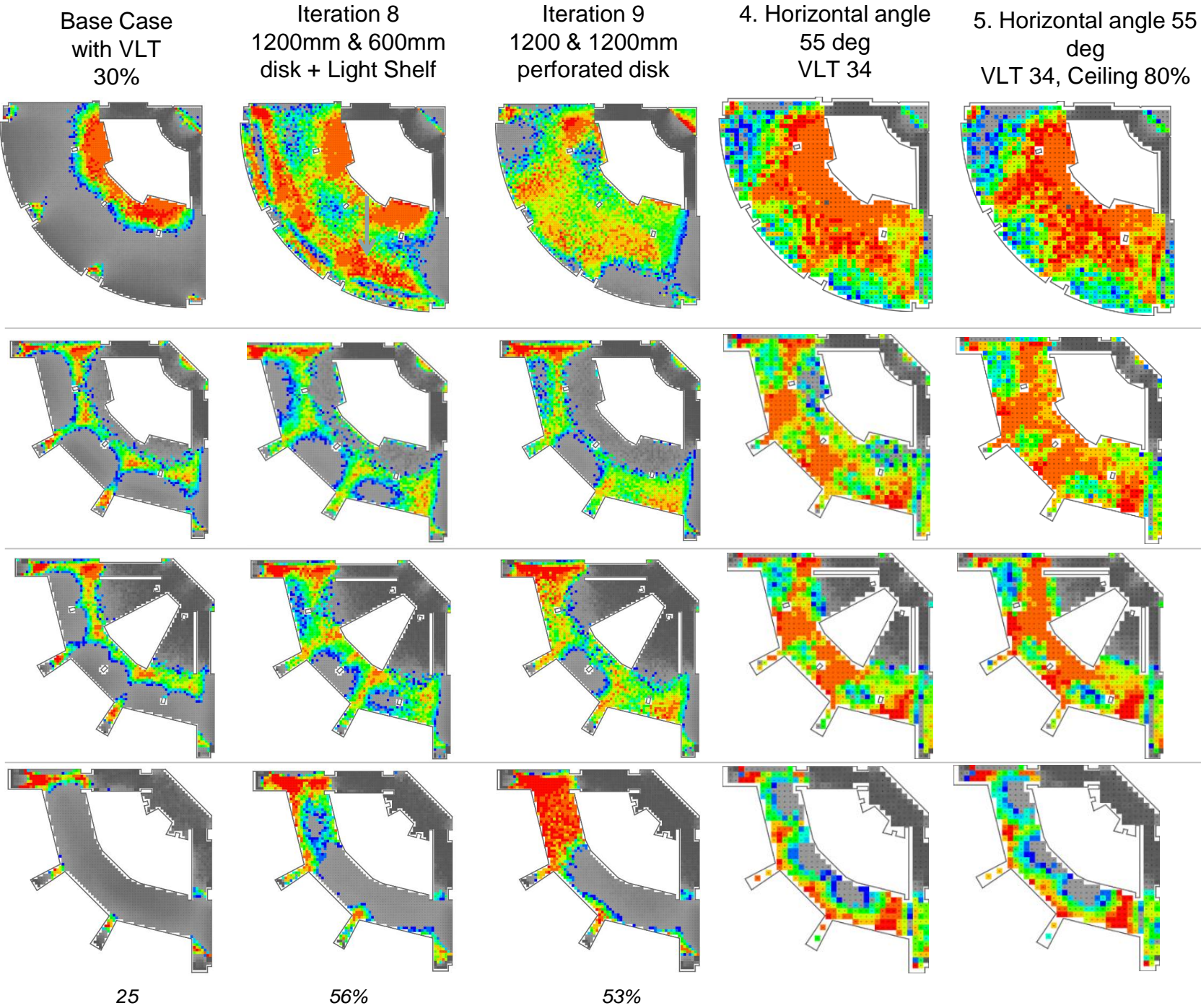
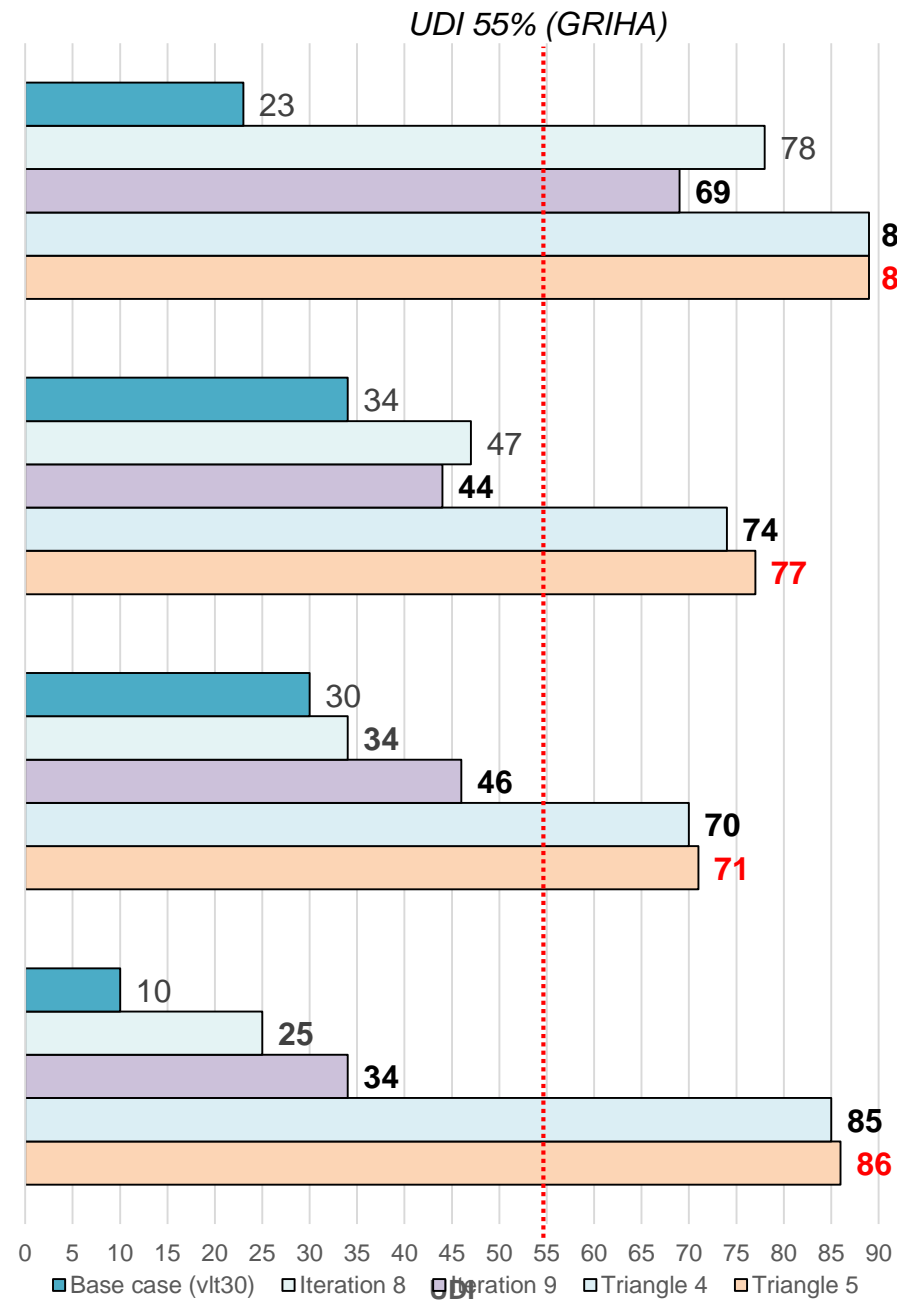
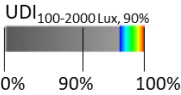
Third Floor



Fourth Floor



Daylight Results | Comparison of Discs with Triangular



Results summary| Observations & design recommendations

Solutions explored in the iterative process

Glazing VLT

BASE CASE GLAZING VLT 60%

- 1. U value - Double Glazed Glass - 1.4 W/m2K
- 2. SHGC - Double Glazed Glass - 0.34
- 3. Reference : Saint Gobain DGU SKN16511 Lumina (VLT 60%)

PROPOSED CASE GLAZING VLT – 34%

Reference1- SKN 444 II – VLT 34%, SHGC Double glazing- 0.2, U value – 1.6 W/m2K

Implication:-

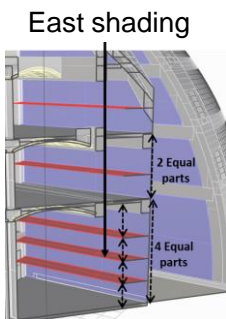
- 1. High improvement (20-25%) in the Daylight performance
- 2. No Architectural implication – design and detail can remain same
- 3. Moderate increase in Capital cost of the glazing.
- 4. Indirect cost benefits- Low SHGC will help reduce HVAC loads and thereby extra cost will offset

East Horizontal Shading

RECOMMENDATION – Horizontal shading on the East with high reflective / white finish to block the harsh Solar angles and reflect light on the ceiling for deeper daylight penetration

Implication:- High improvement (25%) in the Daylight performance

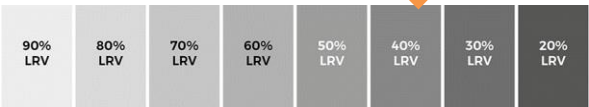
- 1. Additional element- Moderate design & cost implication



Ceiling Reflectance

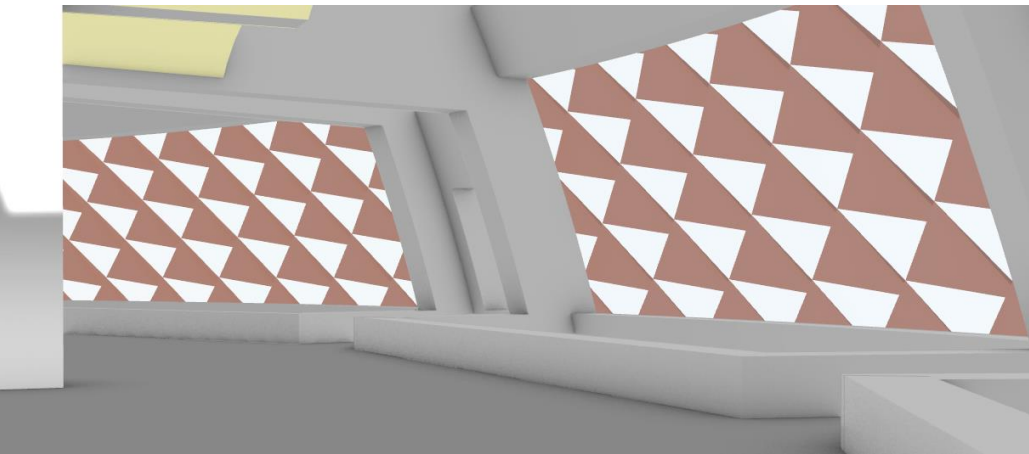
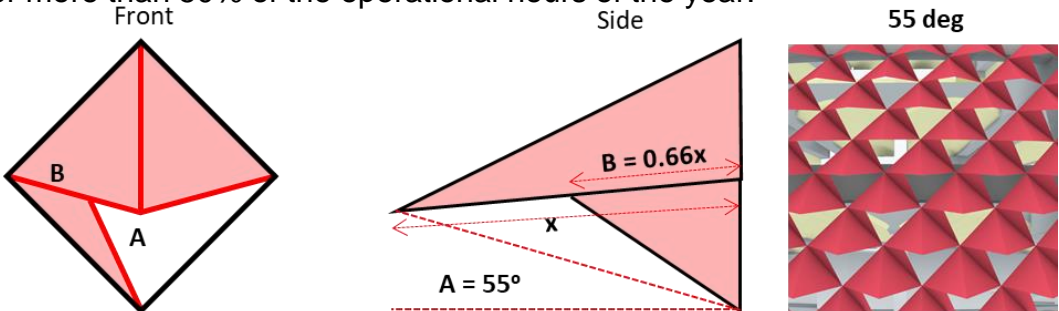
RECOMMENDATION – Minimum 40% reflectance is required.

- 1. 70% reflectance improves daylight performance by 5-7% with current design.
- 2. Limited cost implication. Architecturally this will mean an additional finish
- 3. Reflectance is difficult to control and depends on the construction quality

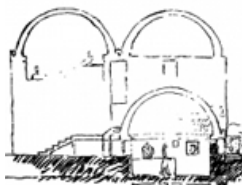


Façade Pattern

RECOMMENDATION – Triangular Pattern option with 55° Shading angle works the best for achieving Minimum ASE and Glare potential and Highest UDI and sDA in the reading spaces of the Library. The design is parametrically evolved to optimize shading and best possible view to the outdoors. The high sDA and UDI not only show exemplary performance in LEED and GRIHA rating but also minimize dependence on electrical lighting for more than 50% of the operational hours of the year.



Implication – Triangular Patterns are developed from dividing the Dome into diagrids. This poses a challenge of each triangle being of a different size and the developed façade lacks modularity. However it ensures the best optimized design for Daylight performance. Consultation with Architect is required to discuss constructability of this façade.



THANK YOU



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