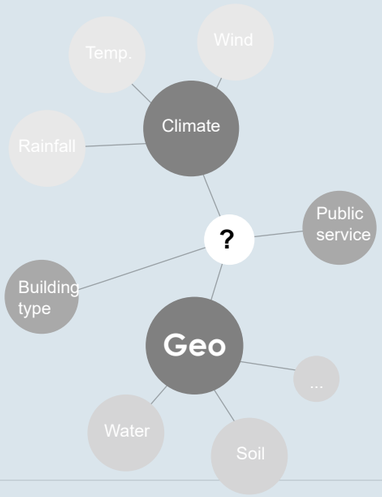
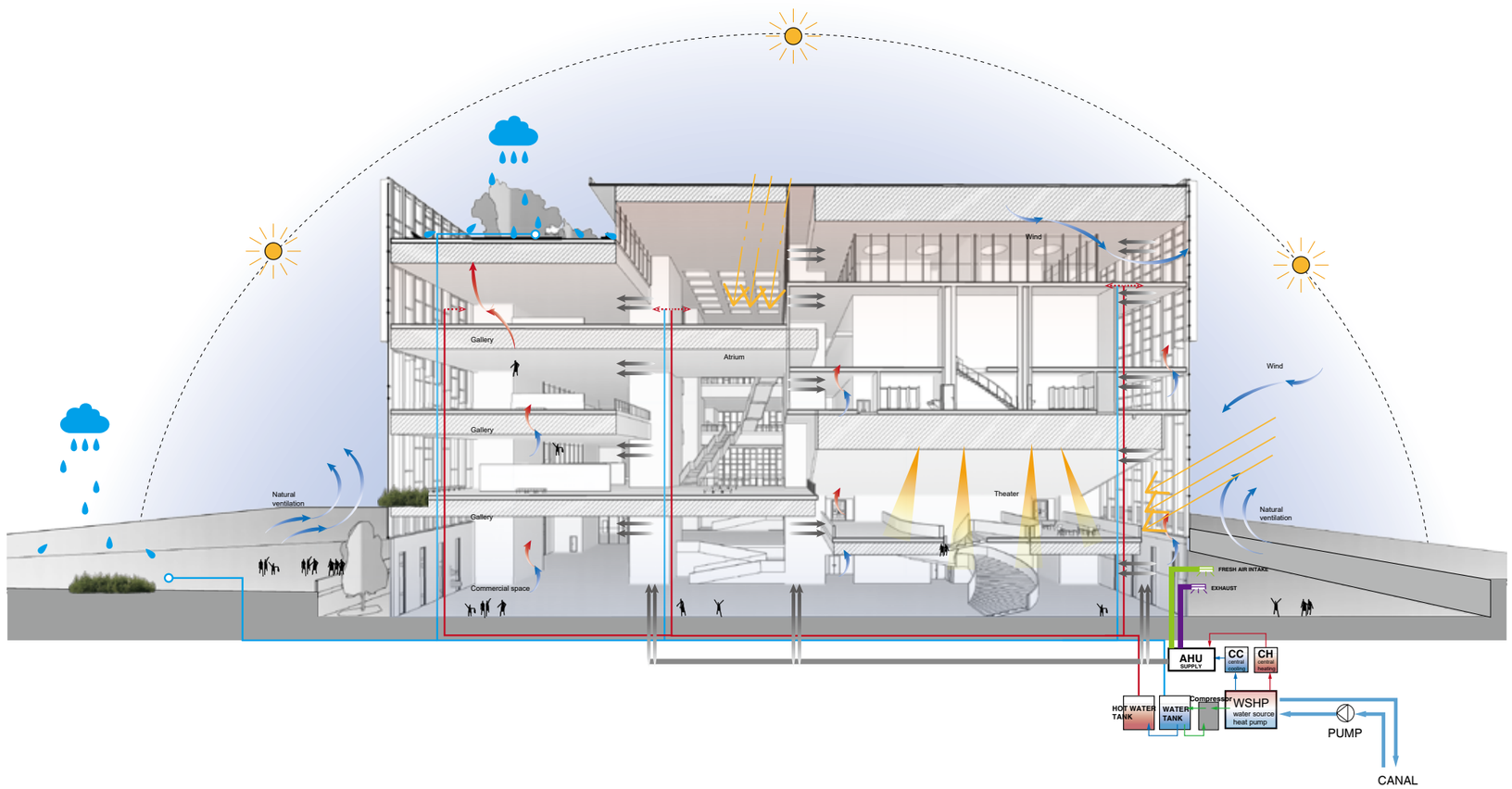
6 ENERGY & BUILDING SERVICE

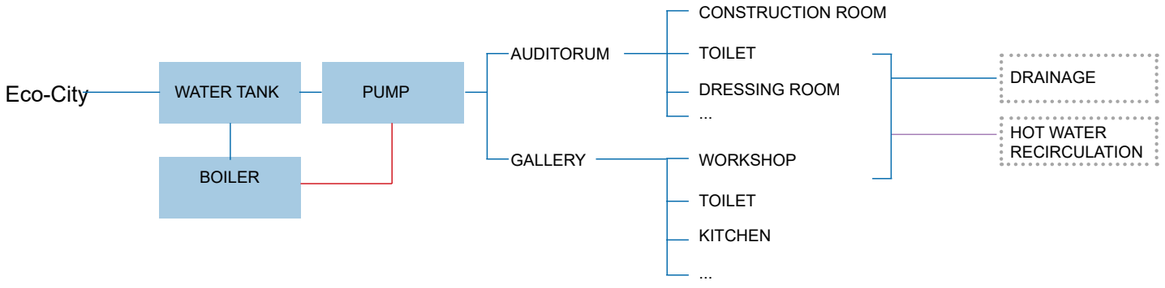


General BSD identification

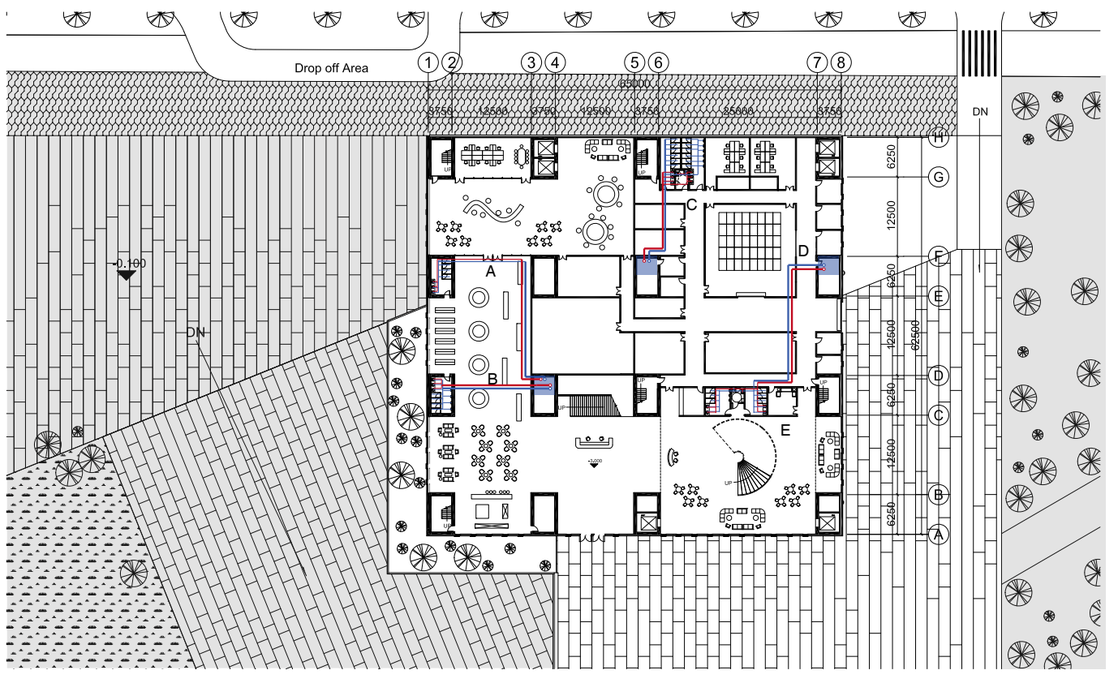


Plumbing system

Water supply schemes



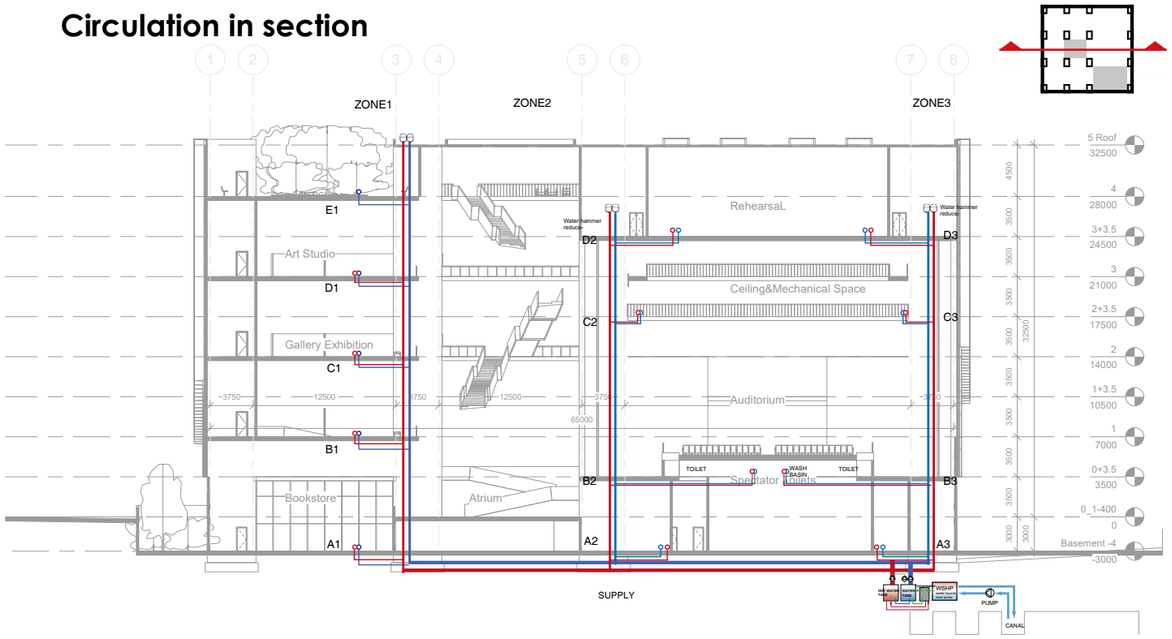
Circulation in plan - typical floor GF layout



LEGEND

- Domestic hot water
- Domestic cold water
- Risers
- Risers area
- **A/B/C/D/E** Plumbing zone

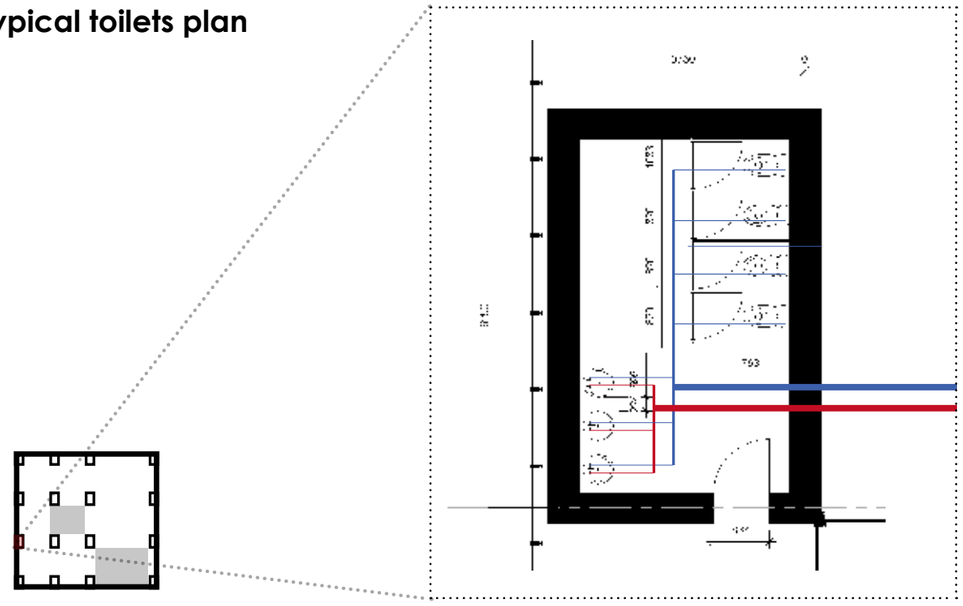
Circulation in section



LEGEND

- Domestic hot water
- Domestic cold water
- Water hammer reducer
- **A/B/C/D/E** Plumbing fixture point

Typical toilets plan

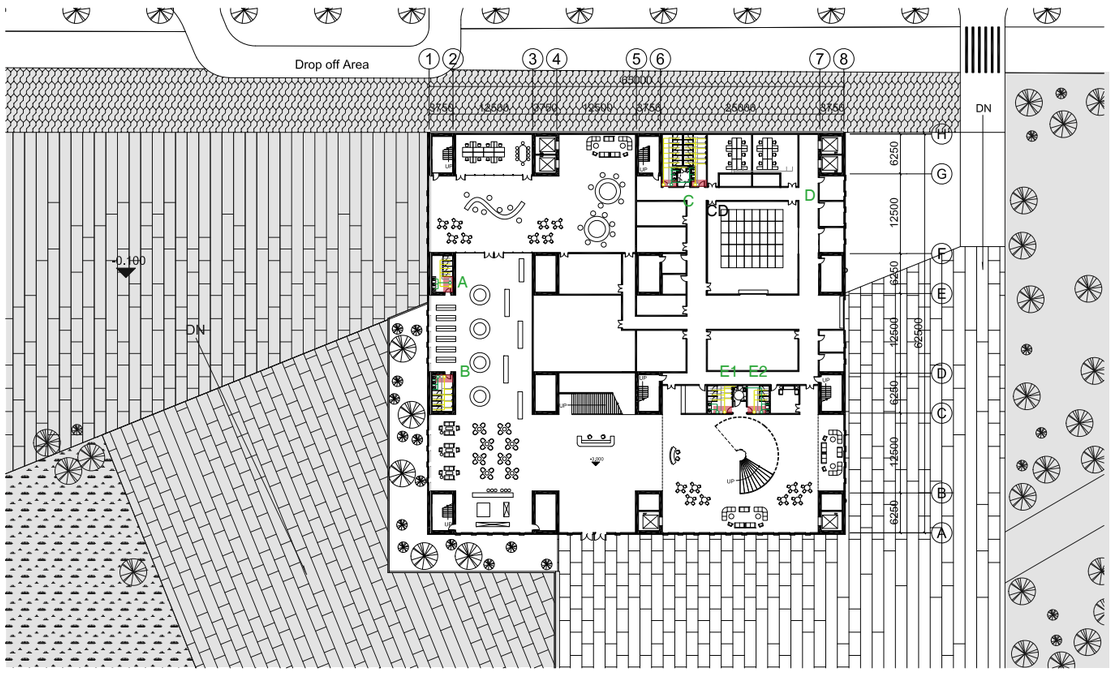


domestic cool & hot water

Drainage & water reuse system

Middle water reuse schemes

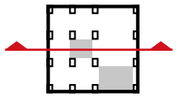
Circulation in plan - typical floor GF layout

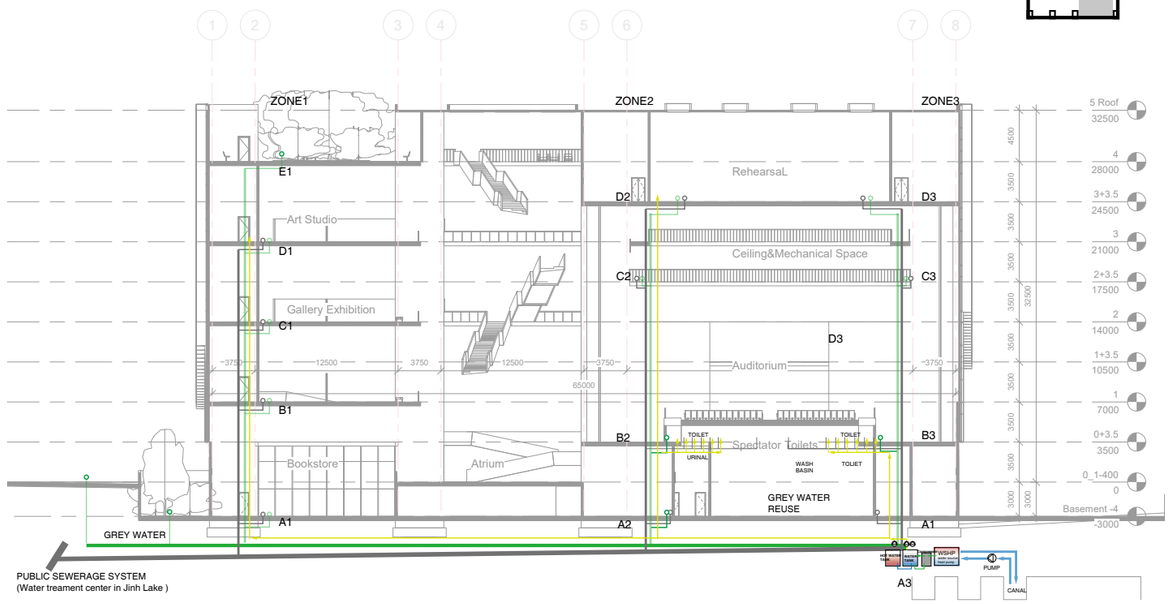


LEGEND

Drainage
Grey water
Reused water
Risers
Risers area
A/B/C/D/E Drainage zone

Circulation in section

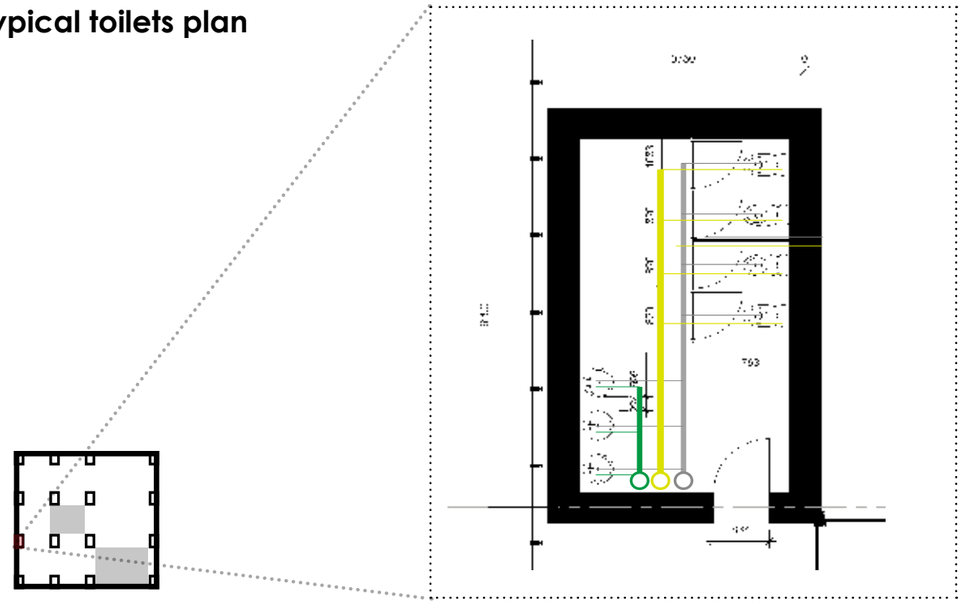




LEGEND

Drainage
Grey water
Reused water
Water hammer reducer
A/B/C/D/E Drainage fixture point

Typical toilets plan



sanitary & reused water

Plumbing system

Circulation in plan

Maximum plumbing horizontal pipe size calculation

EN-806-3 Standard

PLUMBING : Circulation in plan

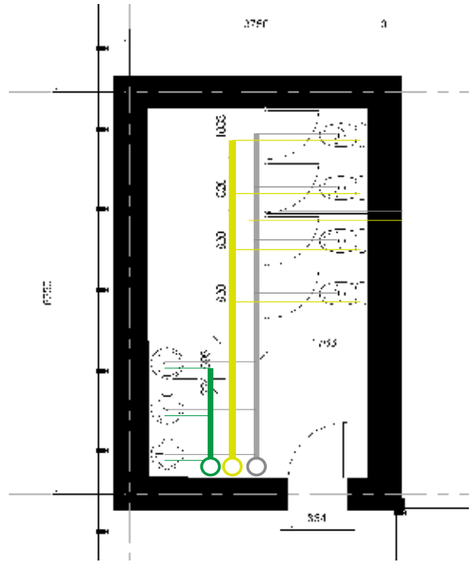
BRANCH	Room	Appliance	Supply	Loading units Cold water AF	Loading units Hot water AC	Loading units Total AF+AC	Number	∑LU Cold water AF	∑LU Hot water AC	∑LU Total AF+AC	LUmax(max.flush) Cold water AF	LUmax(max.flush) Hot water AC	Largest pipe size xs[mm] Cold water AF	Largest pipe size xs[mm] Hot water AC
ZONE1-gallery														
(F)	Kitchen	basin	Mixer	1.5	1.5	2	5							
		kitchen sink	Mixer	1.5	1.5	2	5	25	15	30	2	1.5	32x3	20x2.5
		washing mach	Cold water only	2	0	2	5							
A	Toilet1	washbasin	Mixer	0.75	0.75	1	3							
		sink	Cold water only	2	0	2	5	12.25	2.25	13	10	0.75	20x2.5	16x2
		pan	direct flush	6	0	6	0							
		urinal	direct flush	10	0	10	0							
B	Toilet2	washbasin	Mixer	0.75	0.75	1	3							
		sink	Cold water only	2	0	2	5	12.25	2.25	13	10	0.75	20x2.5	16x2
		pan	direct flush	6	0	6	0							
		urinal	direct flush	10	0	10	0							
ZONE2-auditorum1														
C	Toilet1	washbasin	Mixer	0.75	0.75	1	9							
		sink	Cold water only	2	0	2	19	104.75	6.75	107	10	0.75	40x3.5	18x2
		pan	direct flush	6	0	6	0							
		urinal	direct flush	10	0	10	6							
D	Construction room 1+2+3	washbasin	Mixer	0.75	0.75	1	10	7.5	7.5					
		washbasin	Mixer	0.75	0.75	1	10	7.5	7.5	30	0.75	0.75	26x3	26x3
		washbasin	Mixer	0.75	0.75	1	10	7.5	7.5					
CD	BRANCH C+D							127.25	29.25	137	10.75	1.5	40x3.5	16x2
ZONE2-auditorum2														
E	Toilet2	washbasin	Mixer	0.75	0.75	1	10							
		sink	Cold water only	2	0	2	6	19.5	7.5	22	10	0.75	26x3	18x2
		pan	direct flush	6	0	6	0							
		urinal	direct flush	10	0	10	0							

Like the typical plan G0 shows, our building is divided into 3 zones for plumbing, water are supplied from pumps in -1Floor and circulates from vertical risers in cores to each floor.

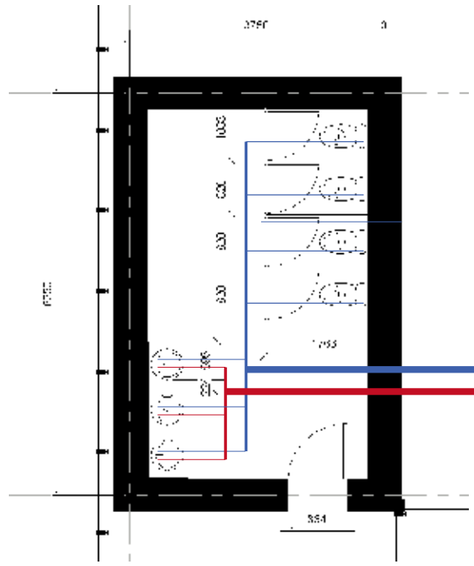
In each ZONE we consider hot water & cold water separately.

ZONE1 - Gallery - Plumbing branch A/B - 1 Riser
ZONE1 - Auditorum - Plumbing branch C/D - 1 Riser
ZONE3 - Auditorum - Plumbing branch E - 1 Riser

Typical toilets plan



sanitary & reuse



domestic cool & hot water

Plumbing system

Circulation in plan

Maximum drainage horizontal pipe size calculation

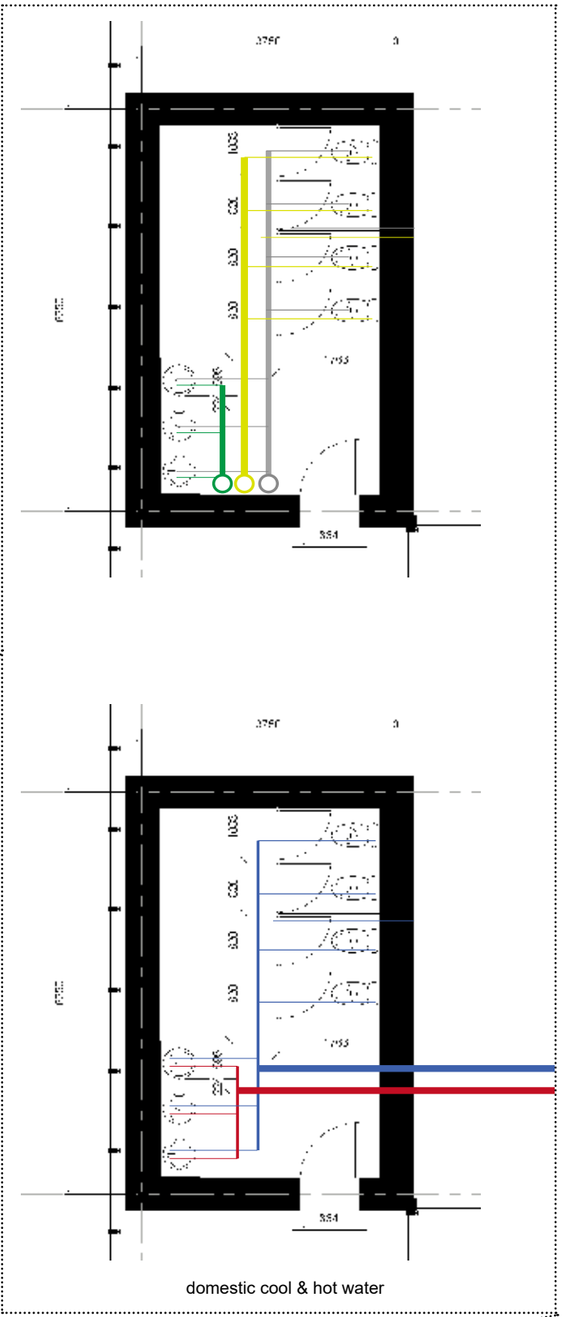
DRAINAGE : Circulation in plan															
ZONE1-gallery															
RISER	Room	Appliance	Supply	Loading units			Number	∑LU			LUmax(max.flush)			Largest pipe size xs[mm]	
				Cold water AF	Hot water AC	Total AF+AC		Cold water AF	Hot water AC	Total AF+AC	Cold water AF	Hot water AC	Total AF+AC	Total AF+AC	
(F)	Kitchen	basin	Mixer	1.5	1.5	2	5								
		kitchen sink	Mixer	1.5	1.5	2	5	25	15	30	2	1.5	3.5	26x3	
		washing mach	Cold water only	2	0	2	5								
A	Toilet1	washbasin	Mixer	0.75	0.75	1	3								
		sink	Cold water only	2	0	2	5	12.25	2.25	13	10	0.75	10.75	20x2.5	
		pan	direct flush	6	0	6	0								
		urinal	direct flush	10	0	10	0								
B	Toilet2	washbasin	Mixer	0.75	0.75	1	3								
		sink	Cold water only	2	0	2	5	12.25	2.25	13	10	0.75	10.75	20x2.5	
		pan	direct flush	6	0	6	0								
		urinal	direct flush	10	0	10	0								
ZONE2-auditorum1															
C	Toilet1	washbasin	Mixer	0.75	0.75	1	9								
		sink	Cold water only	2	0	2	19	104.75	6.75	107	10	0.75	10	40x3.5	
		pan	direct flush	6	0	6	0								
		urinal	direct flush	10	0	10	6								
D		washbasin	Mixer	0.75	0.75	1	10	7.5	7.5						
	Construction room 1+2+3	washbasin	Mixer	0.75	0.75	1	10	7.5	7.5	30	22.5	22.5	30	32x3	
		washbasin	Mixer	0.75	0.75	1	10	7.5	7.5						
ZONE3-auditorum2															
E1	Toilet2	washbasin	Mixer	0.75	0.75	1	3	8.25	2.25	9	2	0.75	2	20x2.5	
		sink	Cold water only	2	0	2	3								
E2	Toilet2	washbasin	Mixer	0.75	0.75	1	3	8.25	2.25	9	2	0.75	2	20x2.5	
		sink	Cold water only	2	0	2	3								

The drainage system are samely divided as the 3 plumbing zones, where the pipes goes directly with risers just adjacent to the sink.

Hot water & cold water contribute to the drainage water. Grey & black water then go through risers to the water treatment center in -1F.

ZONE1 - Gallery - Drainage branch A/B - 1 Riser
ZONE1 - Auditorum - Drainage branch C/D - 1 Riser
ZONE3 - Auditorum - Drainage branch E1/E2 - 2 Risers

Typical toilets plan

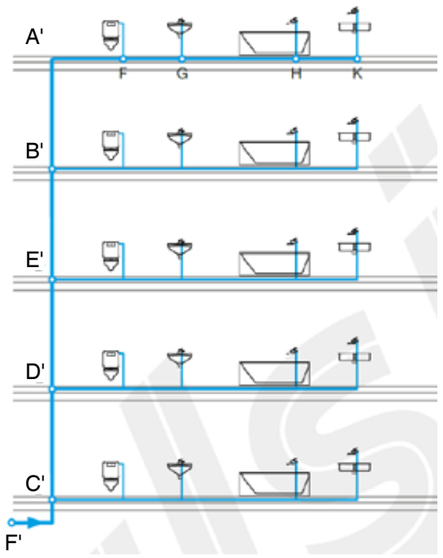


domestic cool & hot water

Plumbing system

Circulation in vertical

Maximum plumbing risers pipe size



Loading unit of risers are sum of loading units in that typical level.

We consider each floor has the same water circulation as GF, in this case, the total water load in each point(A'/B'/C'/...in graphics) is the sum of all the water load above.

ZONE1 - Gallery - Floor 0-4 - 1 Riser
ZONE1 - Auditorum - Floor 0-3 - 1 Riser
ZONE3 - Auditorum - Floor 0-3 - 1 Riser

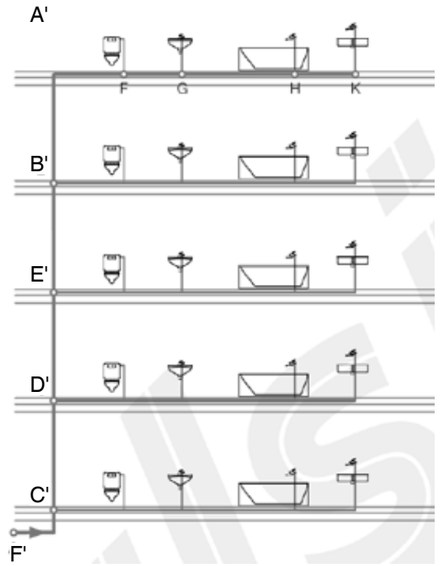
Plumbing risers branch in floors: A'-F'

From valsir QUALITY FOR PLUMBING

PLUMBING : Circulation in vertical						
ZONE1-gallery						
FLOOR	Section	∑LU			Largest pipe size xs[mm]	
		Cold water AF	Hot water AC	Total AF+AC	Cold water AF	Hot water AC
4	AB1	49.5	19.5	69	40X3.5	32X3
3	BC1	99	39	138	40X3.5	32X3
2	CD1	148.5	58.5	207	50X4	32X3
1	DE1	198	78	276	50X4	40X3.5
0	EF1	247.5	97.5	345	50X4	40X3.5
ZONE2-auditorum1						
3	AB2	127.25	29.25	156.5	40X3.5	32X3
2	BC2	254.5	58.5	313	50X4	32X3
1	CD2	381.75	87.75	469.5	50X4	40X3.5
0	DE2	509	117	626	50X4	40X3.5
ZONE3-auditorum2						
3	AB3	19.5	7.5	22	26X3	26X3
2	BC3	39	15	44	32X3	32X3
1	CD3	58.5	22.5	66	32X3	40X3.5
0	DE3	78	30	88	50X4	40X3.5

Circulation in vertical

Maximum drainage risers pipe size



Hot water & cold water contribute to the drainage water. Grey & black water then go through risers to the water treatment center in -1F.

ZONE1 - Gallery - Floor 0-4 - 1 Riser
ZONE1 - Auditorum - Floor 0-3 - 1 Riser
ZONE3 - Auditorum - Floor 0-3 - 2 Risers

Drainage risers branch in floors: A'-F'

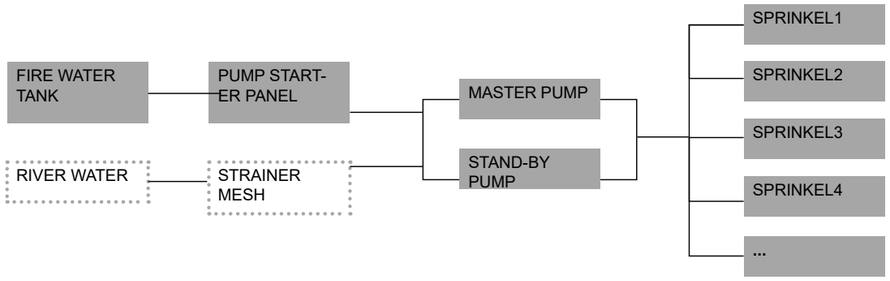
From valsir QUALITY FOR PLUMBING

DRAINAGE : Circulation in vertical						
FLOOR	Section	∑LU			Largest pipe size xs[mm]	
		Cold water AF	Hot water AC	Total AF+AC	Total AF+AC	
4	AB1	49.5	19.5	69		40X3.5
3	BC1	99	39	138		40X3.5
2	CD1	148.5	58.5	207		50X4
1	DE1	198	78	276		50X4
0	EF1	247.5	97.5	345		50X4
ZONE2-auditorum1						
3	AB2	127.25	29.25	156.5		40X3.5
2	BC2	254.5	58.5	313		50X4
1	CD2	381.75	87.75	469.5		50X4
0	DE2	509	117	626		50X4
ZONE3-auditorum2						
3	AB3	16.5	4.5	21		26X3
2	BC3	33	9	42		32X3
1	CD3	49.5	13.5	63		40X3.5
0	DE3	66	18	84		40X3.5

Fire protect system

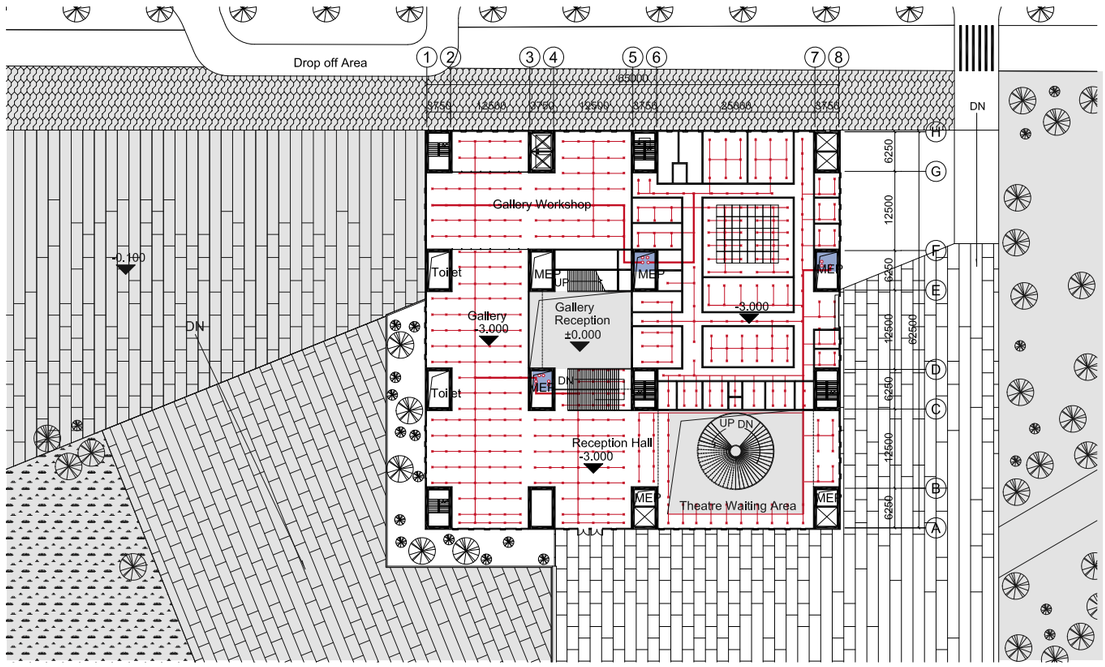
Circulation in plan & section

Deluge system diagram

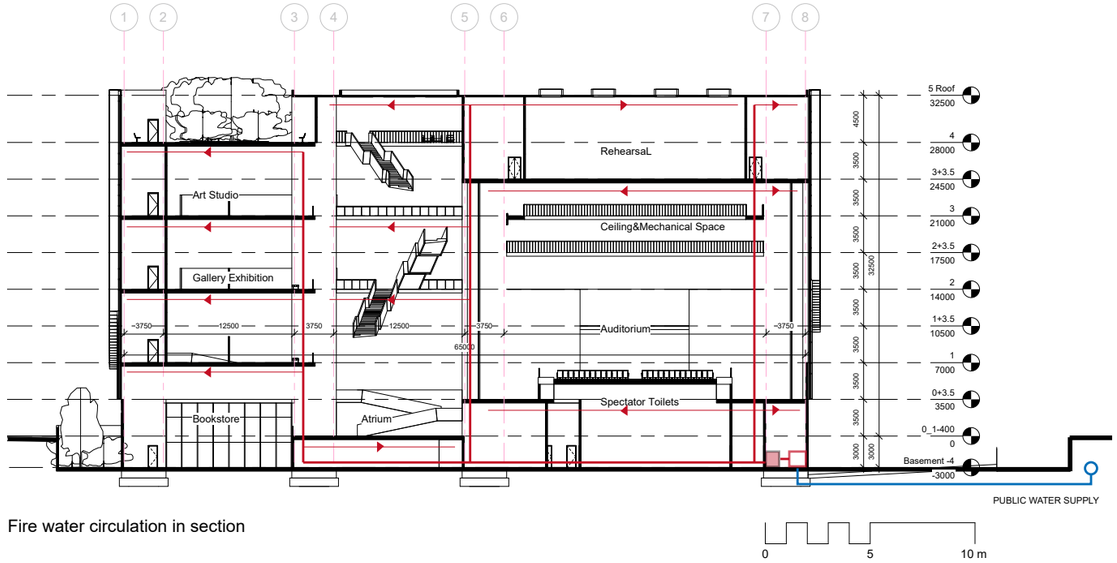


Our building is cultural centre which has auditorum inside, a large stage with several void spaces, and it is a particularly dangerous building that needs to spray water on a large area and quickly extinguish fires in an emergency. The deluge system has fast response speed, large fire extinguishing control area, large water consumption, and more choices of forms, so we choose this system.

Fire water circulation in plan

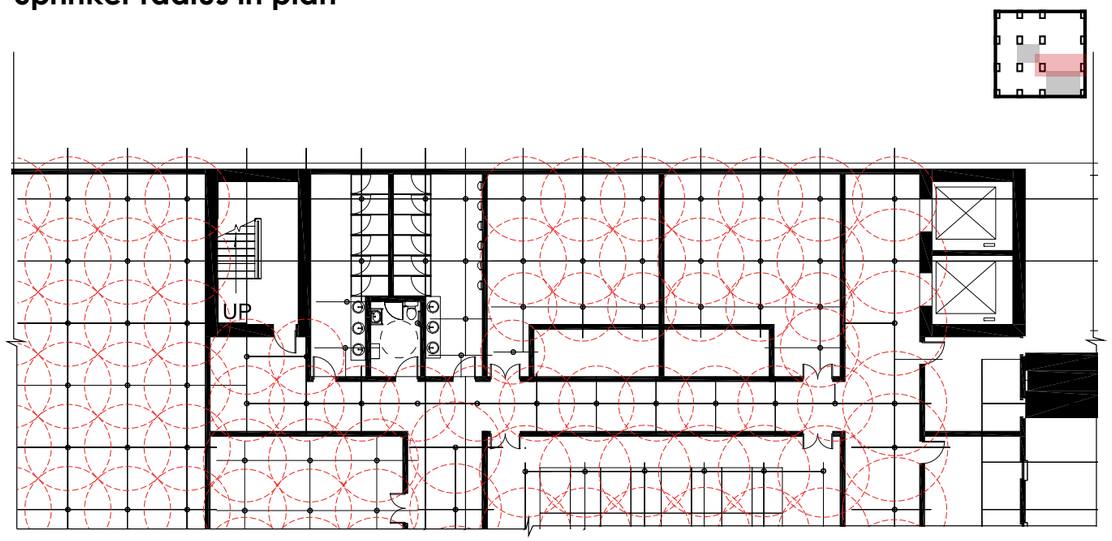


Fire water circulation in section



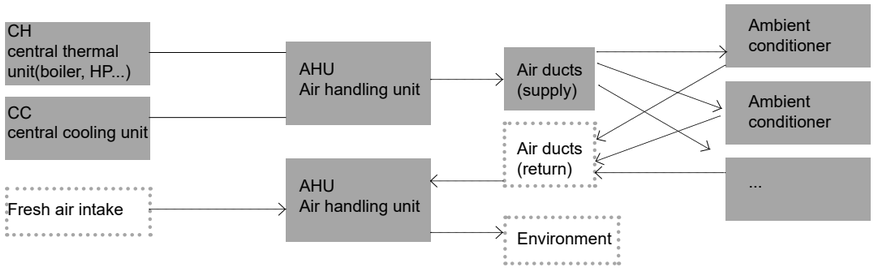
Fire water circulation in section

Sprinker radius in plan



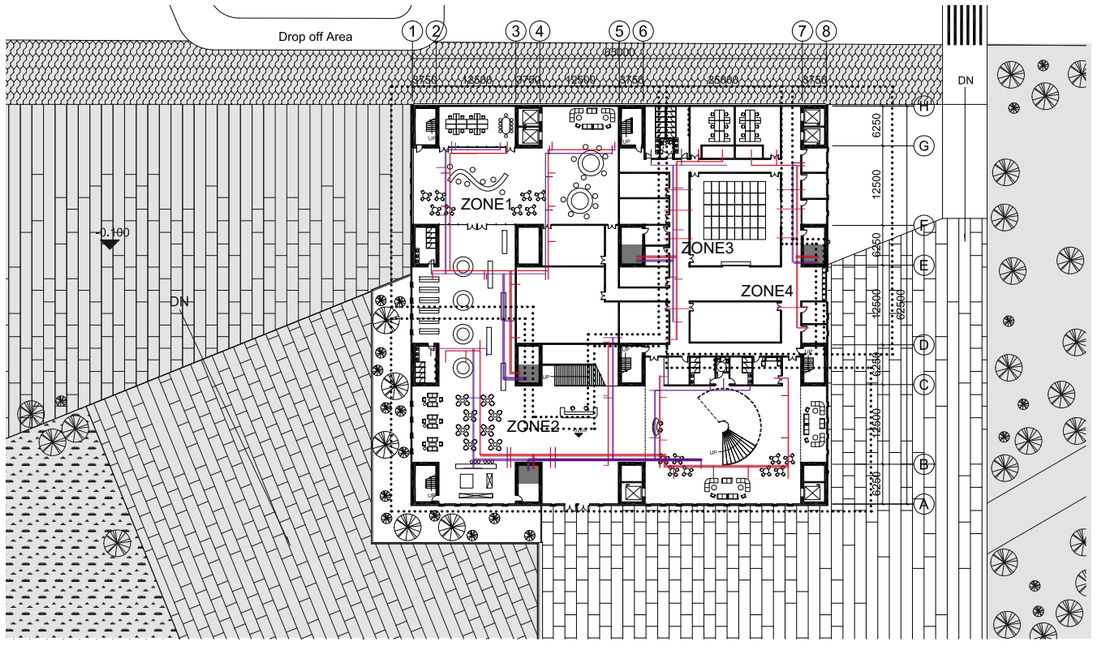
Heating & Ventilation system

HVAC schemes



All air supply & exhaust - theather/culture center

Circulation in plan - typical floor GF layout



LEGEND

Air supplier

Air extract

Risers

Risers area

ZONE1/2/3/4 Ventilation zone

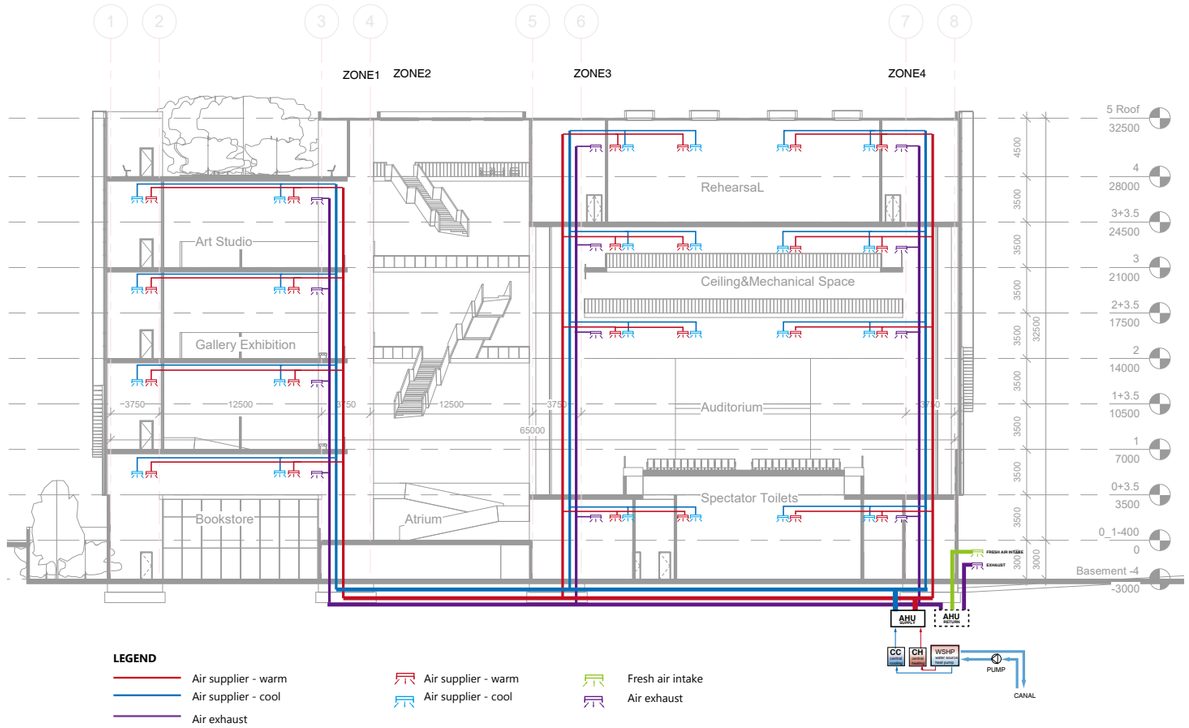
The ventilation system are samely divided as the 4 ventilation zones.

SUPPLY: fresh air are supplied from pumps in -1Floor and circulates from vertical risers in cores to each floor, and then returned back with same circulation.

EXHAUST: air inside rooms are exhausted through pipes to the risers in cores and back to -1F

ZONE1 - Gallery - Riser
ZONE2 - Gallery - 1 Riser
ZONE3 - Auditorum - 1 Riser
ZONE4 - Auditorum - 1 Riser

Circulation in section



LEGEND

Air supplier - warm
Air supplier - cool
Air exhaust
Air supplier - warm
Air supplier - cool
Fresh air intake
Air exhaust

Heating System

SHL - Summer heating load calculation

1. TOTAL VENTILATION LOAD for culture center :

Ventilation Load total (m3/h) = Toal area(sqm) * N(people) *Air supply/person(L/s/person) * Simultaineity (%)

here = 133,553.7 m3/h

Ventilation Loads						
Areas description	Area (m²)	Floors	Total Area (m²)	Ns (people/m²)	Total people	Air supply (l/s/person)
Office/workshop	375	2	750	0.6	450	11
Gallery	412.5	4	1650	1	1650	5.5
Arium	1093.75	1	1093.75	1	1093.75	5.5
Service	/	4	/	0	/	0
Auditorum	1087.5	1	1087.5	1.5	1631.25	12.5
Kitchen/Bar	150	2	300	0.8	240	11
Bathroom	228	4	912		Extraction	
Total						

Simultaineity (%)	Total (m³/h)
100%	17,820
40%	13,068
100%	21,656
0%	/
100%	73,406
80%	7,603
80%	0
133553.7	

2. TOTAL INTERNAL LOAD for culture center :

Constant sensitive internal load Qint,s,cost (W) = total people * Qint,s,pp

here = 688 kW

Constant latent internal load Qint,L,cost (W) = total people * Qint,L,pp

here = 1396.1 kW

Internal Loads					
Areas description	Total people	Qint,S,pp (W)	Total int,S (kW)	Qint,L,pp (W)	Total int,L (kW)
Office/workshop	450	70	31.5	65	29.3
Gallery	1650	110	181.5	265	437.3
Arium	1093.75	75	82.0	80	87.5
Service	/	80	/	115	/
Auditorum	1631.25	210	342.6	450	734.1
Kitchen/Bar	240	210	50.4	450	108.0
Bathroom	/	/	/	/	/
Total			688.0	1425.0	1396.1
Equipament	Qint,S,app	Qint,L,app			
	negligible	negligible			

3. SUMMER HEATING LOAD :

INPUT Fresh air flow = Ventilation Load total we did above in 1.

General data			
Location		Tianjin	-
External temperature(table2)	T_e	32	°C
Daily thermal excursion(table2)	ΔT_e	12	°C
Maximum external humidity(table2)	X_e	14.4	g/kg
Latitude		41.1	°
		27	'
Ambient temperature	T_a	27	°C
Ambient humidity	X_a	12.7	g/kg
Efficiency mass	M_a	160.2	kg/mq
Fresh air flow	V	133553.7	mc/h

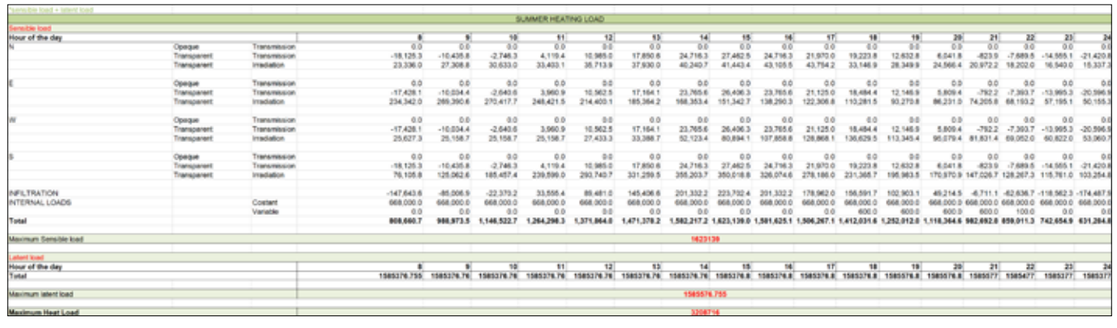
OUTPUT We consider daily time froom 8am to 24pm, after which the cooling system would be closed
We consider the most adverse situation

Summer heating load = Max.sensible load + Max.latent load

here Maximum Sensible load = 1,623,139 W

here Maximum Latent load = 1,585,77 W

In worst case SHL = 3,208,716 W



Heating System

WHL - Winter heating load calculation

*sensible load

WINTER HEAT LOAD															
Qt															
ZONE1-Auditorum/office															
	Tint,1	Te	A1	U1	ei	Qt,1e	bu1	A1'	Q,iae	$figk$	$f\theta,ann$	fWG,k	Qt,ig	Qt,ia	Qt,tot
N	20	-7.4	1843.75	0.89	1.2	53954.025	0.4	187.5	1161.45					0	55115.48
E	20	-7.4	1843.75	0.89	1.15	51705.94063	0.4	187.5	1161.45					0	52867.39
W	20	-7.4	1843.75	0.89	1.1	49457.85625	0.4	187.5	1161.45					0	50619.31
S	20	-7.4	1843.75	0.89	1	44961.6875	0.4	187.5	1161.45					0	46123.14
ZONE2-Store/museum															
N	16	-7.4	1843.75	0.89	1.2	46077.525	0.4	187.5	1161.45					0	47238.98
E	16	-7.4	1843.75	0.89	1.15	44157.62813	0.4	187.5	1161.45					0	45319.08
W	16	-7.4	1843.75	0.89	1.1	42237.73125	0.4	187.5	1161.45					0	43399.18
S	16	-7.4	1843.75	0.89	1	38397.9375	0.4	187.5	1161.45					0	39559.39
Qv															
Ta	Te	V	n	ρ	cp	Qv									
20	-7.4	25812.5	2	1.168	1	458.9347778									
Qhu															
Ai	φhu	Qhu													
4062.5	4	16250													
Qtot = Qt + Qv + Qhu															
N	Qtot	119063.3848													
E	Qtot	114895.4035													
W	Qtot	110727.4223													
S	Qtot	102391.4598													

We consider the most adverse situation, Thermal bridge negligible

Winter heating load = Max.sensible load

Qtot = Qt + Qv + Qhui

here Qtot,max = 119,063 W

Ventilation System
Total heating tonage & System size

Fresh air supply pipe size

Cross section of total air supply(not considering the units)

Cross section(in total) = Airflow rate(m3/s) / Air speed (m/s)

here — Cross section(in total) = 4.64 m2

MAIN FRESH AIR DUCT SIZE							
Qsensible (W)	m air (kg/s)	Airflow rate (m³/s)	c p,air	T air,amb,sp	T air,in	Air speed (m/s)	Cross section (m²)
1,623,139	45	37.1	1000	20	56.5	8	4.64

In real situation, we have 4 units for fresh air supply, the size of each riser is 1/4 of the value we get. So,
Cross section of each riser = 4.64 / 4 = 1.16 m2

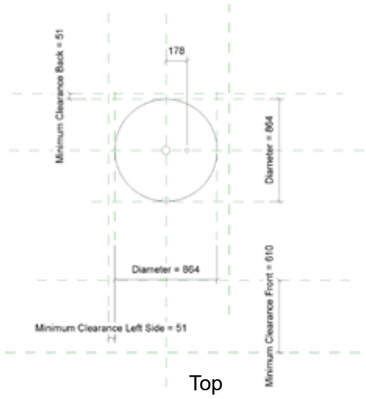
Number of units	Cross section of required duct	Size of the duct
4	1.159320313	1X1.2m

In this case,

Dimension of the main supply duct we defined as 1 x 1.25 (m)

Dimension of the main return duct is same as 1 x 1.25 (m)

3d



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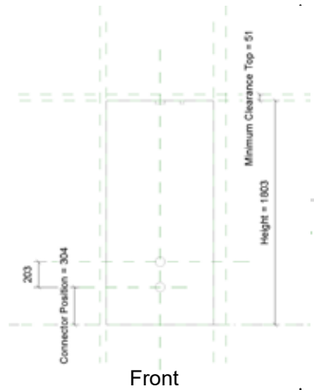
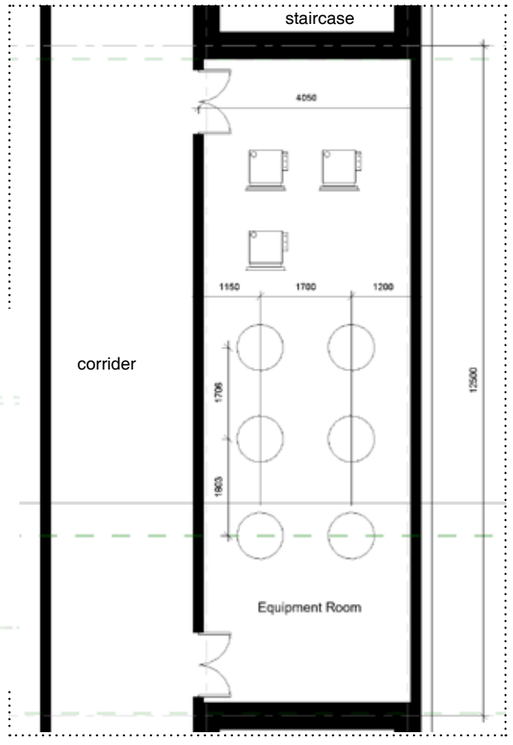


Front



We thoose water source heat pumps of cooling capacity at 36,300 x 3

Total heating tonage & System size

We consider the adverse situation, maximum of total heat load = 3,327,779 W

In order to choose the number & size of heating unit
Which converted to BTU/h is maximum of total heat load = 975,275 BTU/h

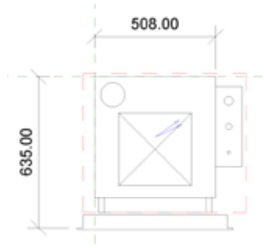
Total tonage — total tonage of final system = 81.27 t

SYSTEM TONAGE		
	Units	Value
Total winter heat load	W	119,063.38
Total summer heat load	W	3,208,715.77
Total heat load	W	3,327,779.15
Heat load converted to BTU/Hr	1W = 3.412142 BTU/hr	975,275.69
Total BTU/Hr divided 12000 to final system tonage	TR	**81.27**

In this case, we thoose Accumulation tank of minimum 81.27 t capacity.

Model	Flow rate (USGPM)	Cooling	Heating	Water loop conditions*				Ground water conditions				Ground loop conditions***			
				Cooling		Heating		Cooling		Heating		Cooling		Heating	
		Air flow (SCFM)		Capacity (BTUH)+	EER	Capacity (BTUH)++	COP	Capacity (BTUH)+	EER	Capacity (BTUH)++	COP	Capacity (BTUH)+	EER	Capacity (BTUH)++	COP
09	2.4	375	400	9,700	15.6	12,800	5.2	11,400	25.0	10,300	4.4	10,000	17.5	7,900	3.5
12	2.8	450	500	11,900	15.5	15,000	5.0	13,900	22.5	12,200	4.3	12,400	17.5	9,600	3.5
15	3.75	520	580	14,800	16.4	16,900	5.1	17,100	23.5	14,000	4.6	15,500	18.5	10,600	3.6
18	5	700	750	18,400	16.0	21,400	5.6	21,600	24.4	17,800	4.7	19,000	18.0	13,700	3.7
24	6.2	850	950	24,300	16.0	28,900	5.7	27,000	24.8	23,800	4.9	25,300	18.5	18,600	4.0
30	7.5	1075	1075	30,100	16.6	34,000	5.6	34,200	24.4	27,900	4.8	31,300	18.5	21,800	3.8
36	9	1100	1250	36,300	15.3	44,000	5.1	40,800	23.2	35,900	4.4	37,400	17.0	27,800	3.6

Dimensions of which is as the graphics showed below.



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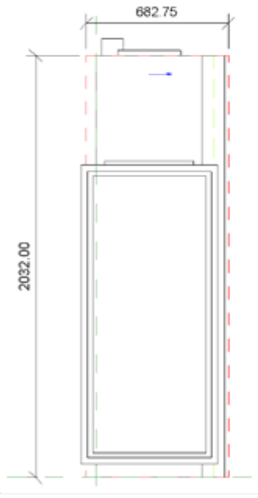
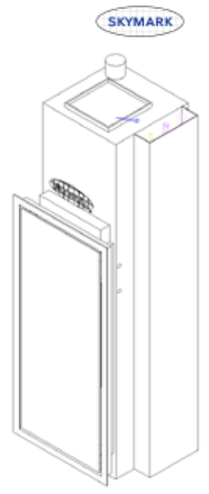
VPCS09 - EC motor (ECM)
Water Source Heap Pumps