

Hydropower plant 1 (200 MW)

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1.	Input receipt (FEM-program)	vacant
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1. GENERAL/MEASUREMENTS

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	Hydropower plant 1 (200 MW)	Status :	Page : 2
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1.1 STRCTURAL TYPE

This report describes the design of hydropower plant between baseline 1 and baseline 2. The structure is termed Part I.

The structure is exposed to the loads mentioned bellow.

- Dead load
- Water load
- Live load
- Earthquake load

	Hydropower plant 1 (200 MW)	Status :	Page : 3
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1.2 PRODUCTION SCHEME

The production scheme assumes that the structure is cast-in situ.

	Hydropower plant 1 (200 MW)	Status :	Page : 4
		Date :	Created :

1.3 FOUNDATION

The foundation assumes the bottom slab rests directly on solid unweathered rock.

Theoretical foundation level : +51.50 ∴ +53.00-1.50

Water level at completion : +53.63 to +62.94 (+64.50)

Level	Flow	Remark
+62.94	8110	10000 year
+61.62	5859	1000 year
+55.10	240	Design flow*
+53.63	13.4	Ecological flow
m	m ³ /s	-

* = Corresponds to 100 year flow

Water level during production fase : < +51.50

Backfill : rockfill

	Hydropower plant 1 (200 MW)	Status :	Page : 5
		Date :	Created :

1.4 TECHNICAL SPECIFICATION AND BUILDNING CODE

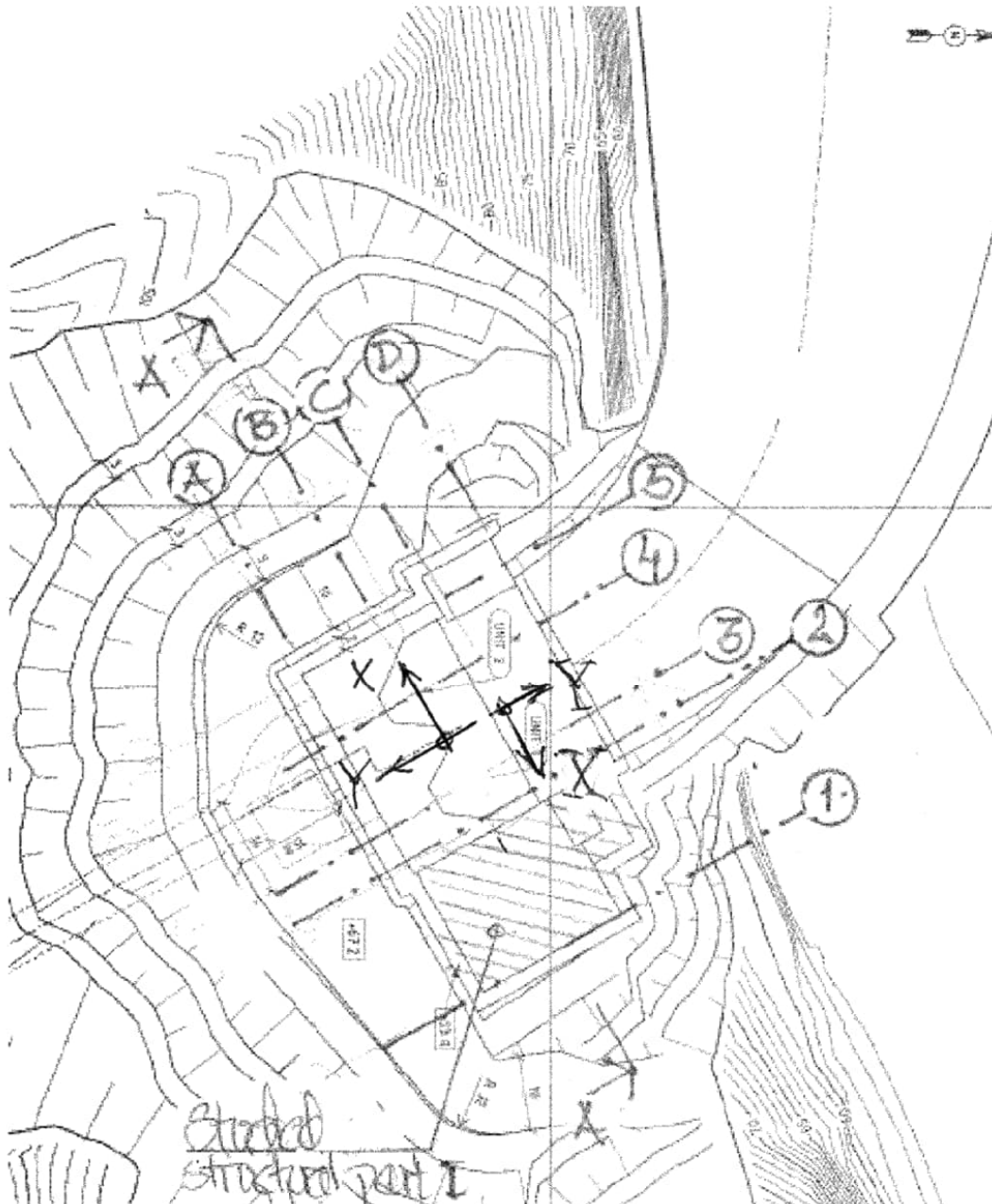
Building Code Requirements for Structural Concrete (ACI 318-05).

	Hydropower plant 1 (200 MW)	Status :	Page : 6
		Date :	Created :

1.5 MEASUREMENTS

1.5.1 Orientation measurements

Plane.:

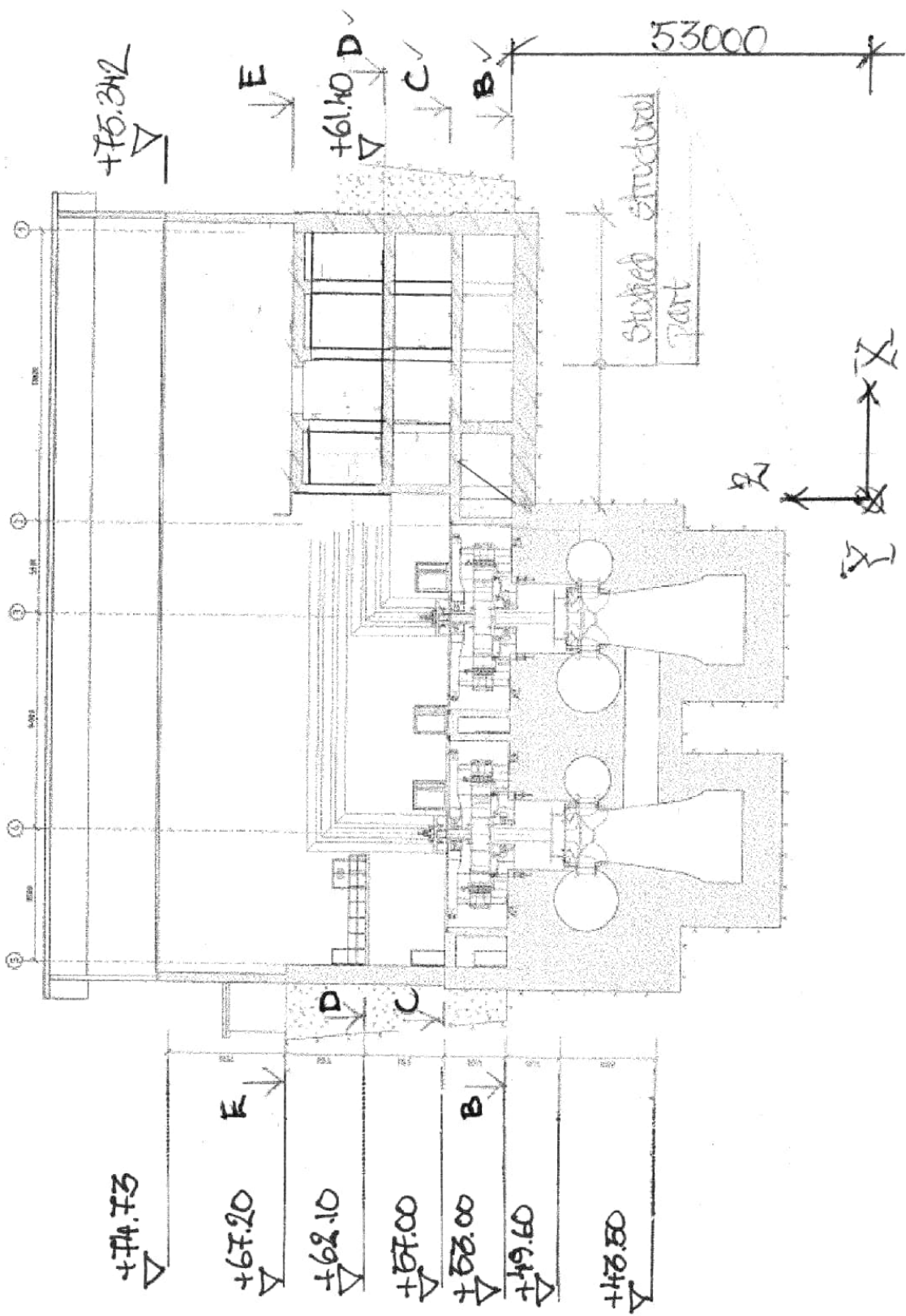


Koordinatsystem in drawing : $x/y/z$

Koordinatsystem in analysis : $X/Y/Z$

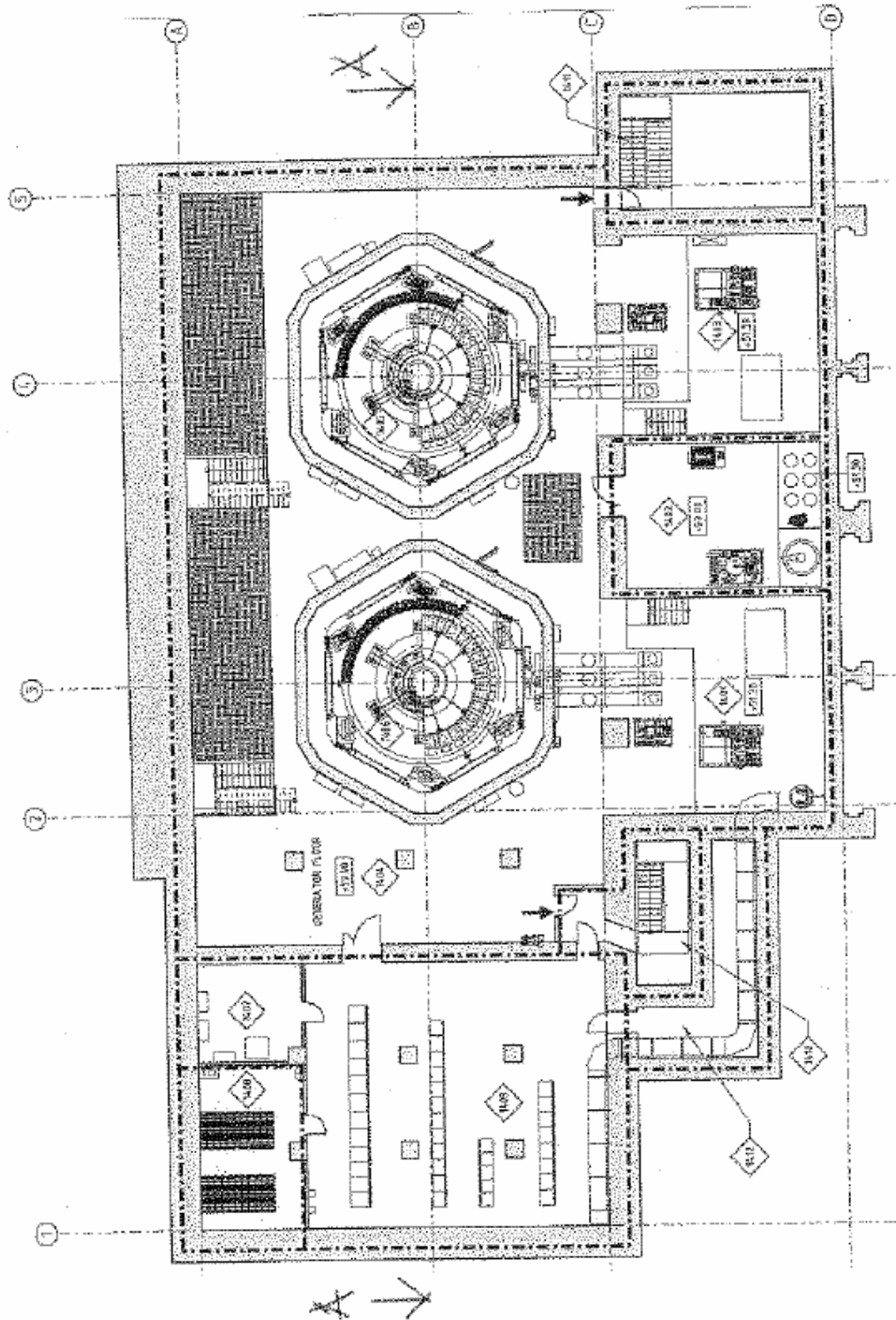
	Hydropower plant 1 (200 MW)	Status :	Page : 7
		Date :	Created :

Section A-A :



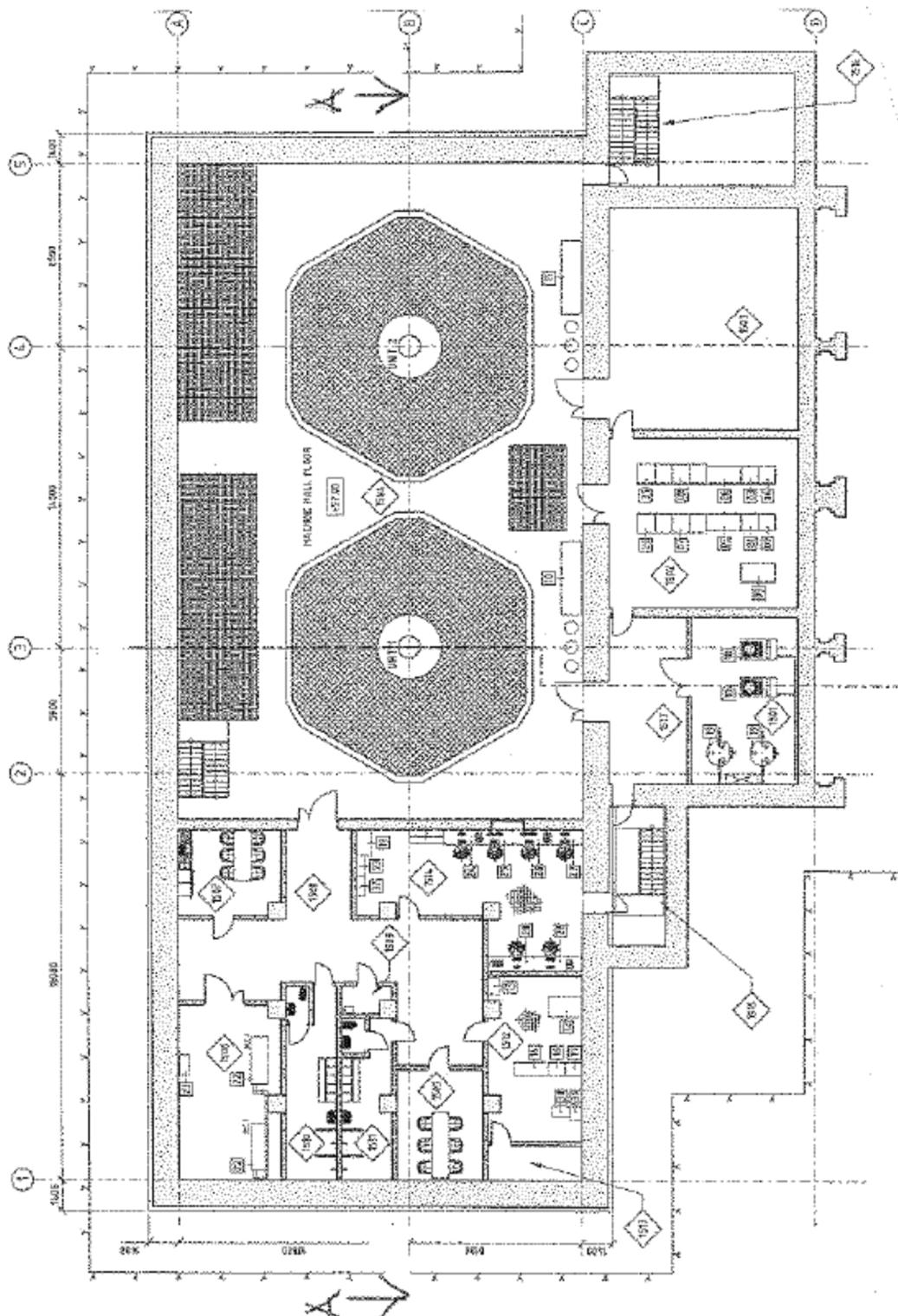
	Hydropower plant 1 (200 MW)	Status :	Page : 8
		Date :	Created :

Section B-B (Generator floor +53.00):



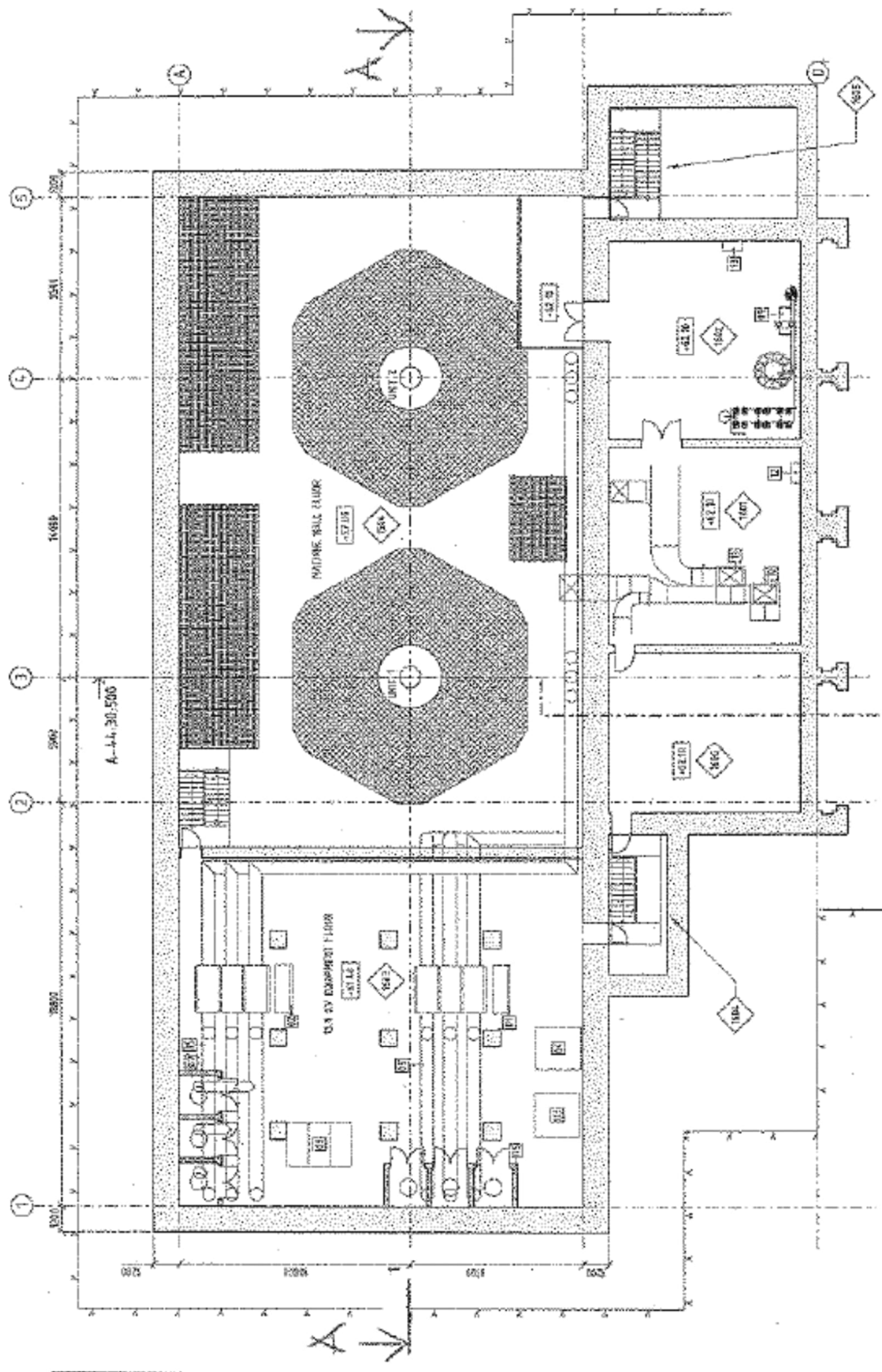
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		Date :	Created :

Section.C-C.(Mashine hall floor.+57.00.):



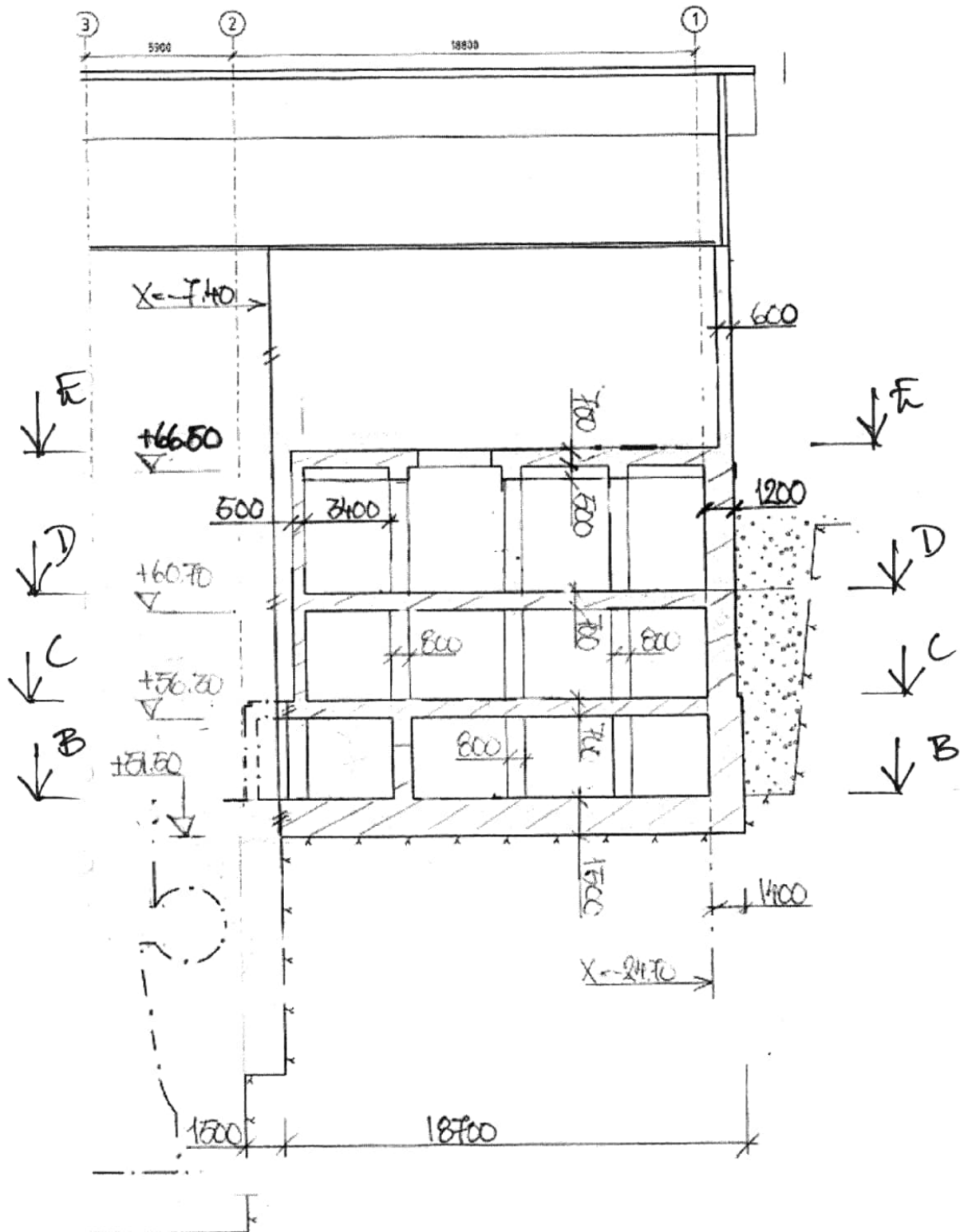
	Hydropower plant 1 (200 MW)	Status :	Page : 10
		Date :	Created :

Section D-D. (Mashine hall floor +57.00 & Repair bay floor +67.20).



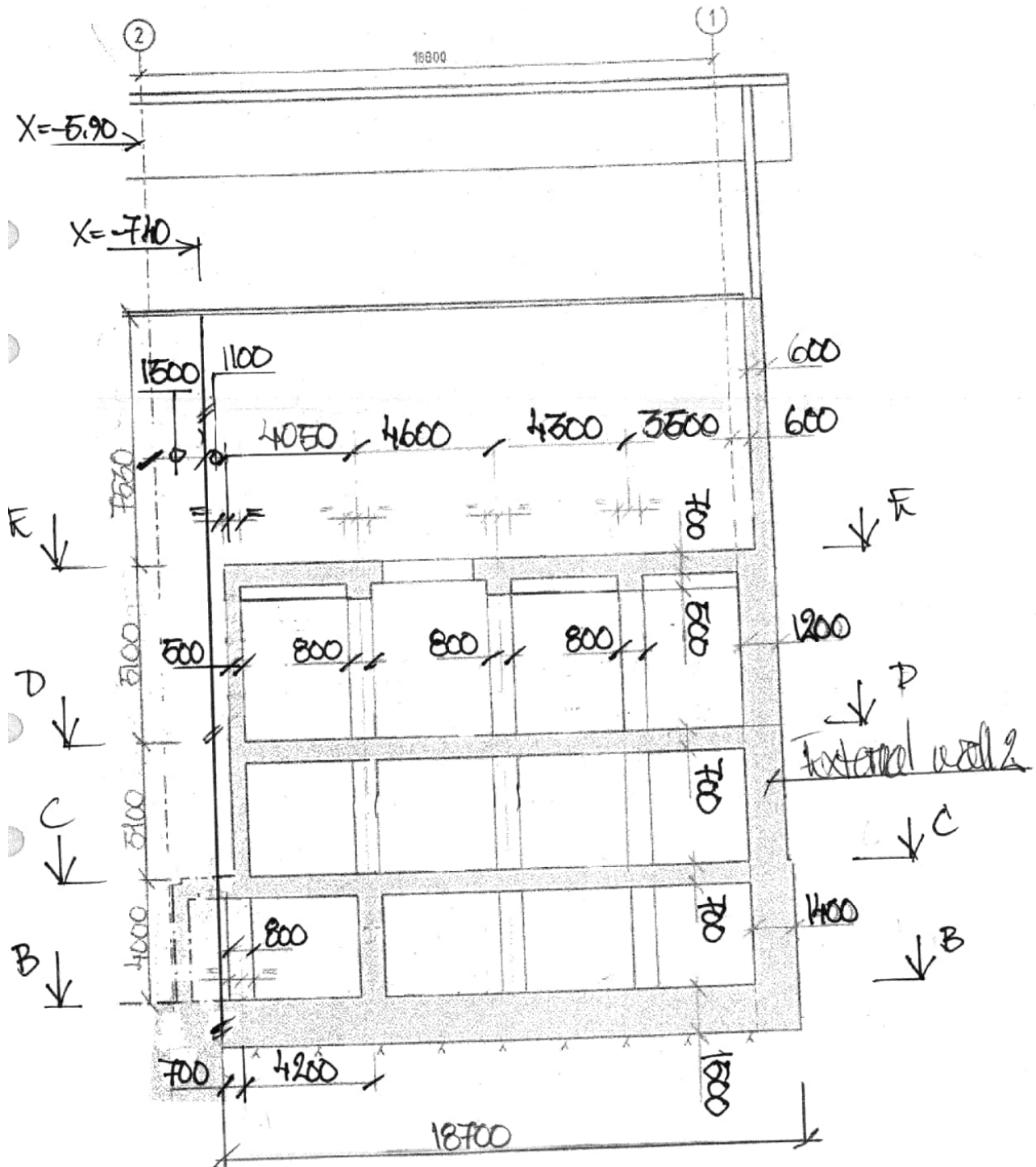
	Hydropower plant 1 (200 MW)	Status :	Page : 11
		Date :	Created :

1.5.2 Design measurements



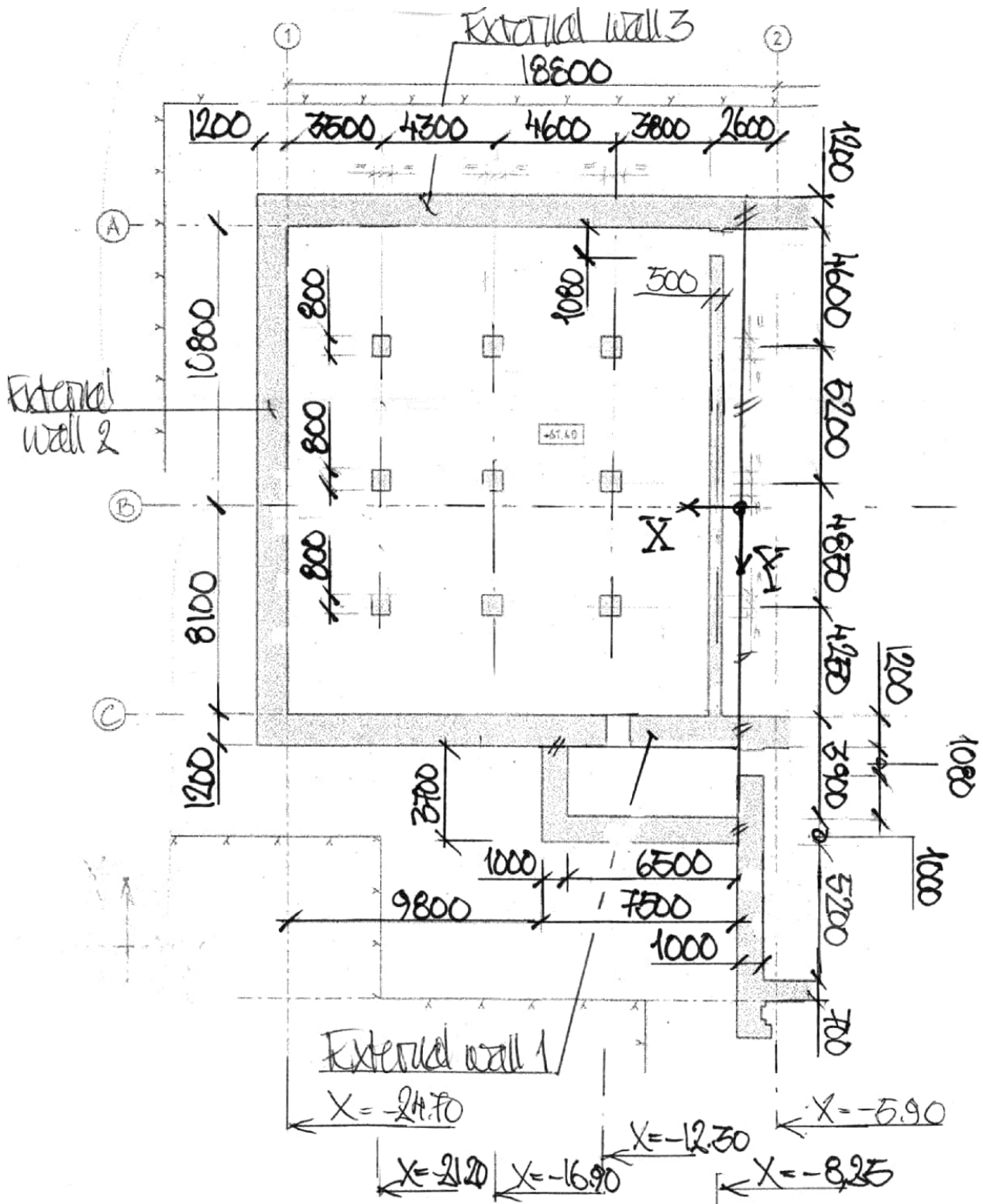
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Section A-A :



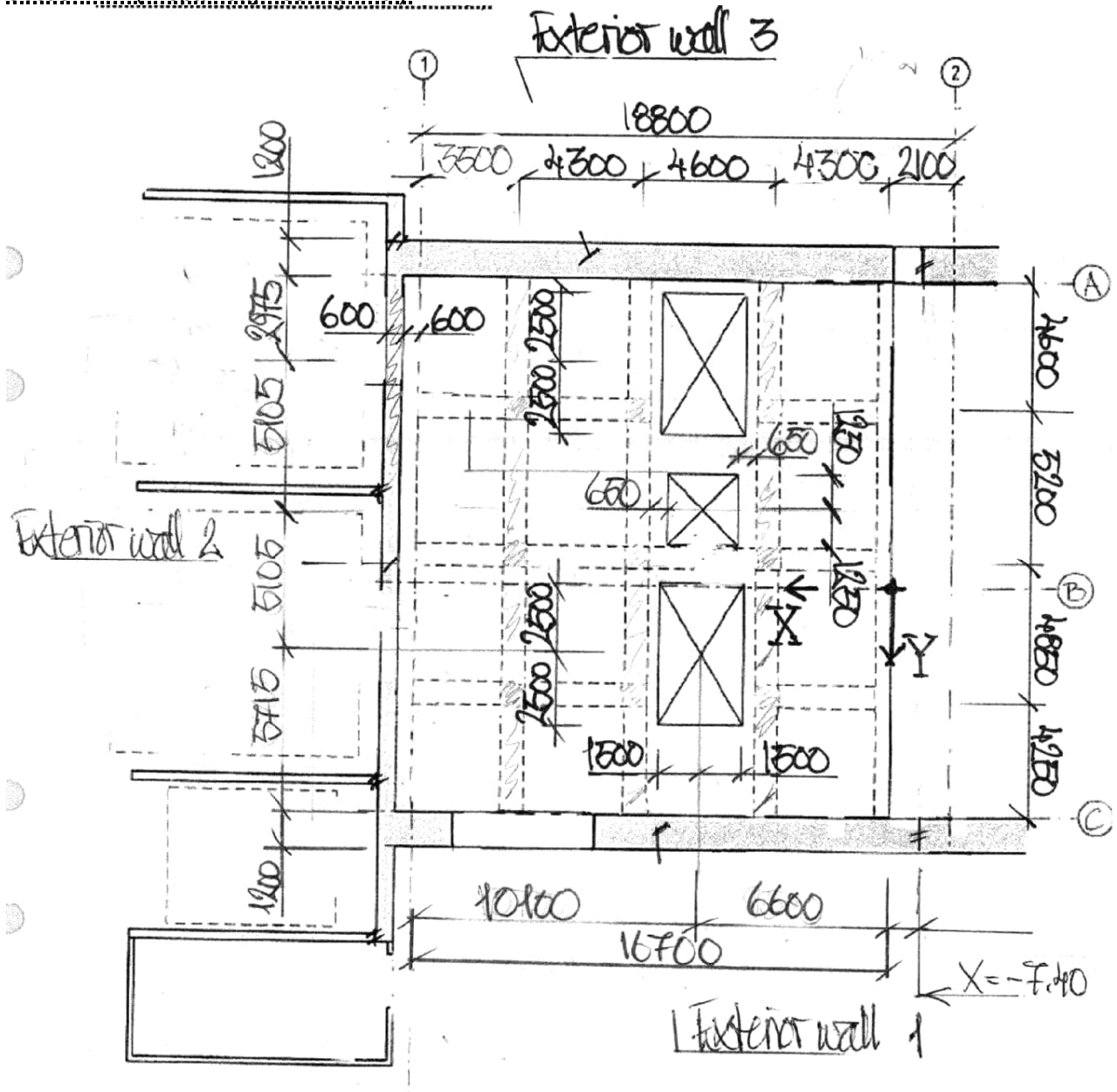
	Hydropower plant 1 (200 MW)	Status :	Page : 15
		Date :	Created :

Section D-D. (13.8 kV Equipment floor +61.40.):



	Hydropower plant 1 (200 MW)	Status :	Page : 16
		Date :	Created :

Section E-E (Repair bay floor +67.20):



	Hydropower plant 1 (200 MW)	Status :	Page : 17
		Date :	Created :

2. STATICAL SYSTEM

2.1	GENERAL	page 18
2.2	STATICAL SYSTEM	page 19-64
2.3	CROSSECTION PROPERTY	page 65-75
2.4	MATERIAL	page 2:76
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2.6	SEARCH AREA	page 2:81-87

	Hydropower plant 1 (200 MW)	Status :	Page : 18
		Date :	Created :

2.1 GENERAL

The structure is designed as a reinforced concrete-structure resting on unweathered rock.

The structure is modelled using rigid vertical springs underneath each column/wall connected to the bottom slab at level +53.00.

The structure termed Part I is connected to the rest of Powerhouse baseline 2 offset by 1.5 m.

For this reason a rigid horizontal spring is in X-direction along Exterior wall 1 and Exterior wall 2.

	Hydropower plant 1 (200 MW)	Status :	Page : 19
		Date :	Created :

2.2 STATIC MODEL

2.2.1 Geometry

In order to describe the structures geometry first *POINTS* have to be defined. From these *LINES* and *SURFACES* are generated.

Shell elements are applied to *SURFACES*.

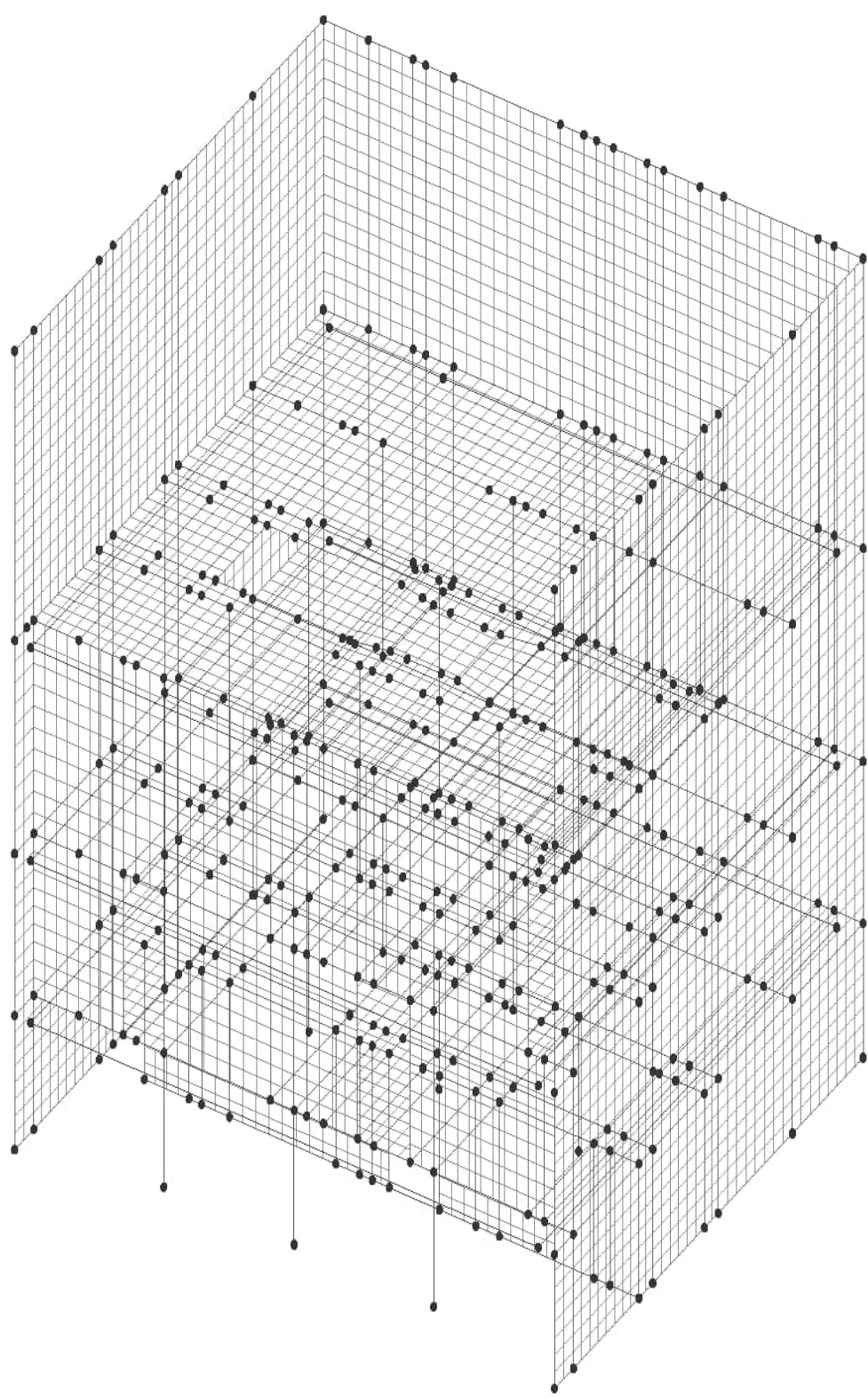
Beam elements are applied to *LINES*.

All coordinates defining *POINTS* are presented in appendix 1.

All *LINES* used to define *SURFACES* are presented in appendix 1.

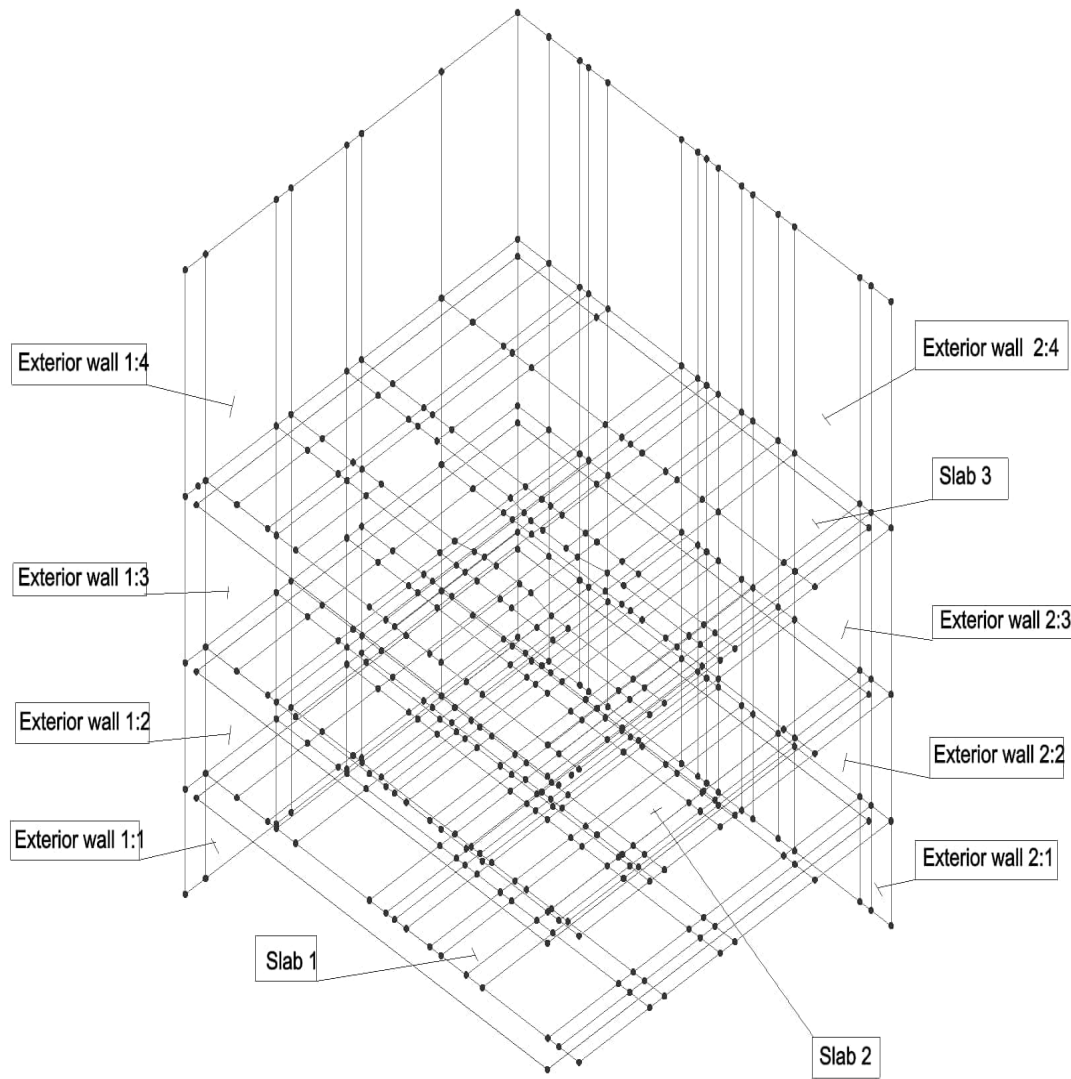
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		Date :	Created :

Overview...



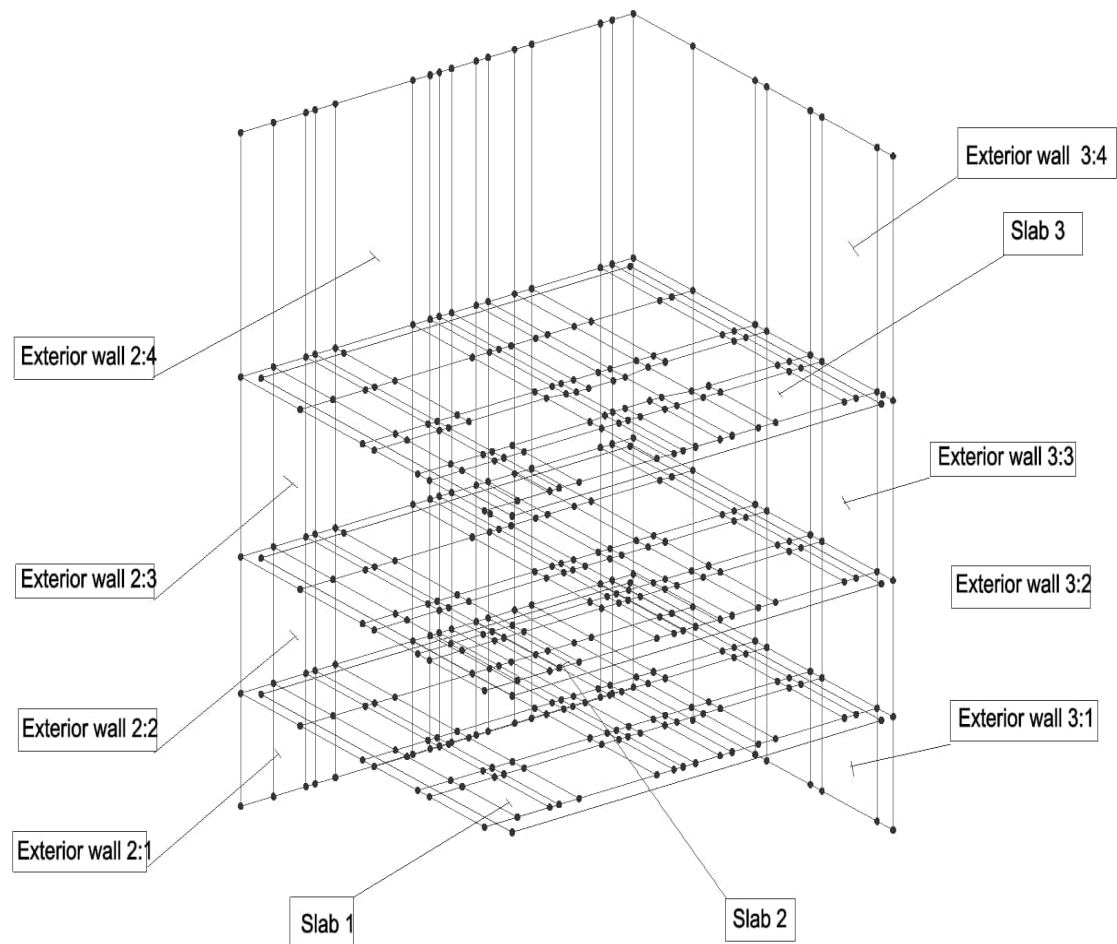
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View - Exterior wall 1/ Exterior wall 2 / Slab 1 / Slab 2 / Slab 3 :



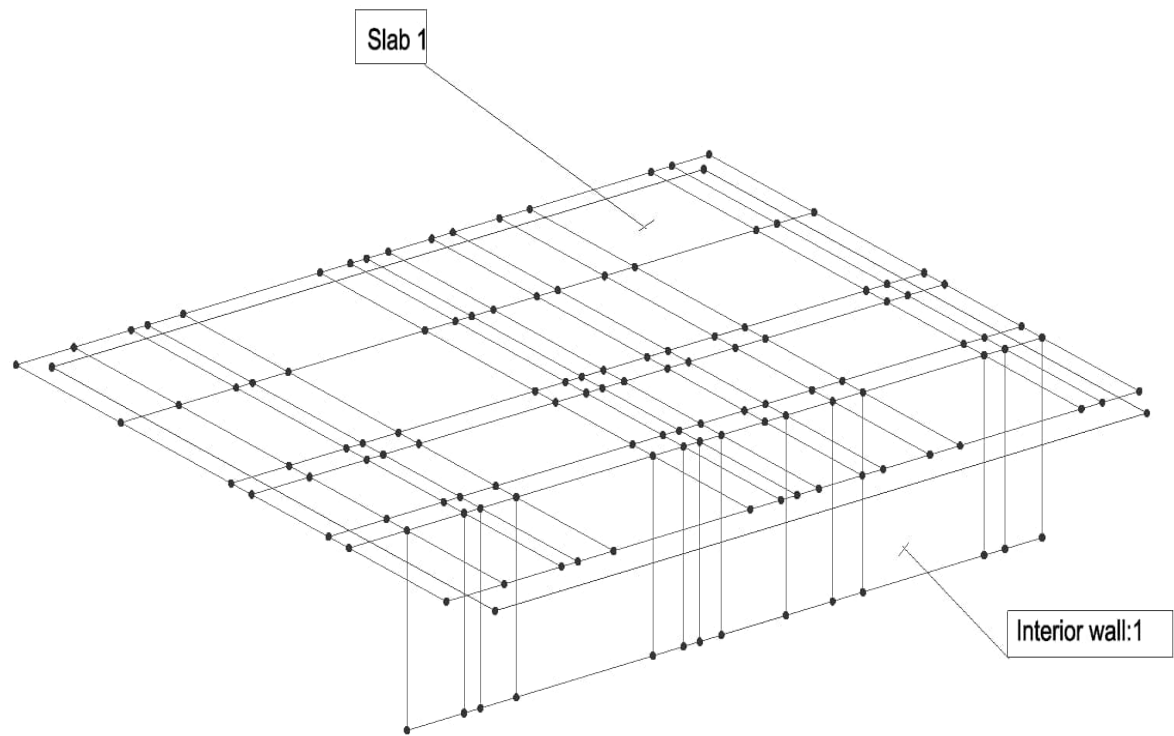
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		Date :	Created :

View - Exterior wall 2 / Exterior wall 2 / Slab 1 / Slab 2 / Slab 3 :



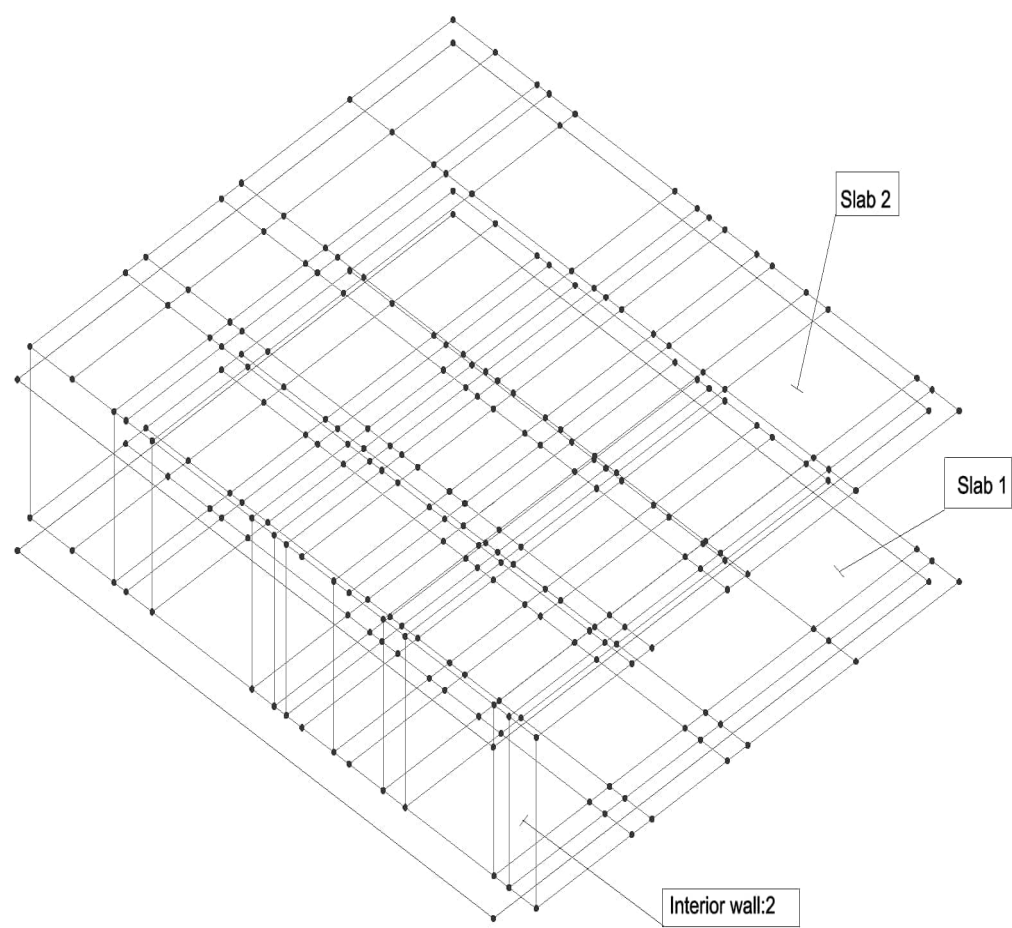
	Hydropower plant 1 (200 MW)	Status :	Page : 23
		Date :	Created :

View – Interior wall 1/ Slab 1:



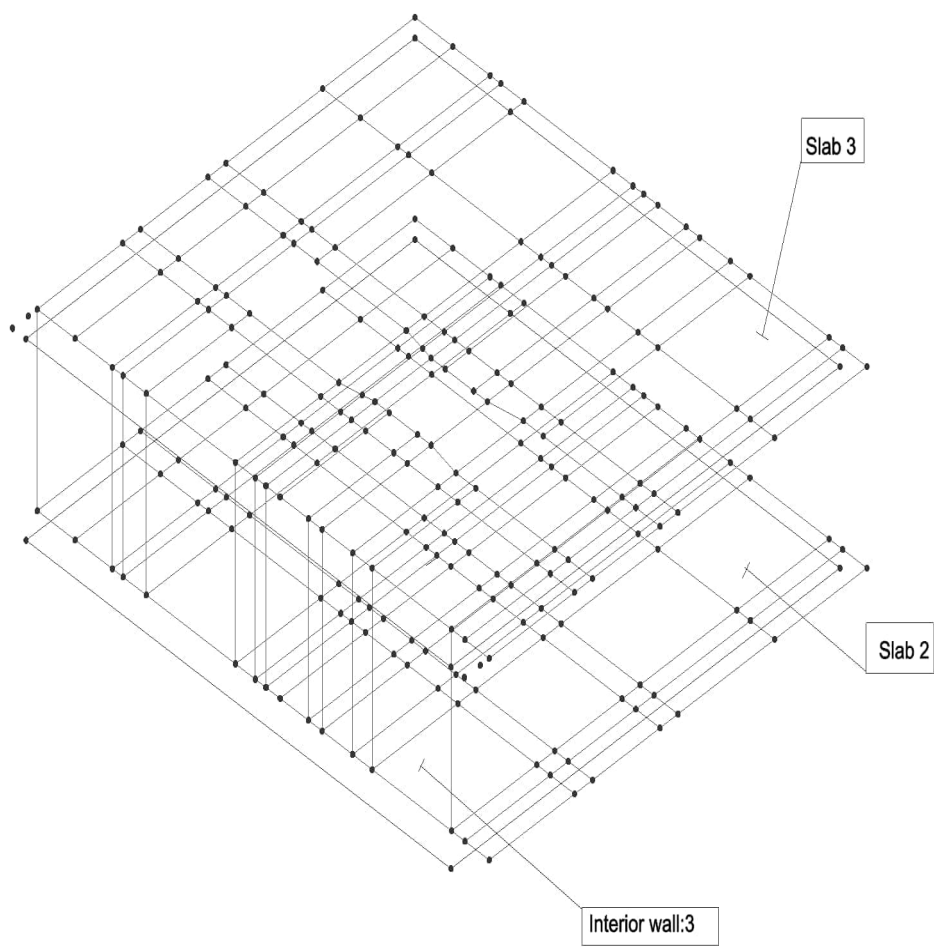
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		Date :	Created :

View – Interior wall 2/ Slab 1 / Slab 2:



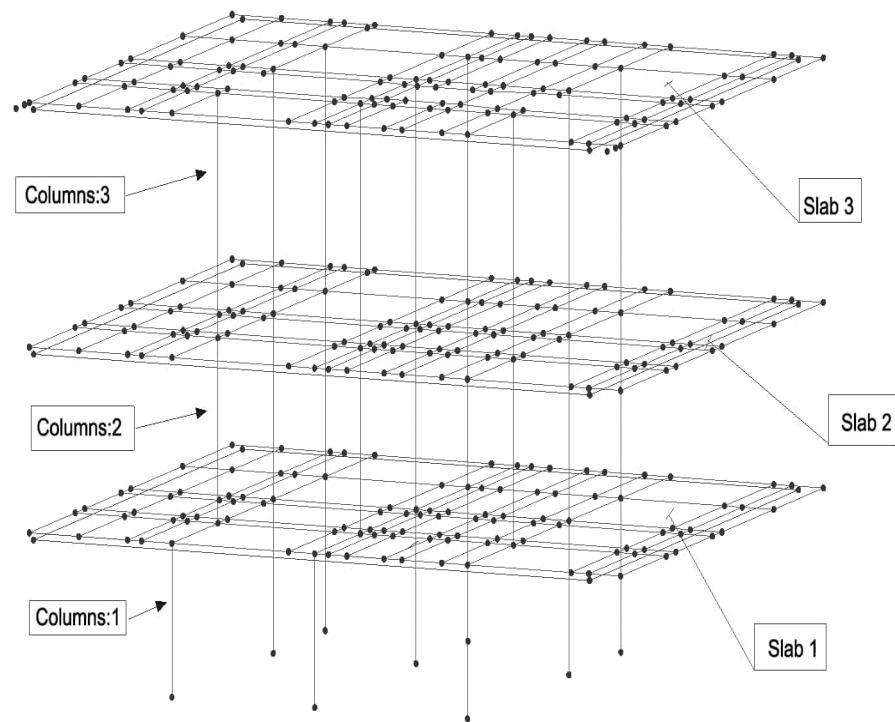
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View – Interior wall 3/ Slab 2 / Slab 3.:



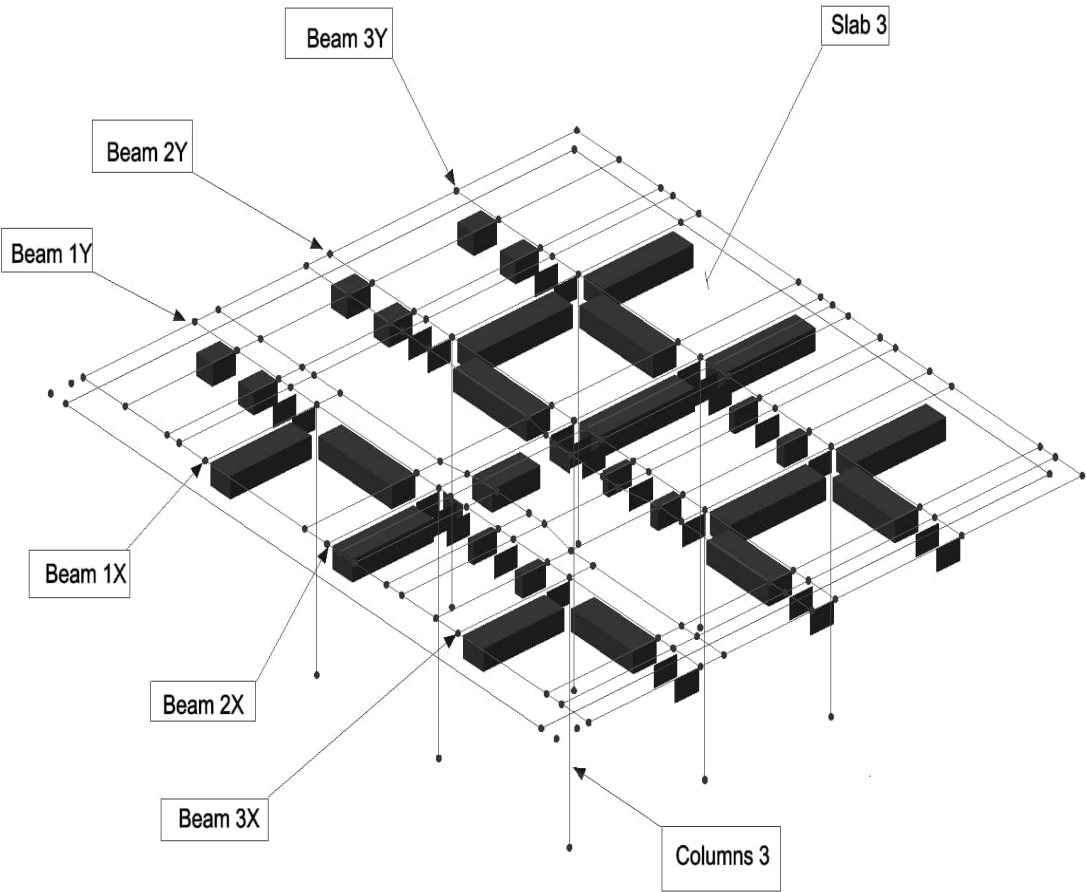
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		Date :	Created :

View – Columns 1 / Columns 2 / Columns 3 / Slab 1 / Slab 2 / Slab 3 :



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		Date :	Created :

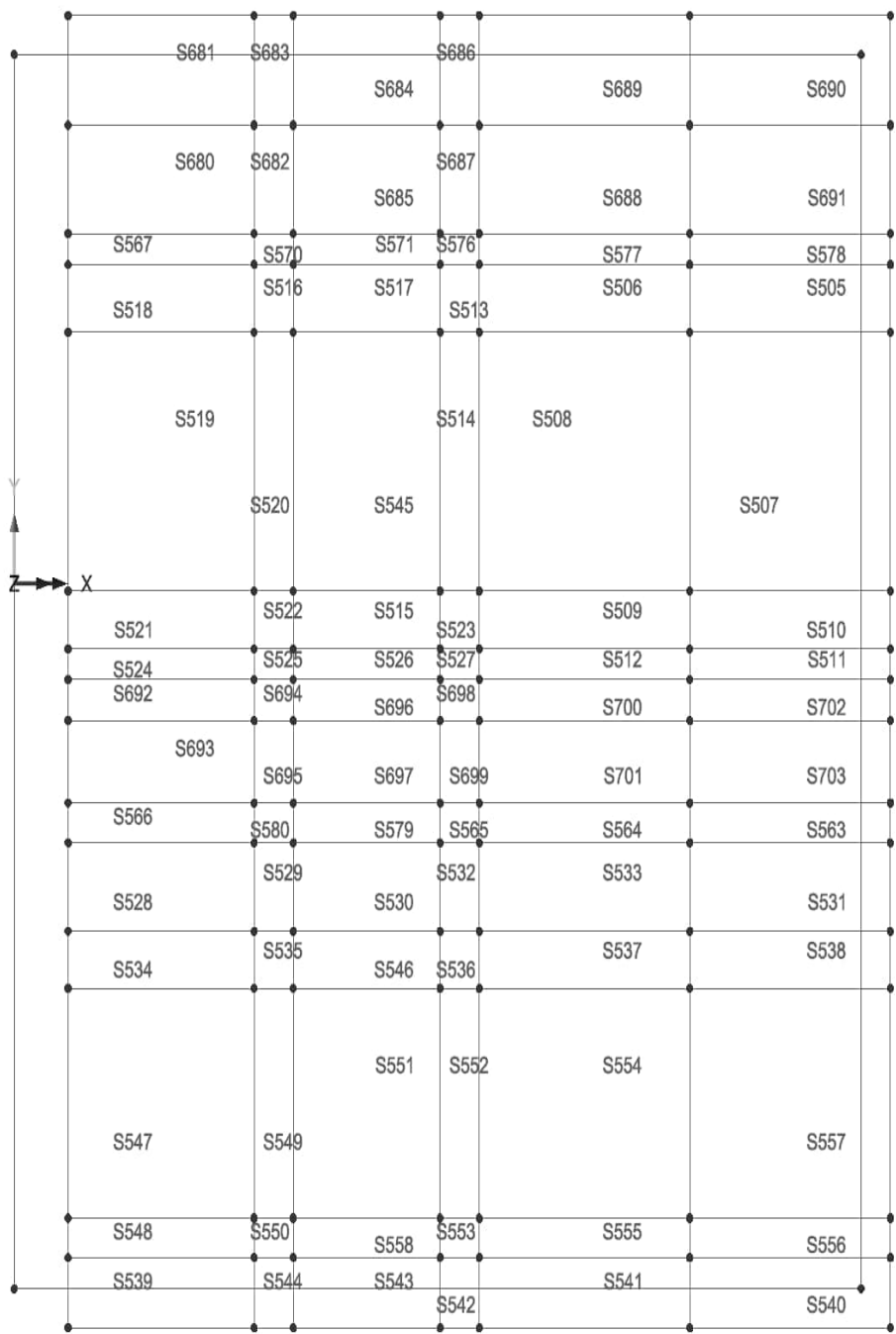
View – Beams 1X, 3X / Beams 1Y, 3Y / Columns 3 / Slab 3:



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		Date :	Created :

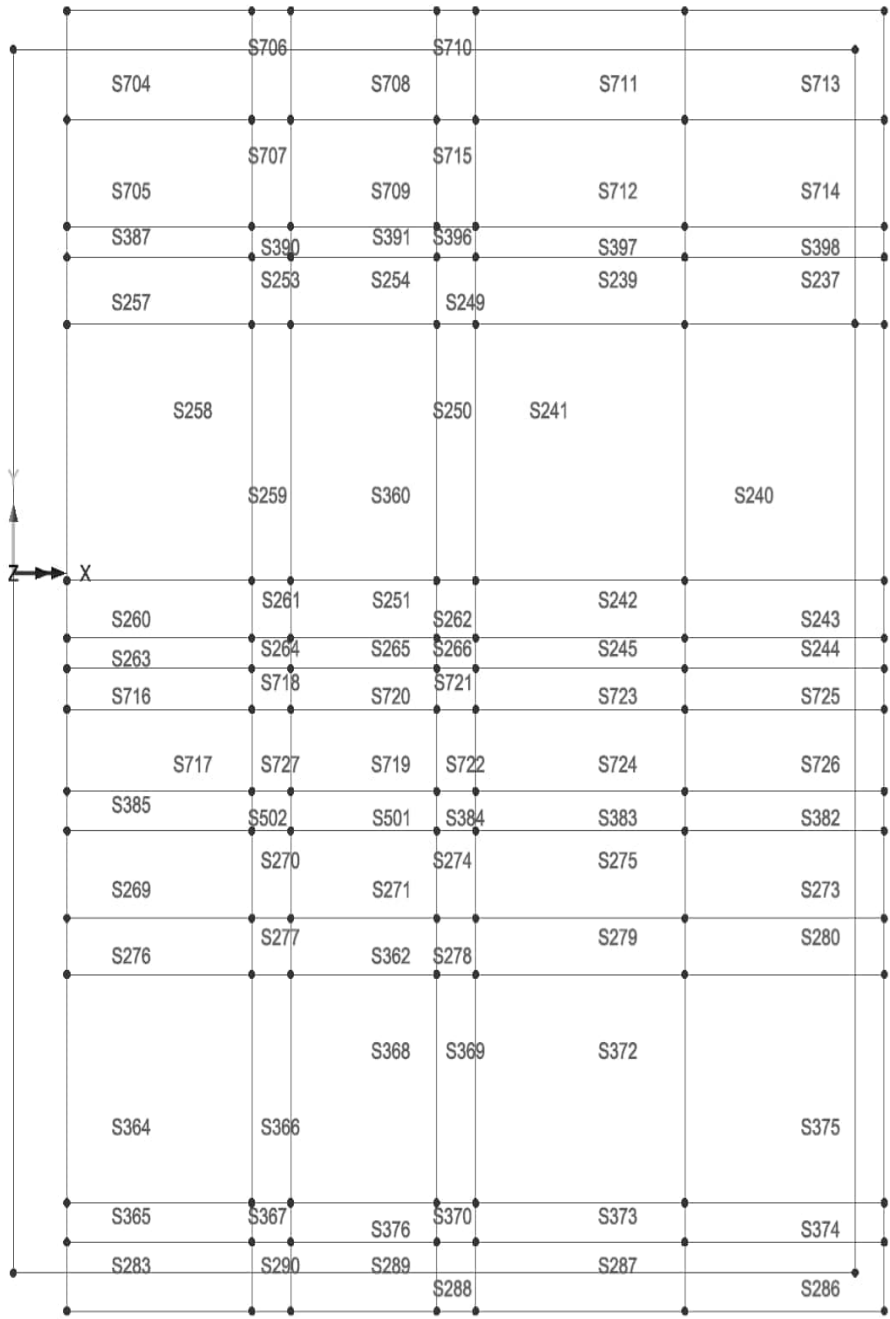
2.2.1.1 Geometry : SURFACES

Slab 1 – level +56.65.:



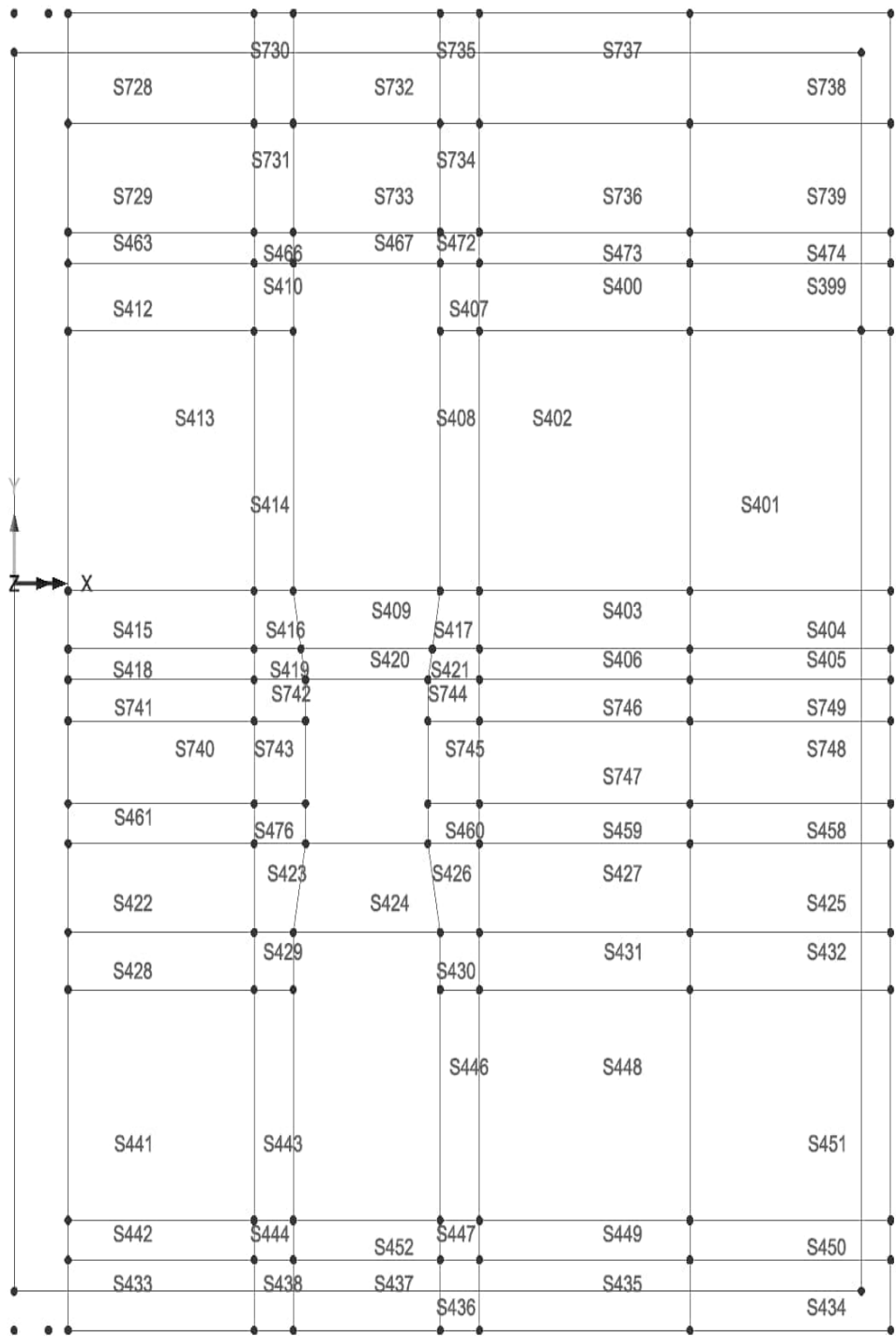
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Slab 2- level +61.05.:



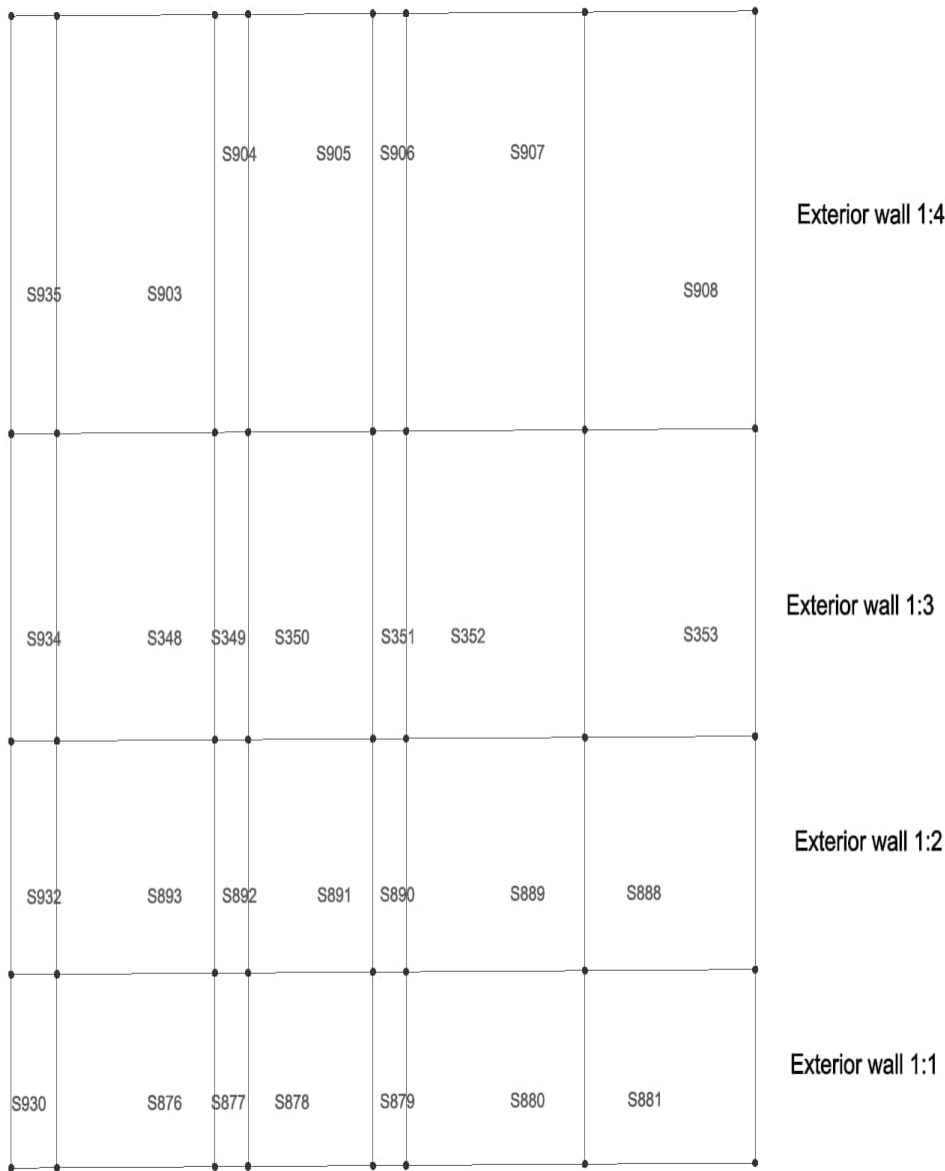
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Slab 3 – level +66.85.:



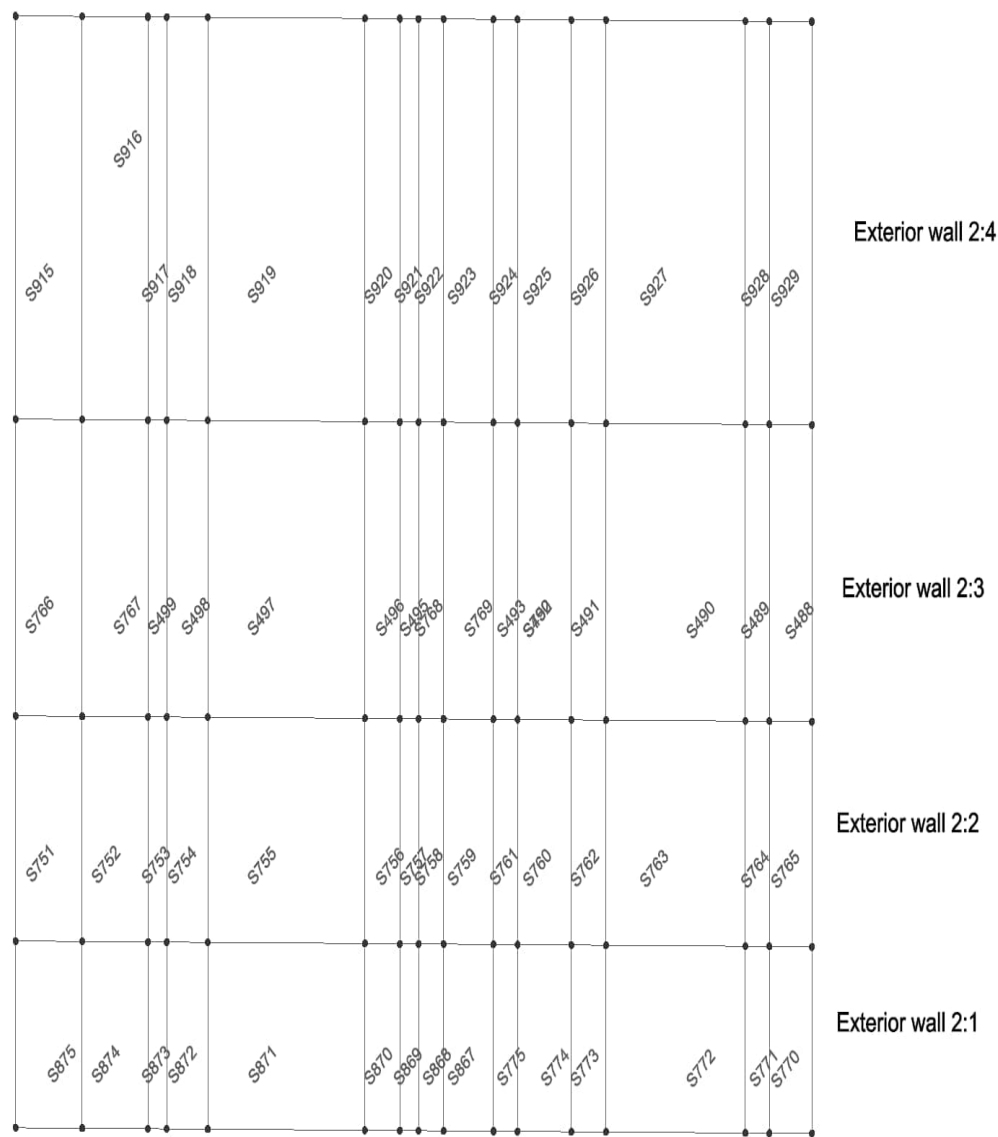
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Exterior wall 1 - northern wall :



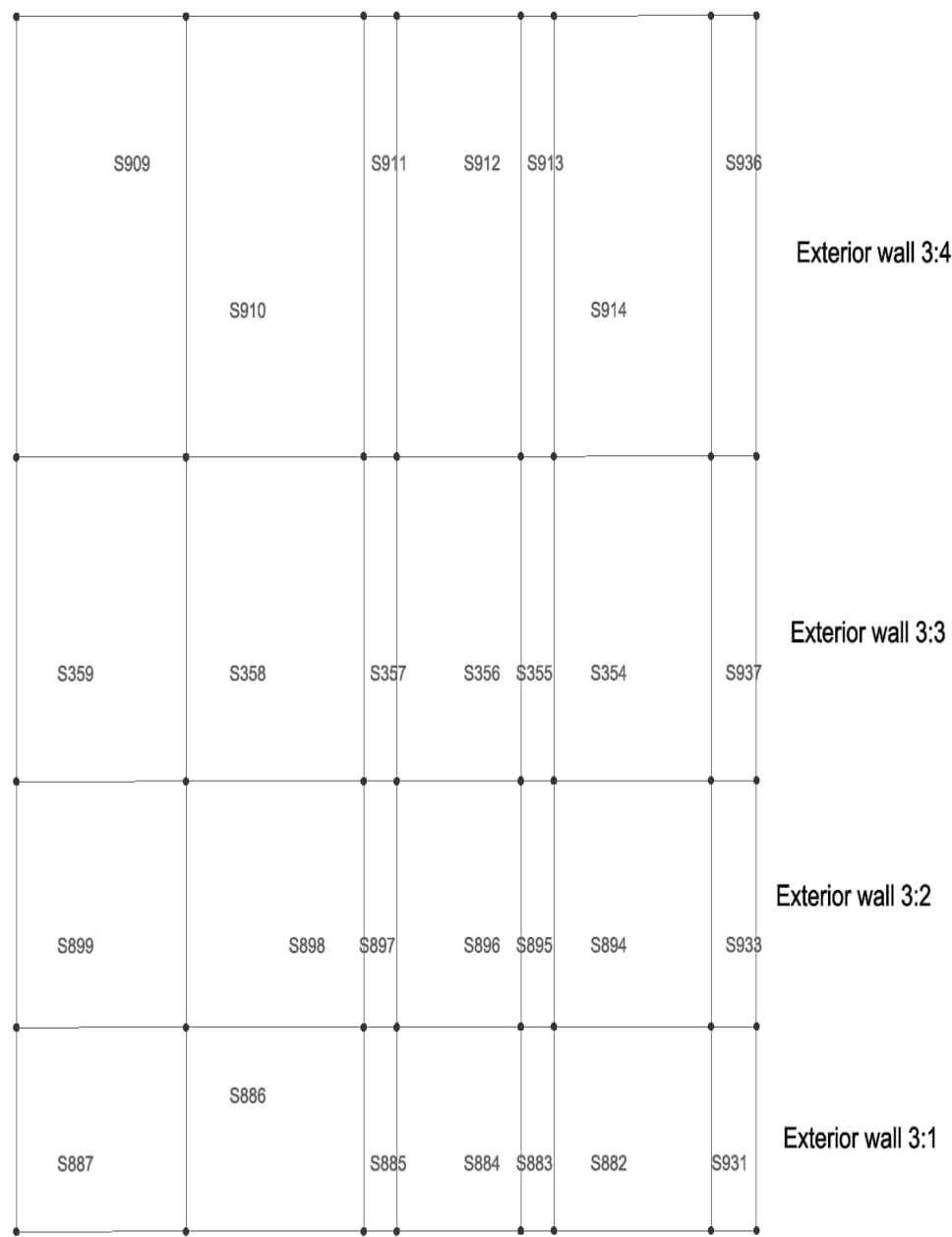
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Exterior wall 2 - eastern wall :



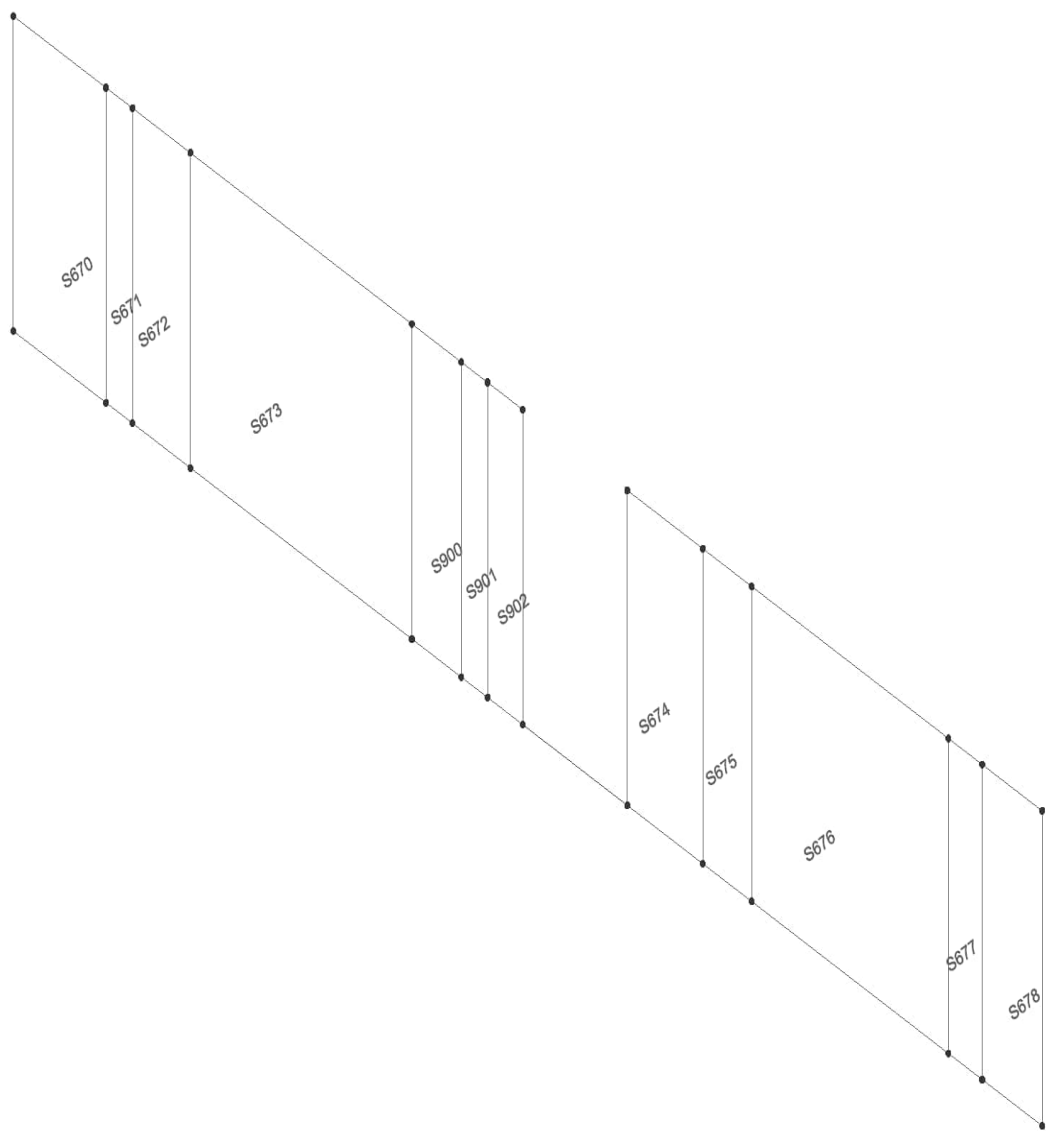
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		Date :	Created :

Exterior wall 3 - southern wall .:



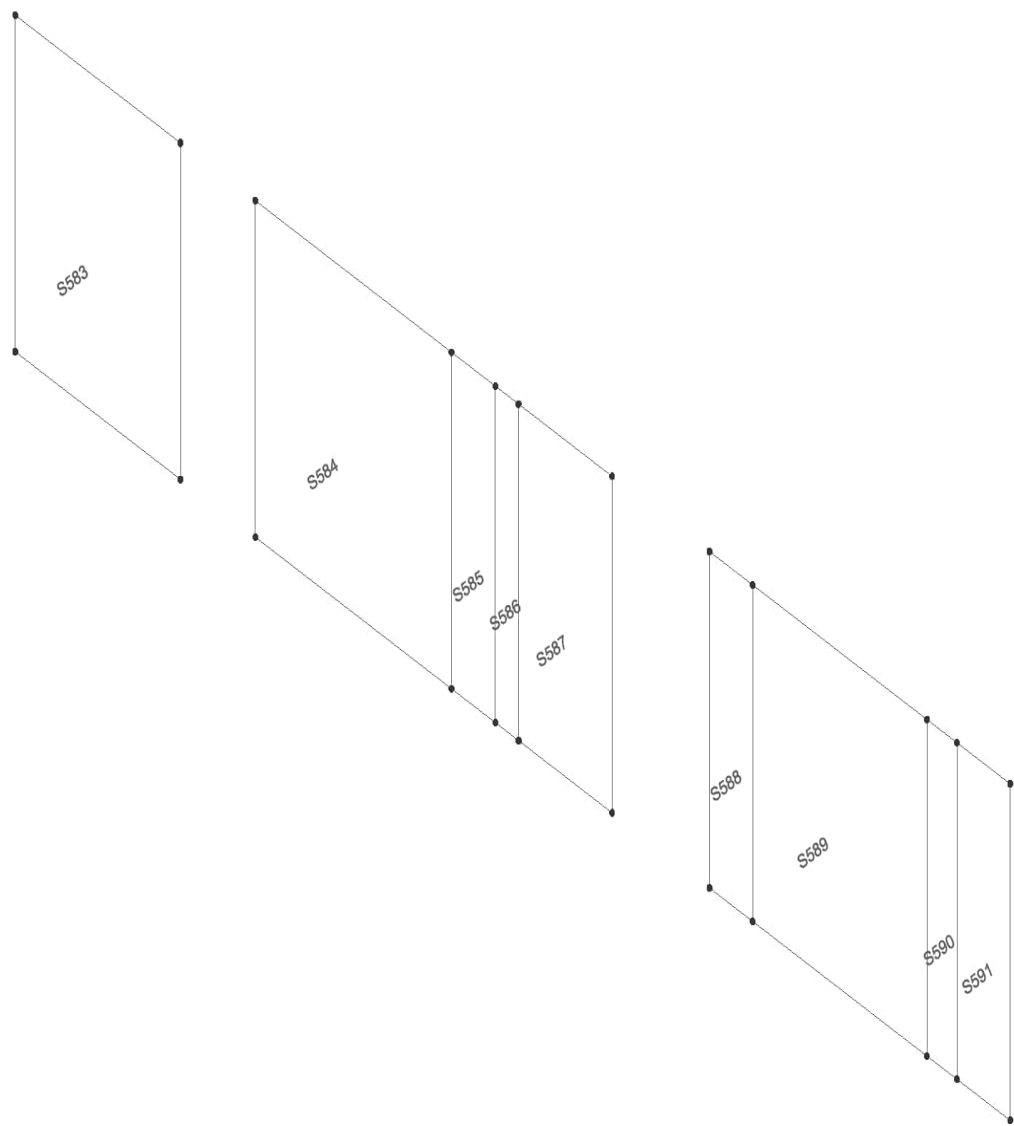
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Interior wall 1 :



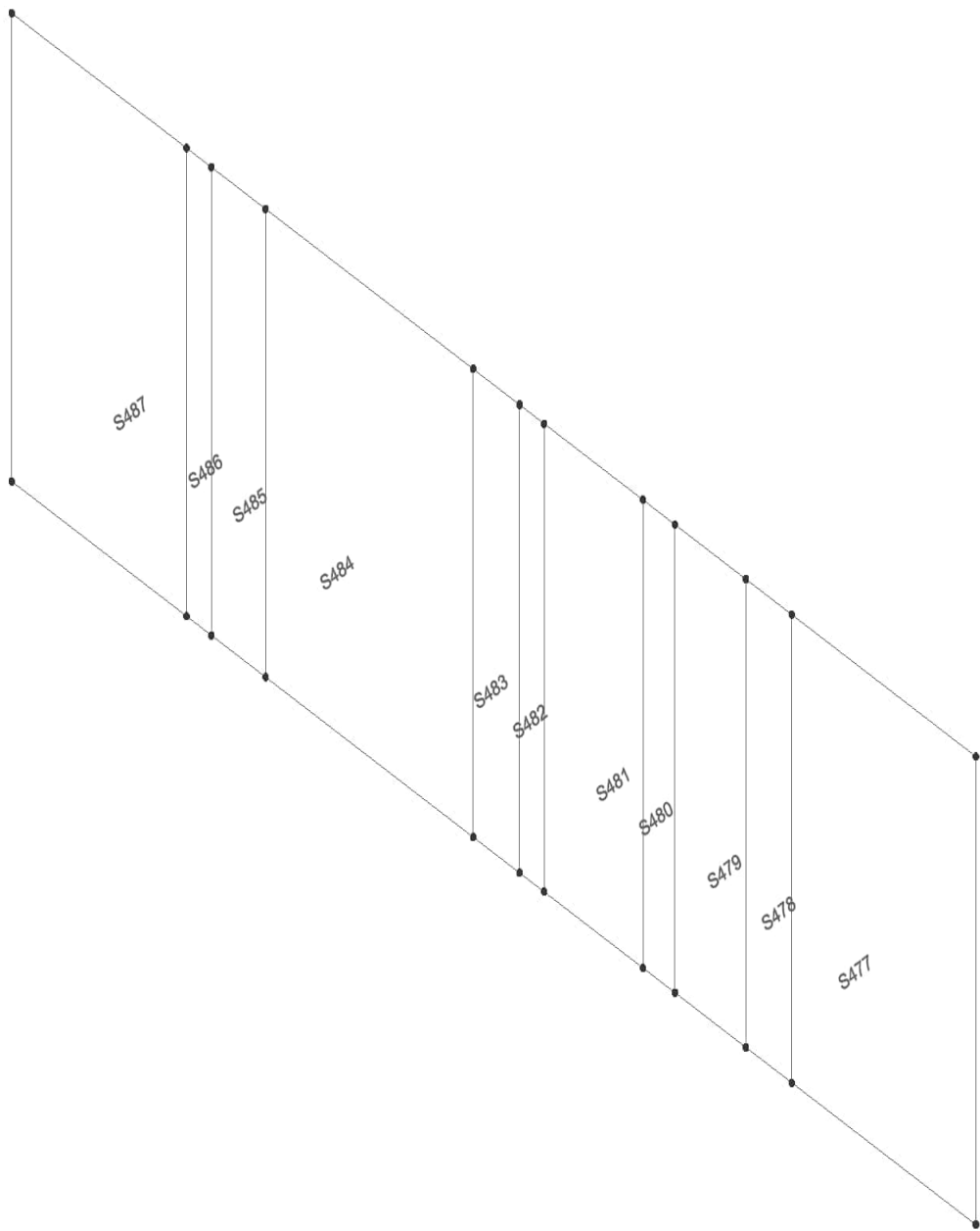
	Hydropower plant 1 (200 MW)	Status :	Page : 35
		Date :	Created :

Interior wall 2 :



	Hydropower plant 1 (200 MW)	Status :	Page : 36
		Date :	Created :

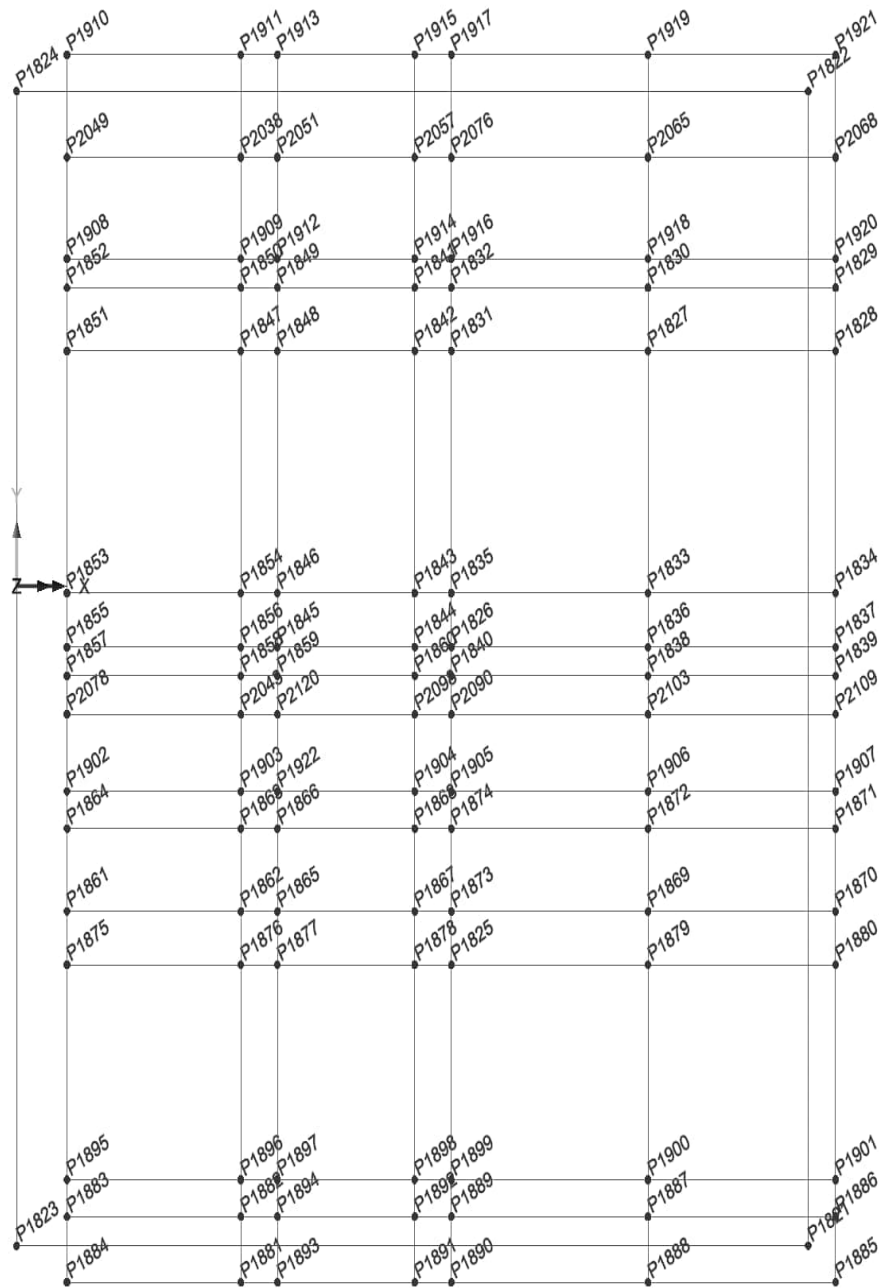
Interior wall 3 :



	Hydropower plant 1 (200 MW)	Status :	Page : 37
		Date :	Created :

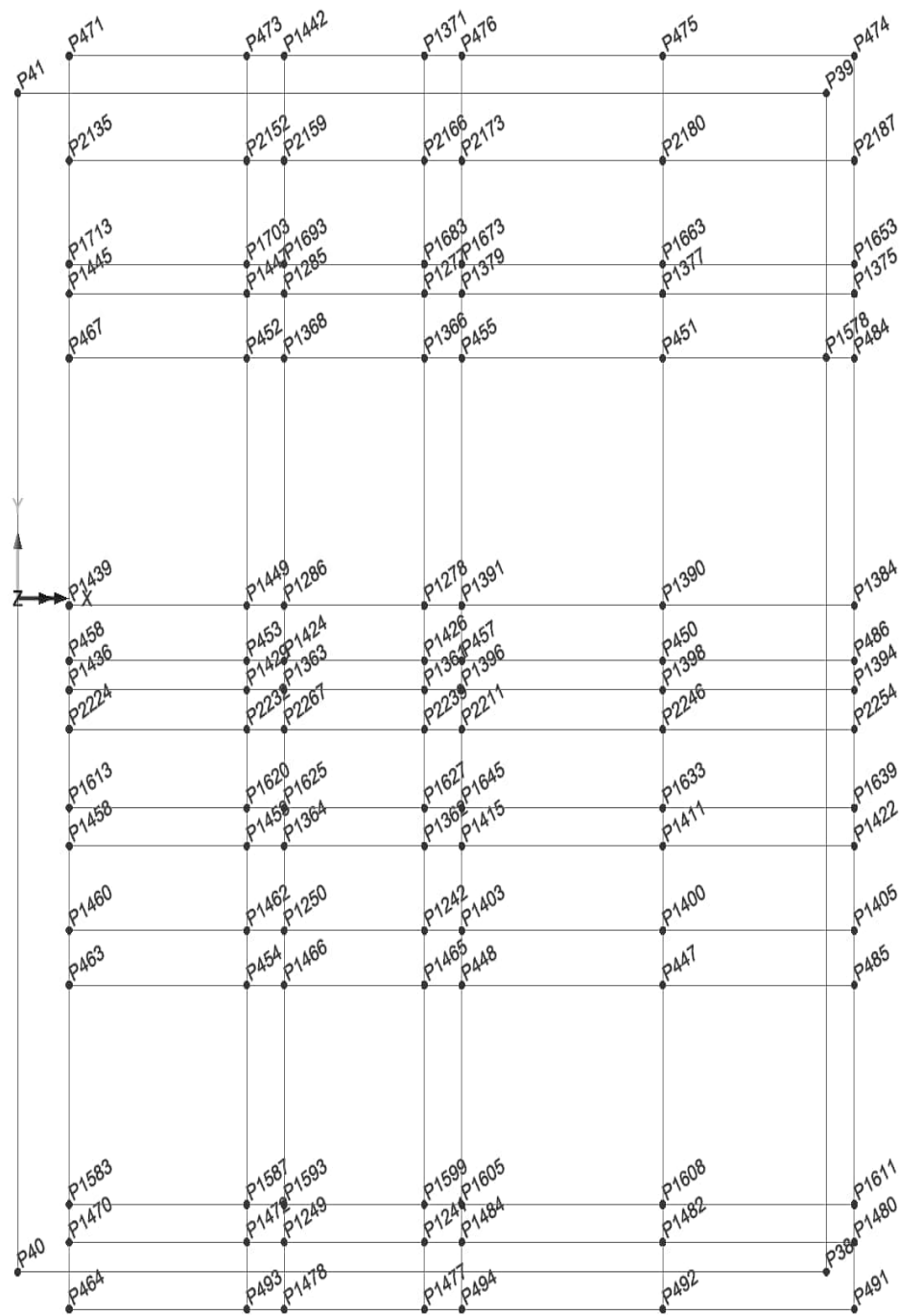
2.2.1.2 Geometry : POINTS

Slab 1 – level +56.65.:



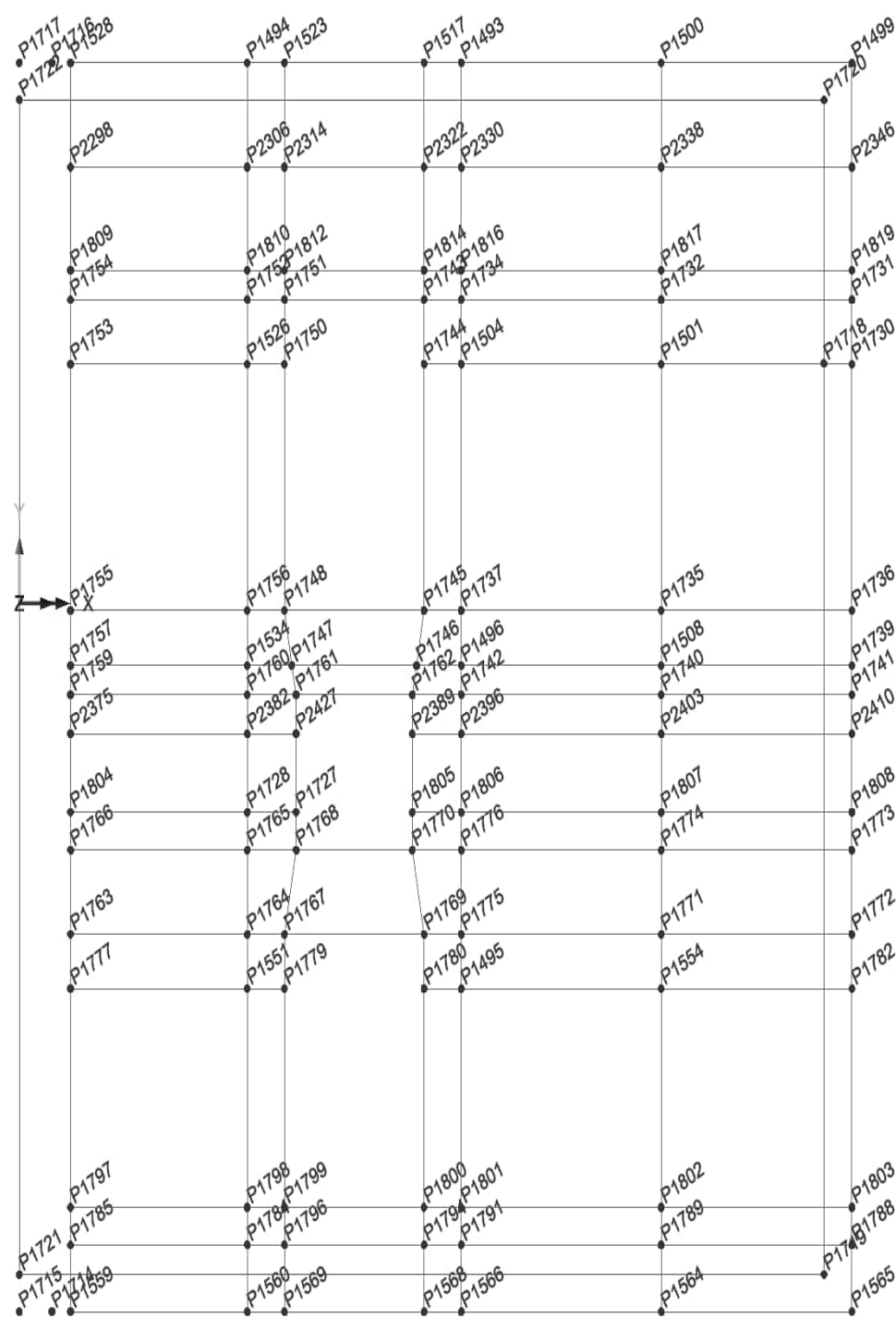
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Slab 2- level +61.05.:



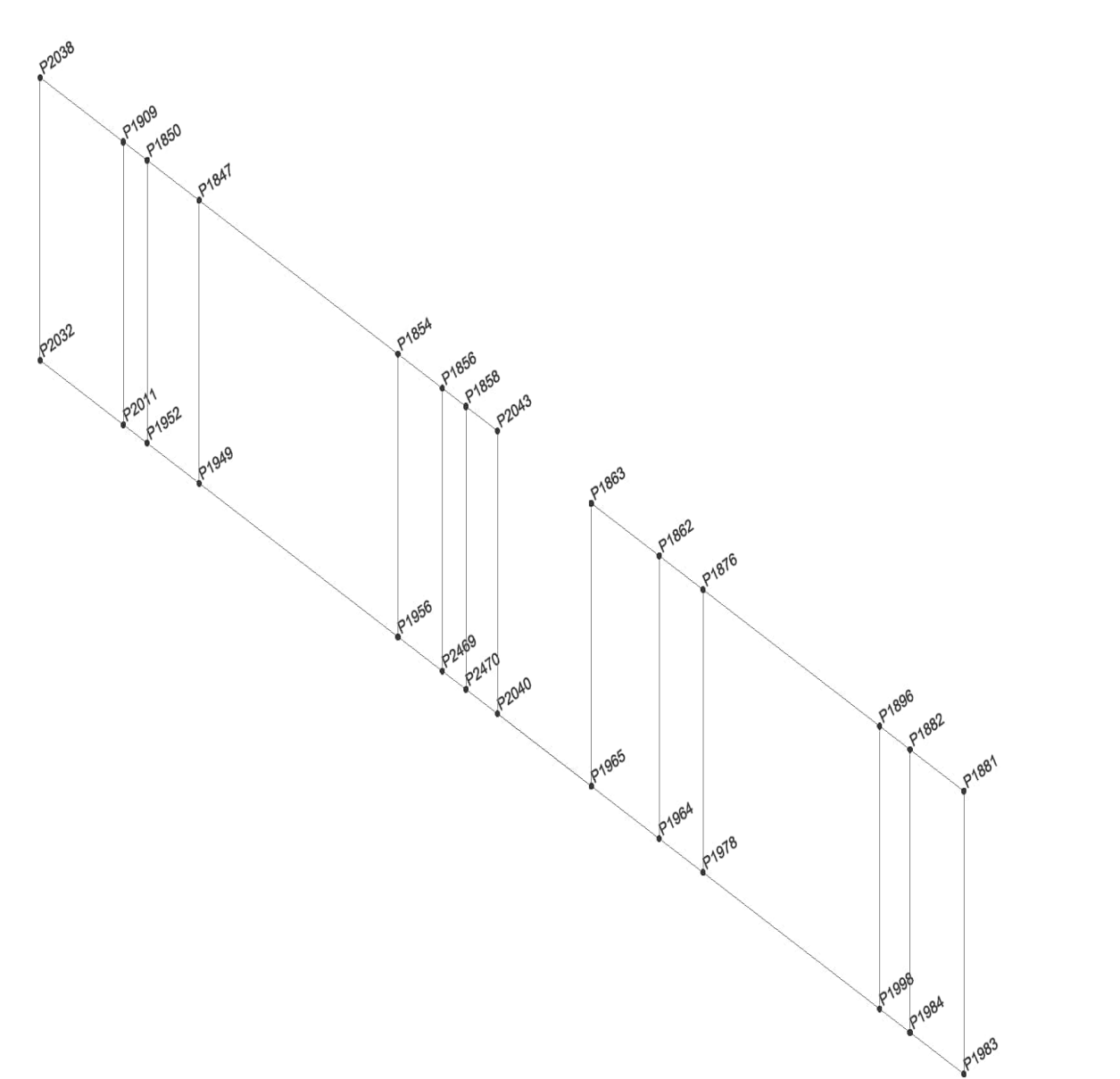
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Slab 3 – level +66.85 :



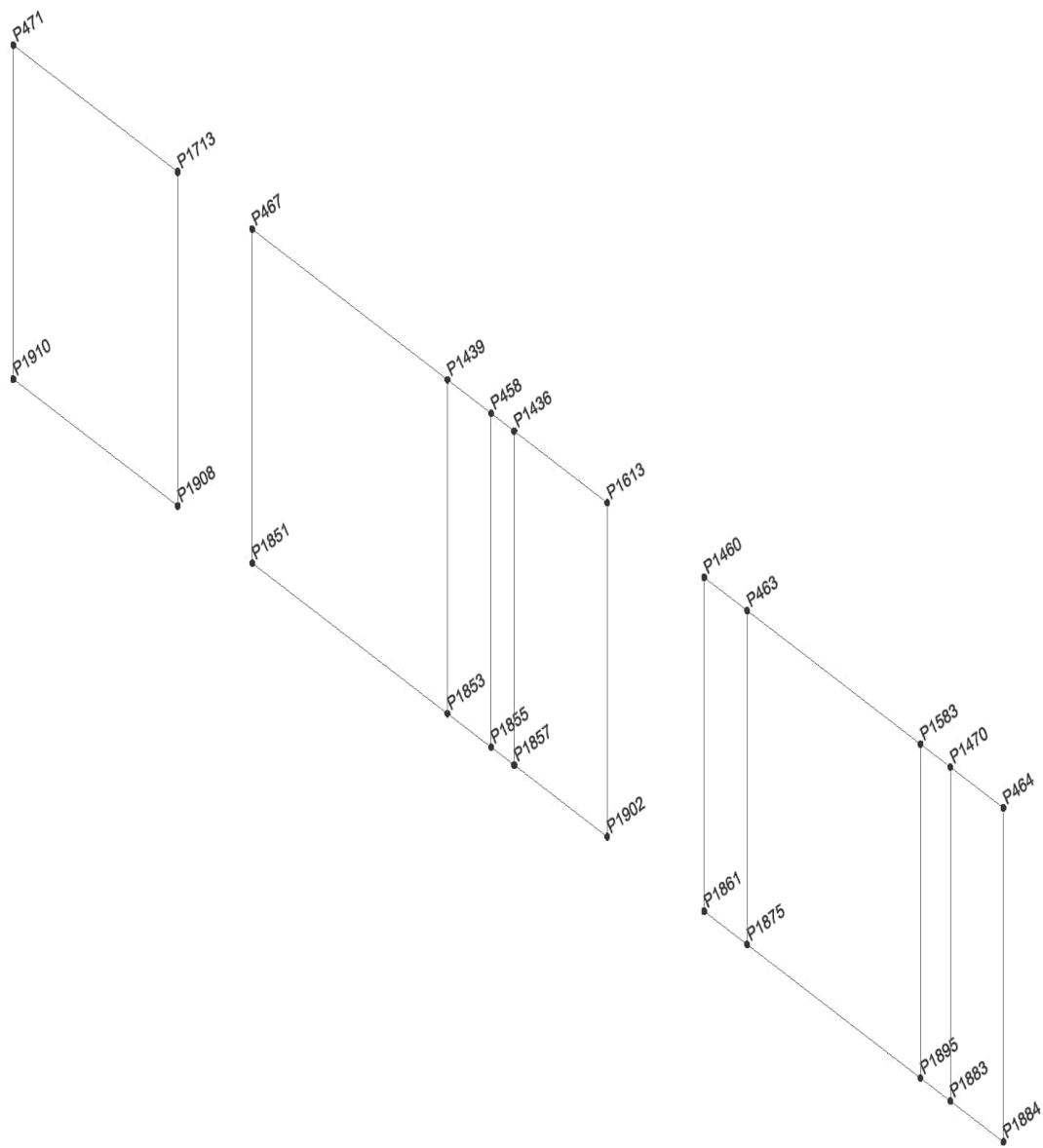
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		Date :	Created :

Interior wall 1 :



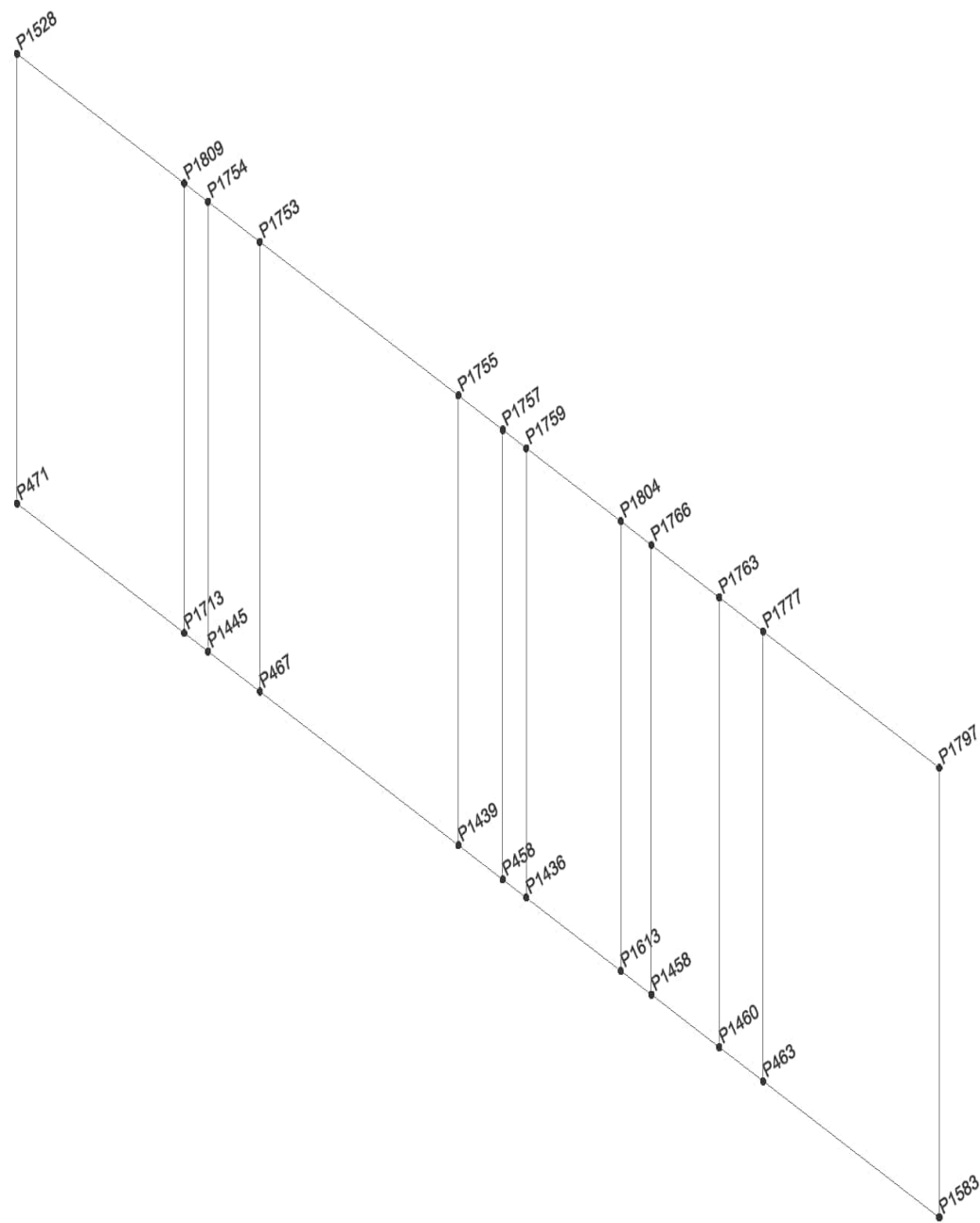
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Interior wall 2 :



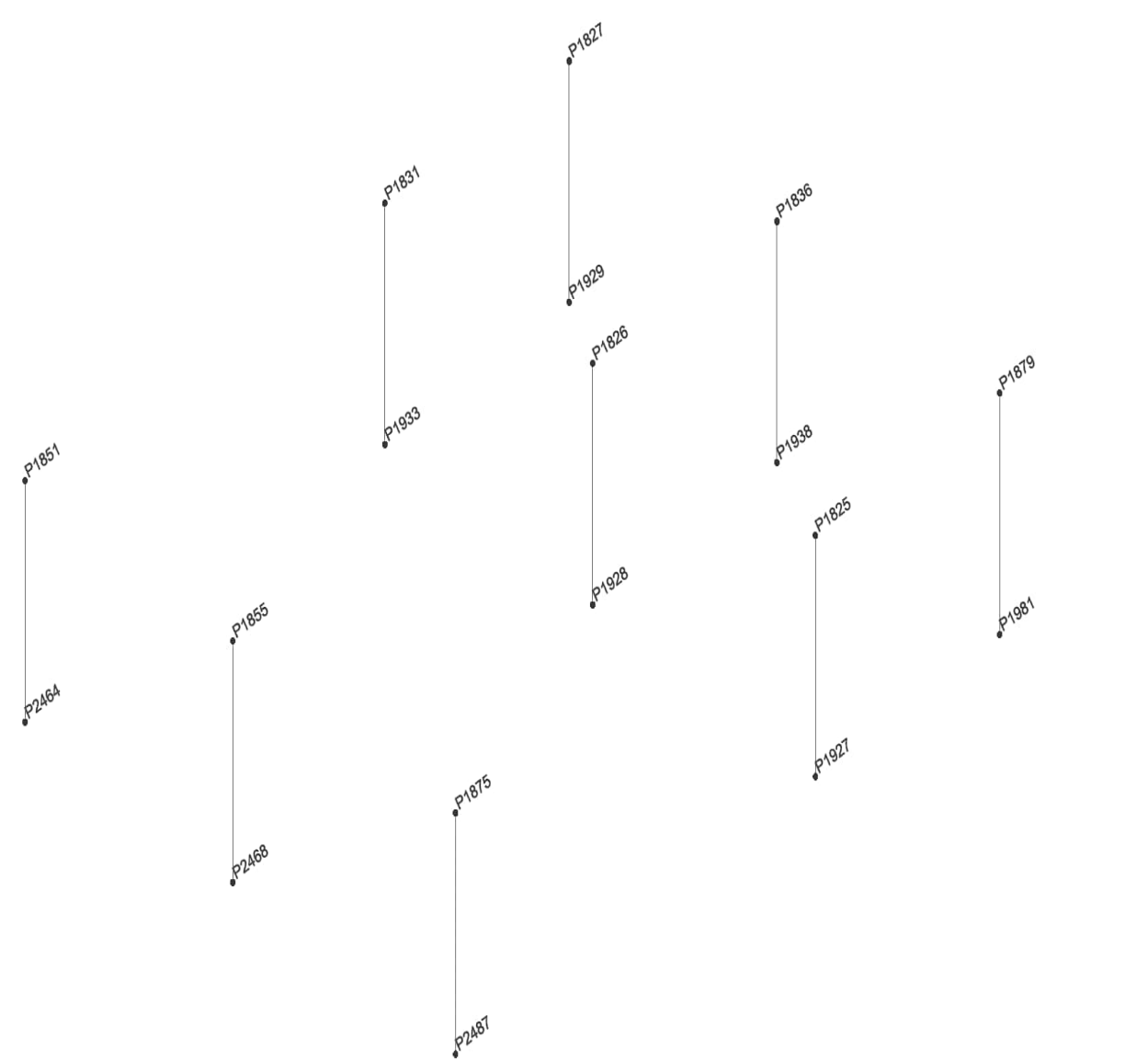
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		Date :	Created :

Interior wall 3 :



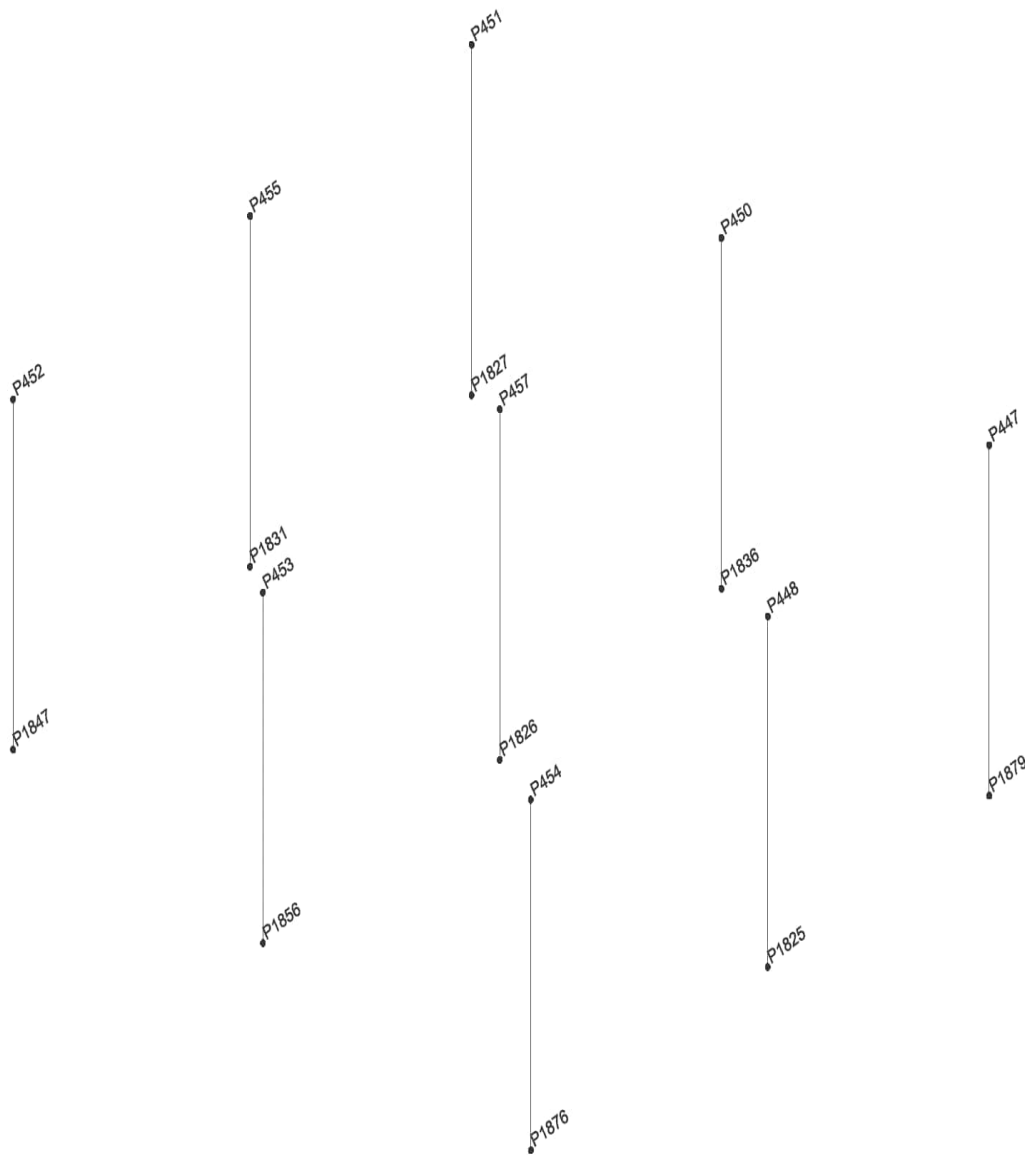
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		Date :	Created :

Columns 1.:



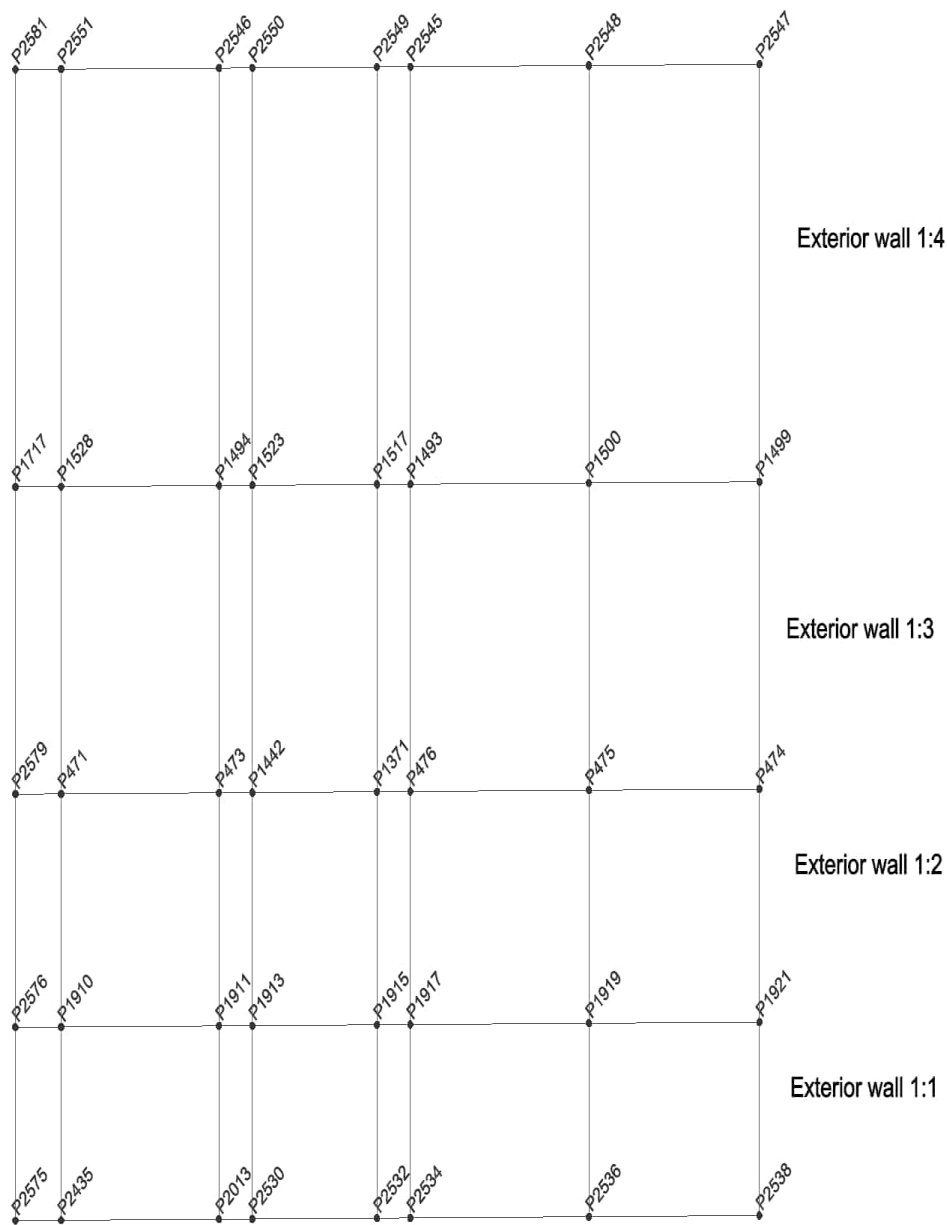
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Columns 2 :



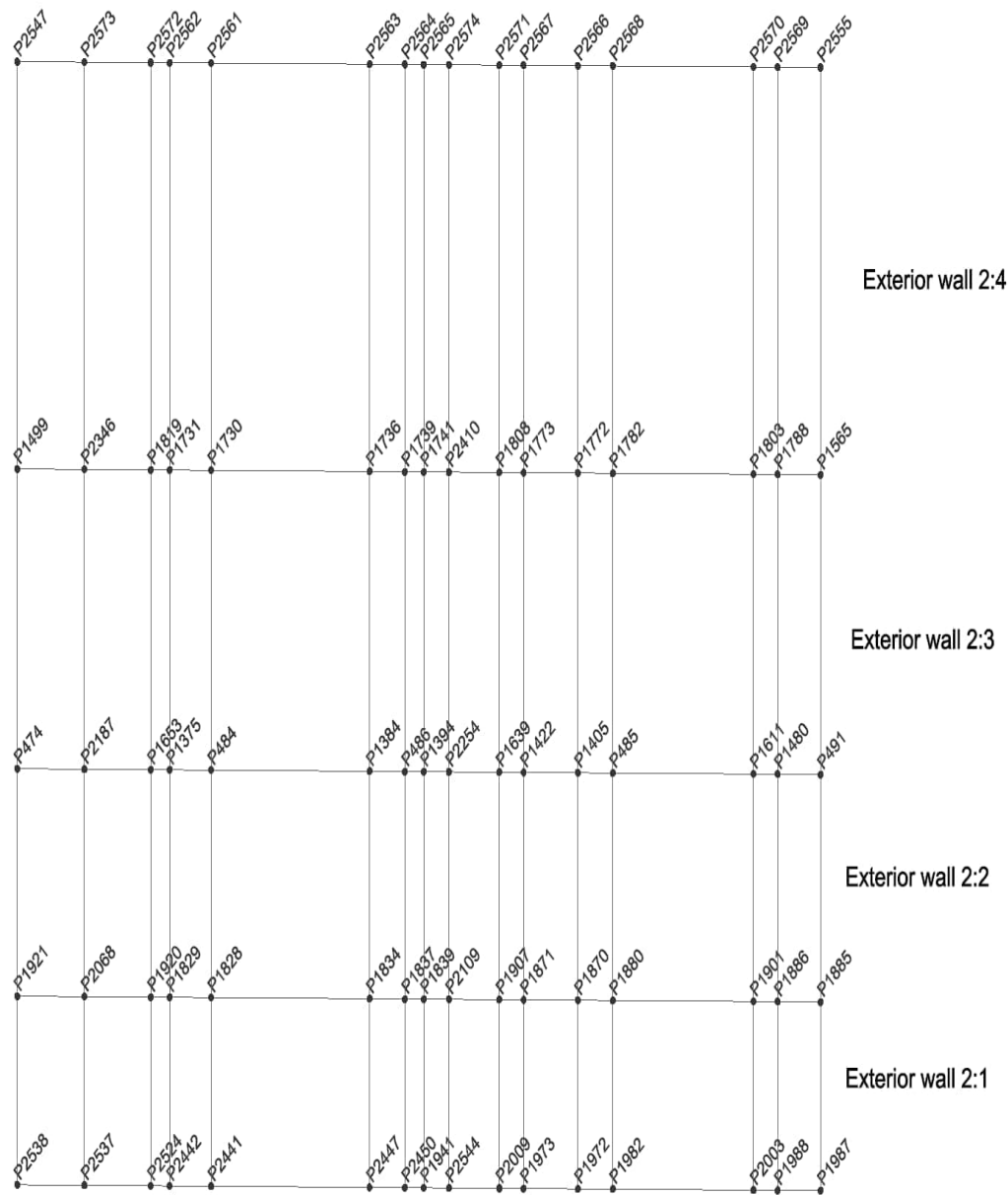
	Hydropower plant 1 (200 MW)	Status :	Page : 46
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Exterior wall 1 - northern wall :



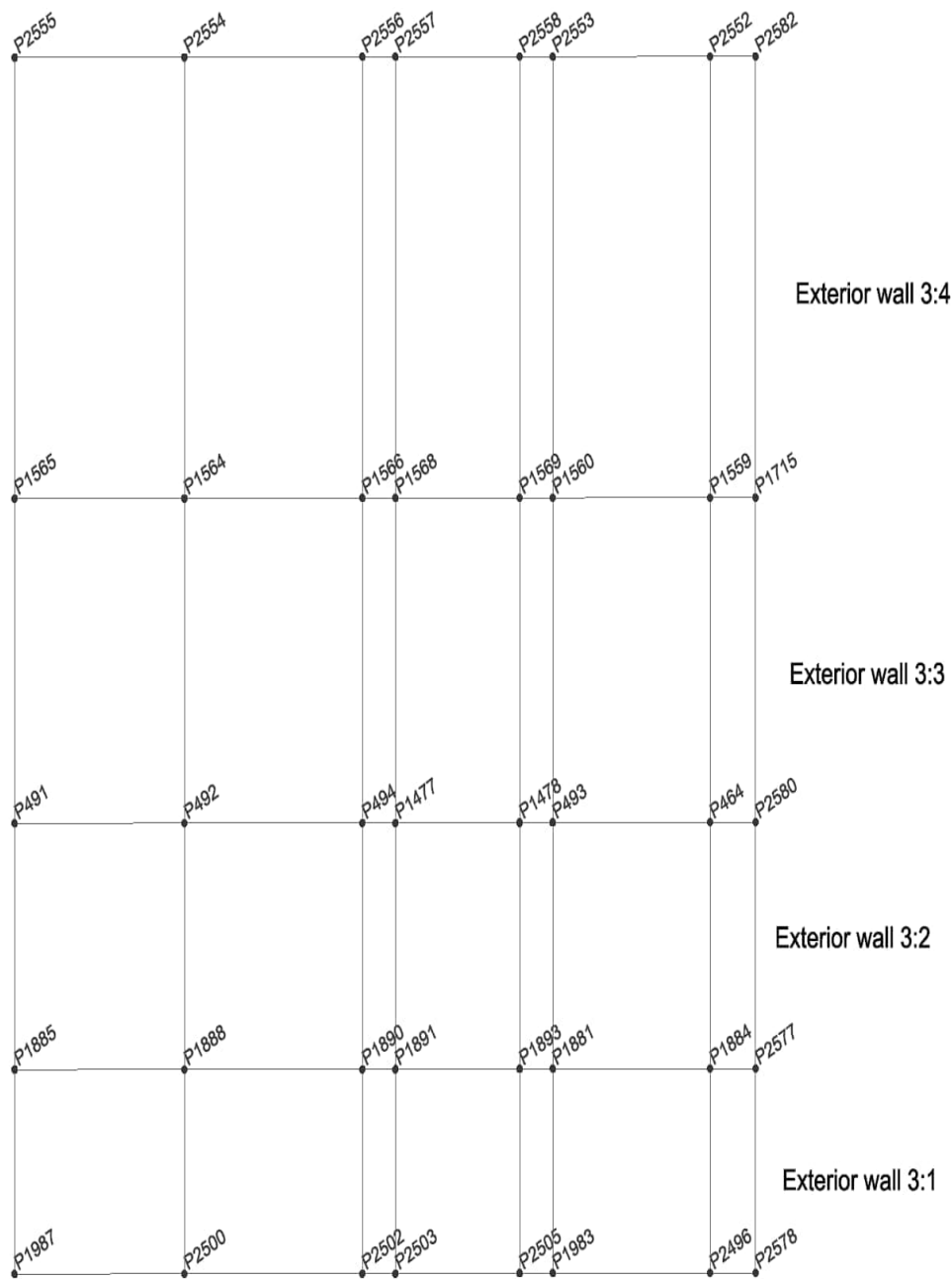
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Exterior wall 2 - eastern wall :



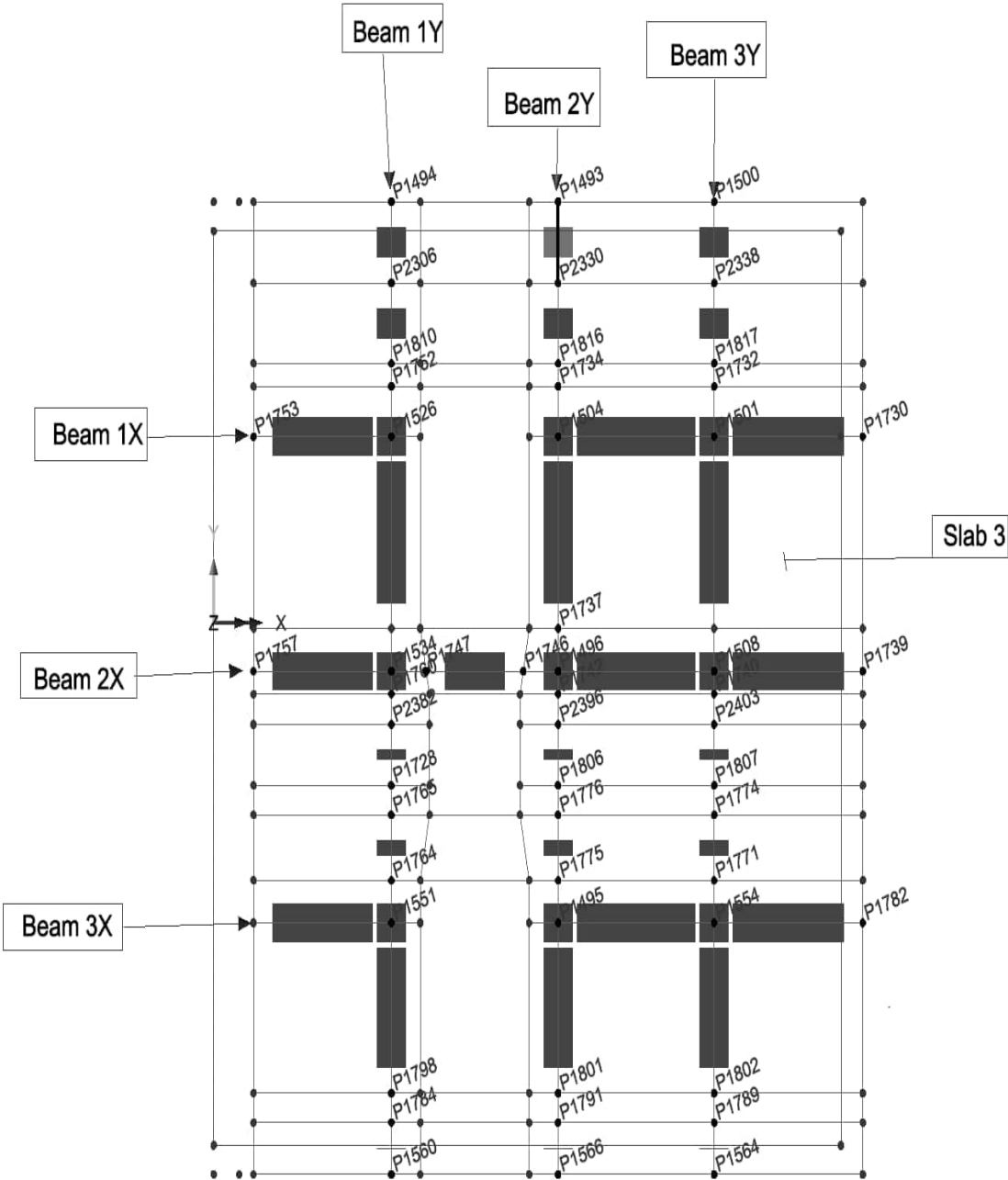
	Hydropower plant 1 (200 MW)	Status :	Page : 48
		Date :	Created :

Exterior wall 3 - southern wall :



	Hydropower plant 1 (200 MW)	Status :	Page : 49
		Date :	Created :

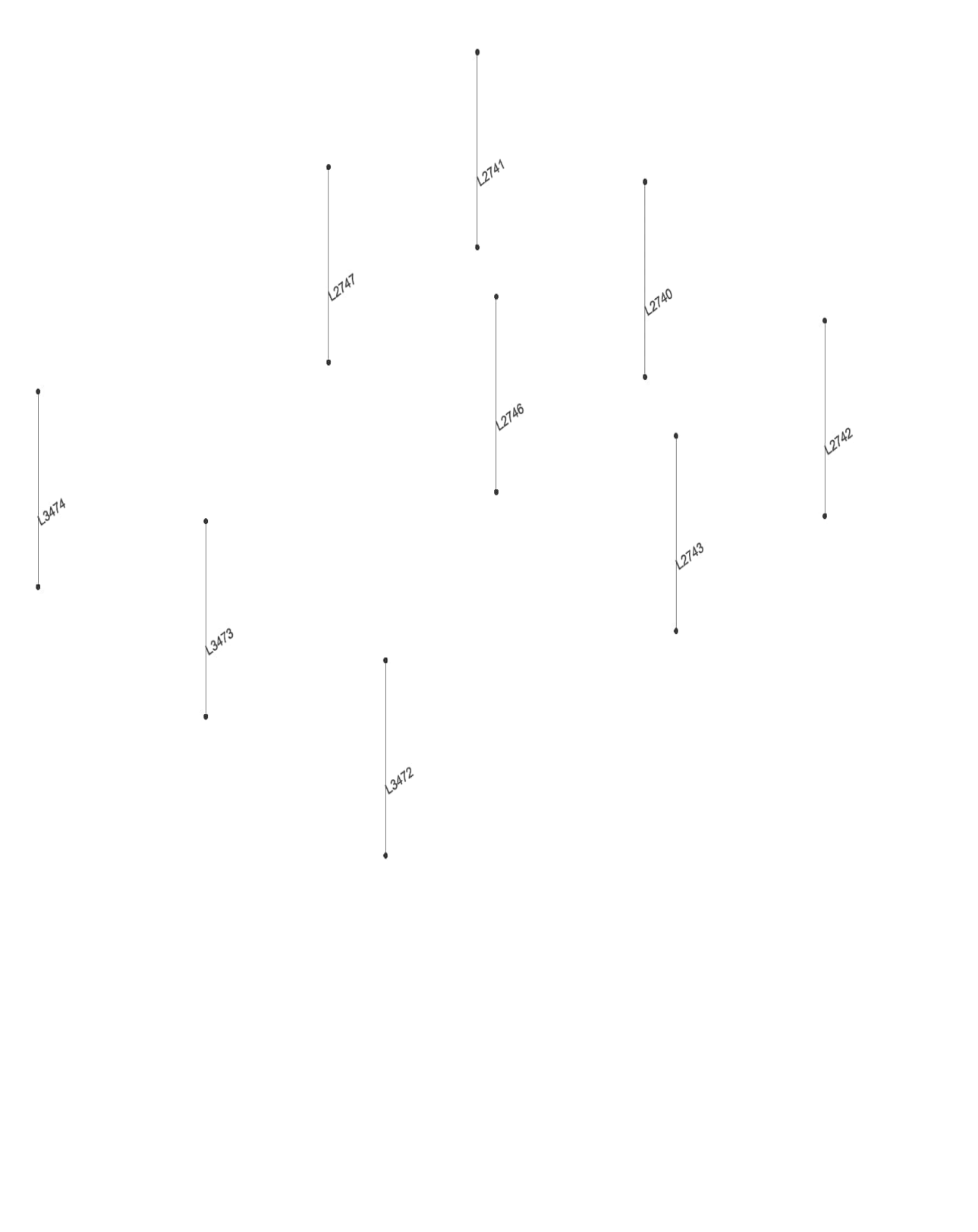
Beams 1X,3X / Beams 1Y,3Y :



	Hydropower plant 1 (200 MW)	Status :	Page : 50
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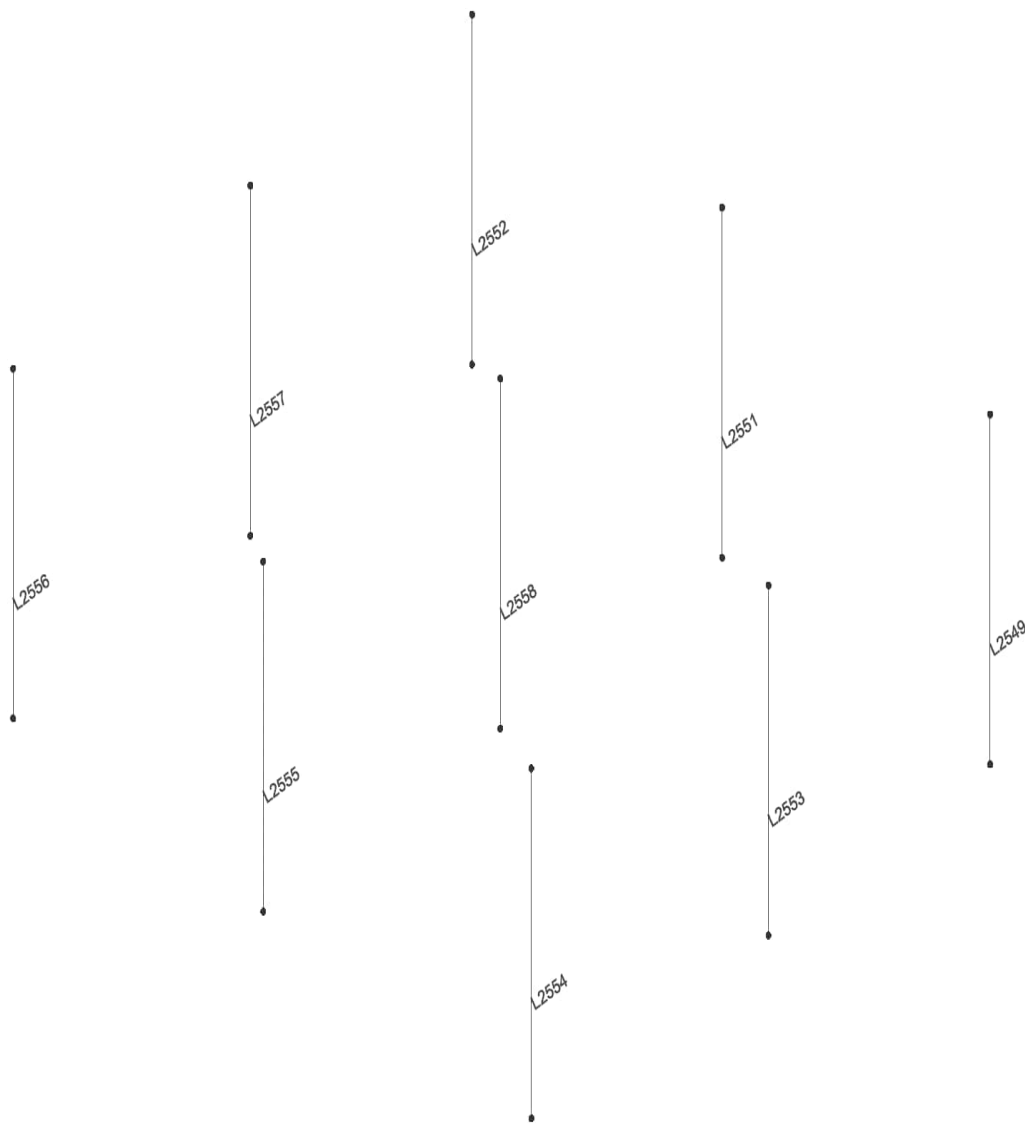
2.2.1.3 Geometry : LINES

Columns 1 :



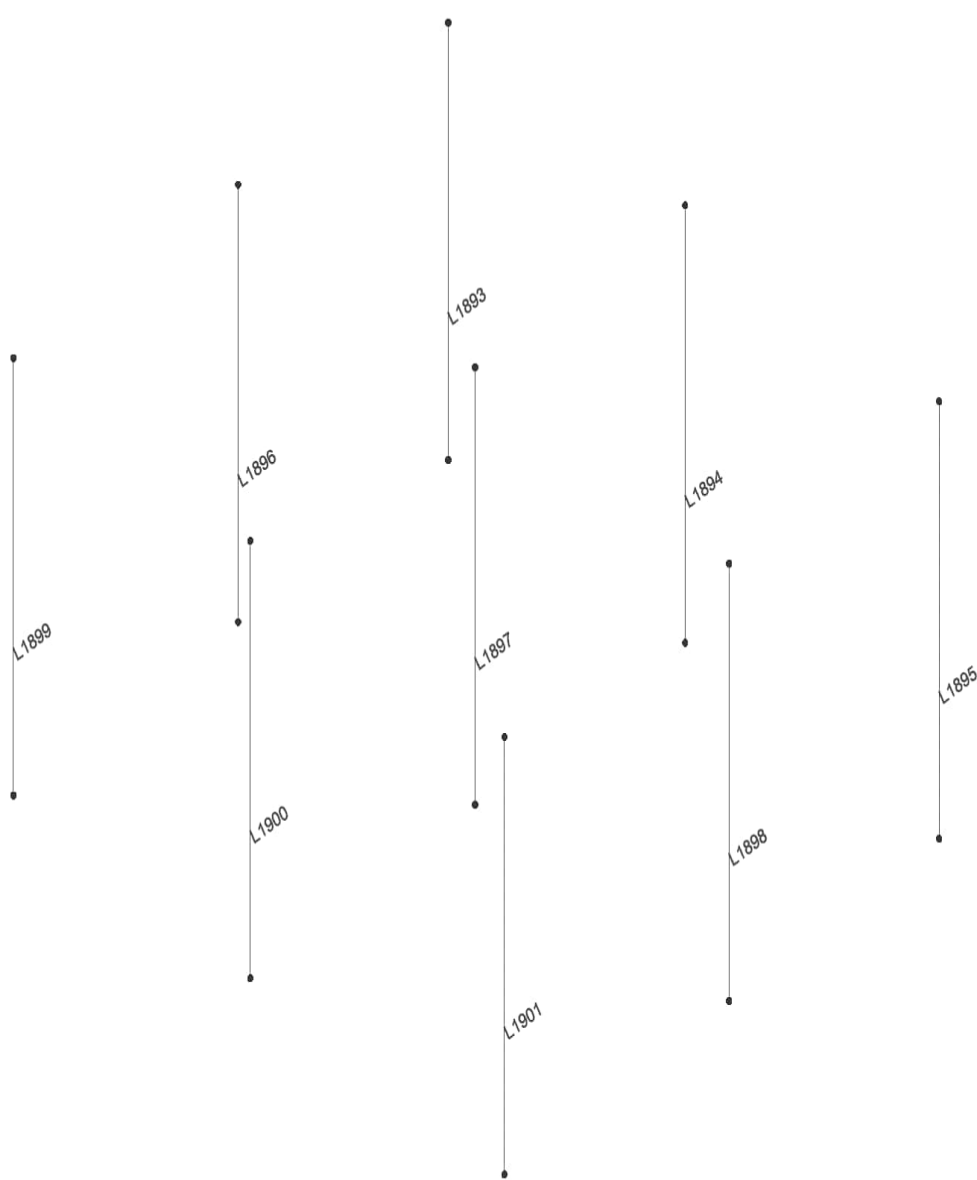
	Hydropower plant 1 (200 MW)	Status :	Page : 51
		Date :	Created :

Columns.2.:



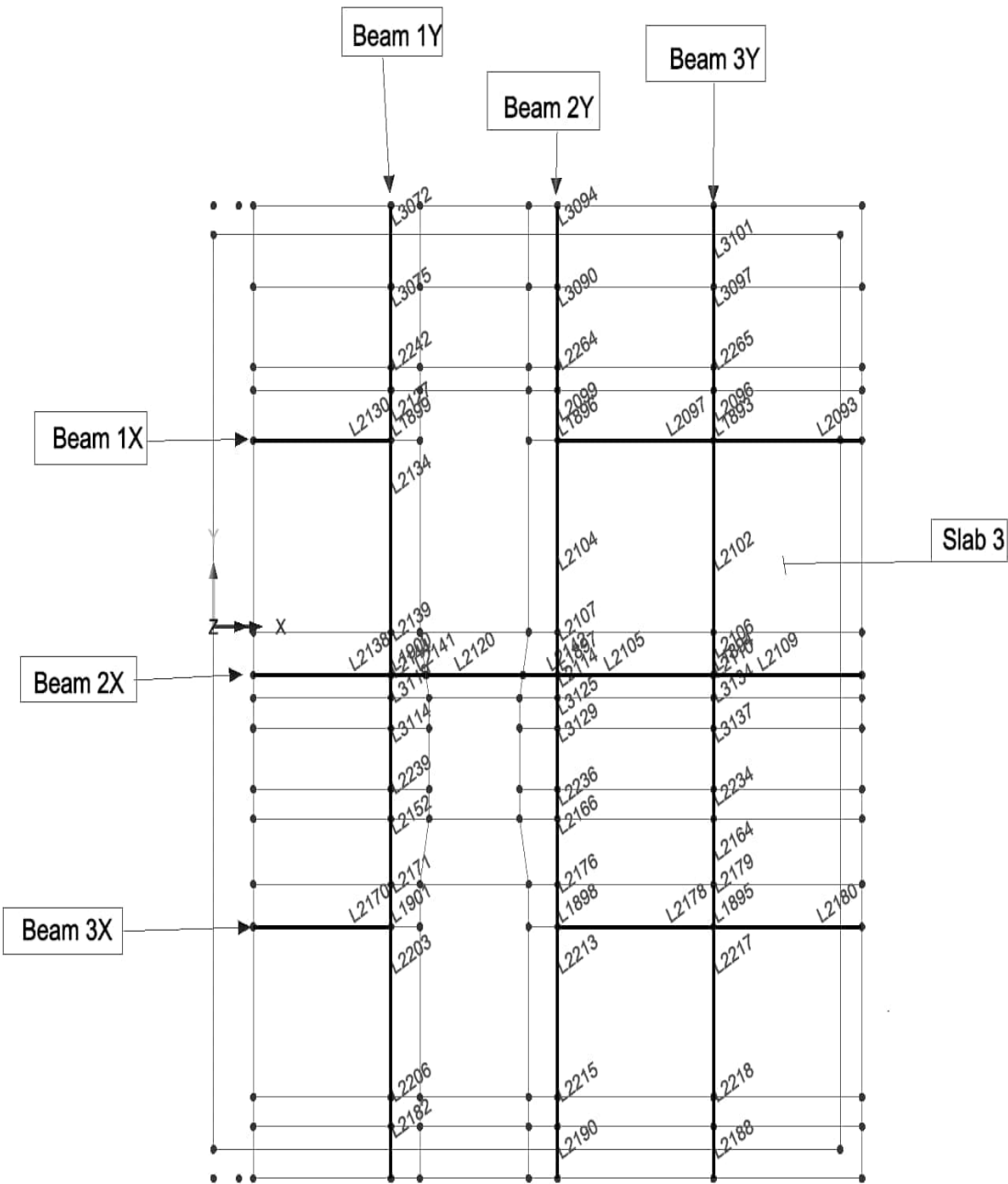
	Hydropower plant 1 (200 MW)	Status :	Page : 52
		Date :	Created :

Columns 3 :



	Hydropower plant 1 (200 MW)	Status :	Page : 53
		Date :	Created :

Beams 1X, 3X / Beams 1Y, 3Y :



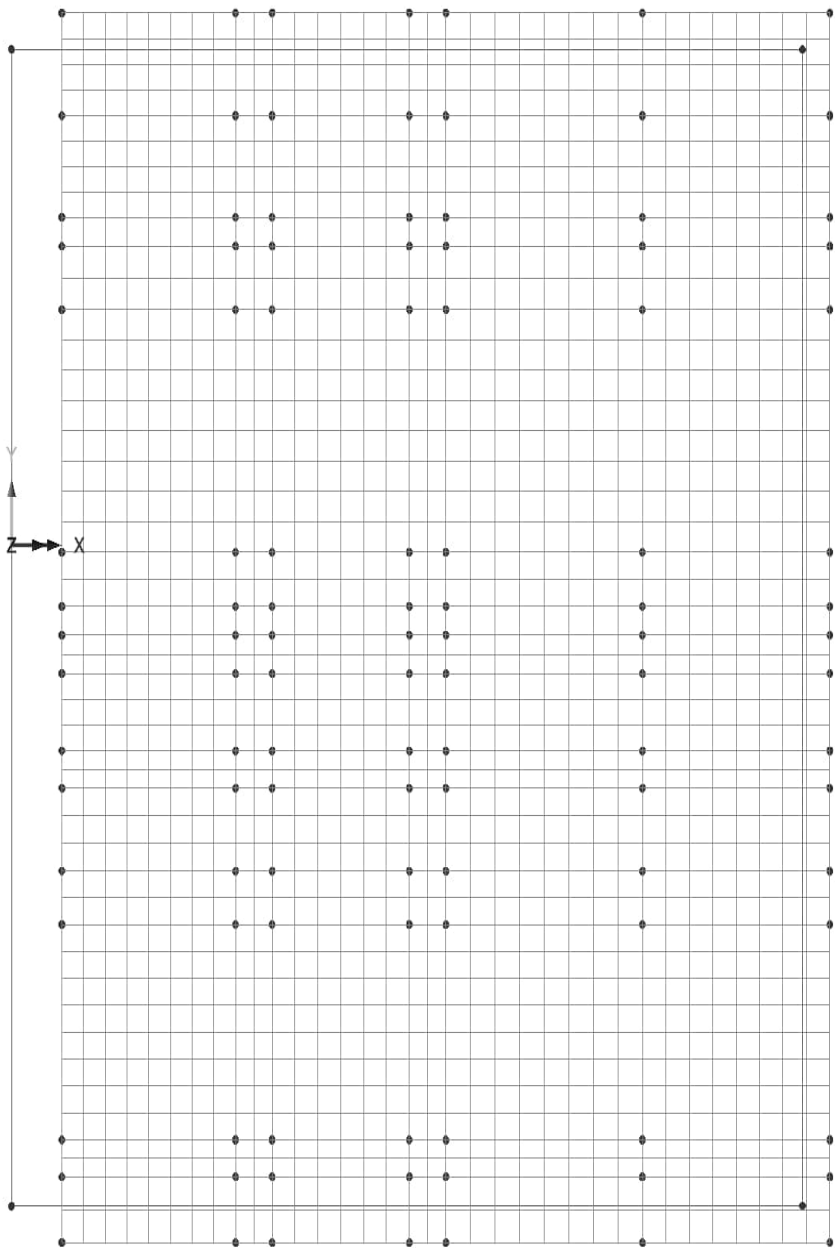
	Hydropower plant 1 (200 MW)	Status :	Page : 54
		Date :	Created :

2.2.2 MESH

The previously defined *LINES/SURFACES* are given attributes for generation of *MESH*.

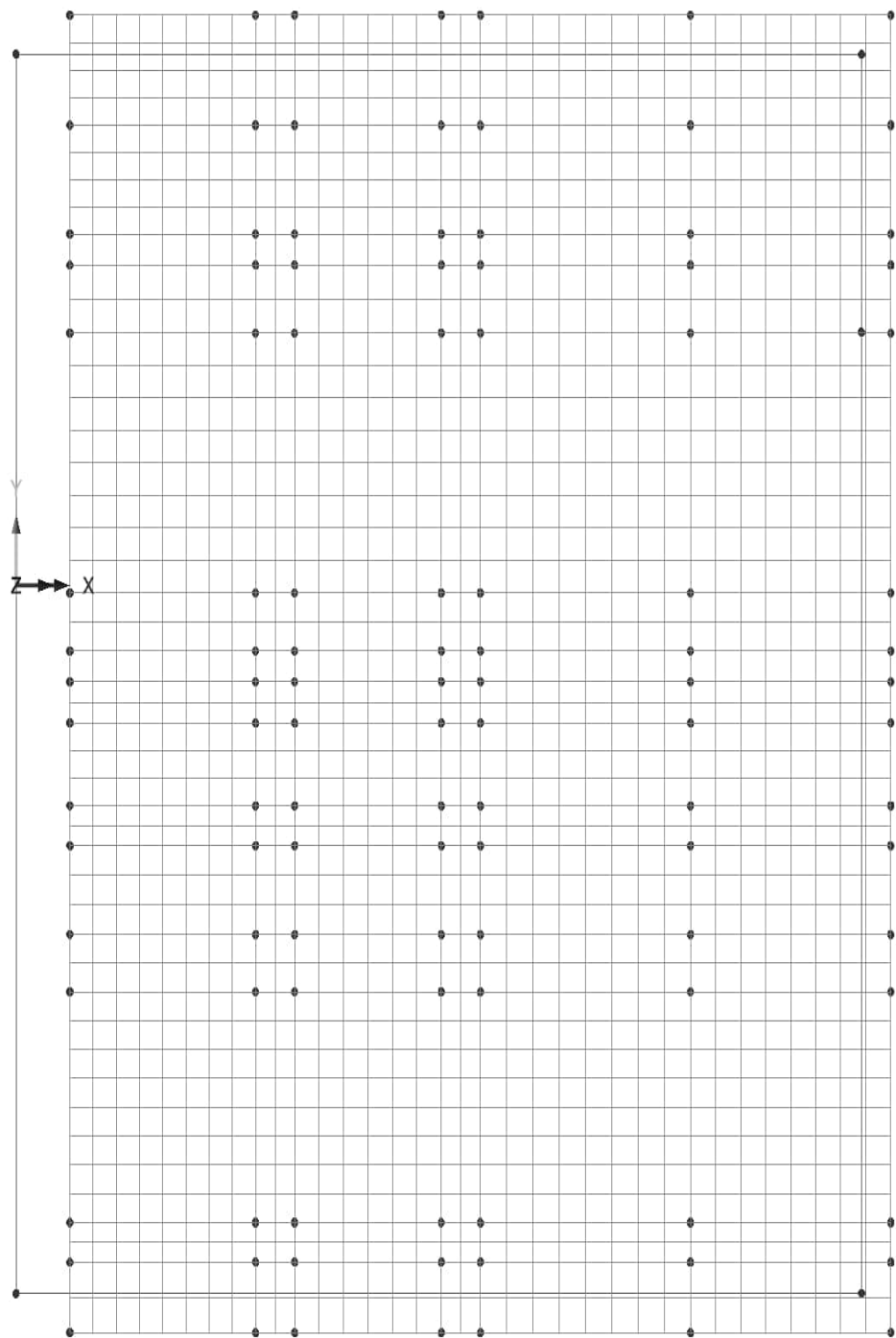
During the generation of *MESH* the underlying *ELEMENTS* and *NODES* are created. They are found in appendix 1.

Slab 1 – level +56.65 :



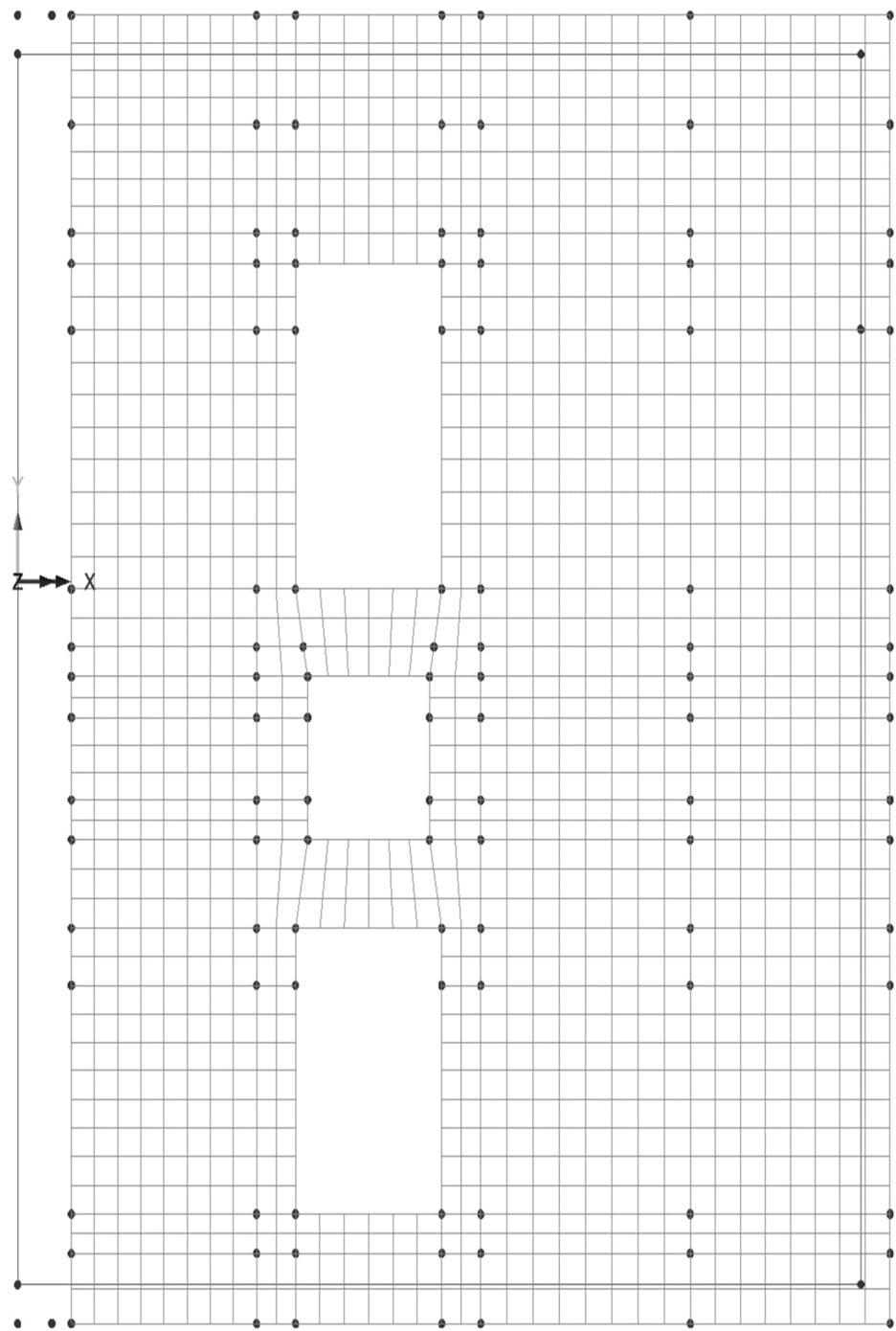
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Slab 2- level +61.05.:



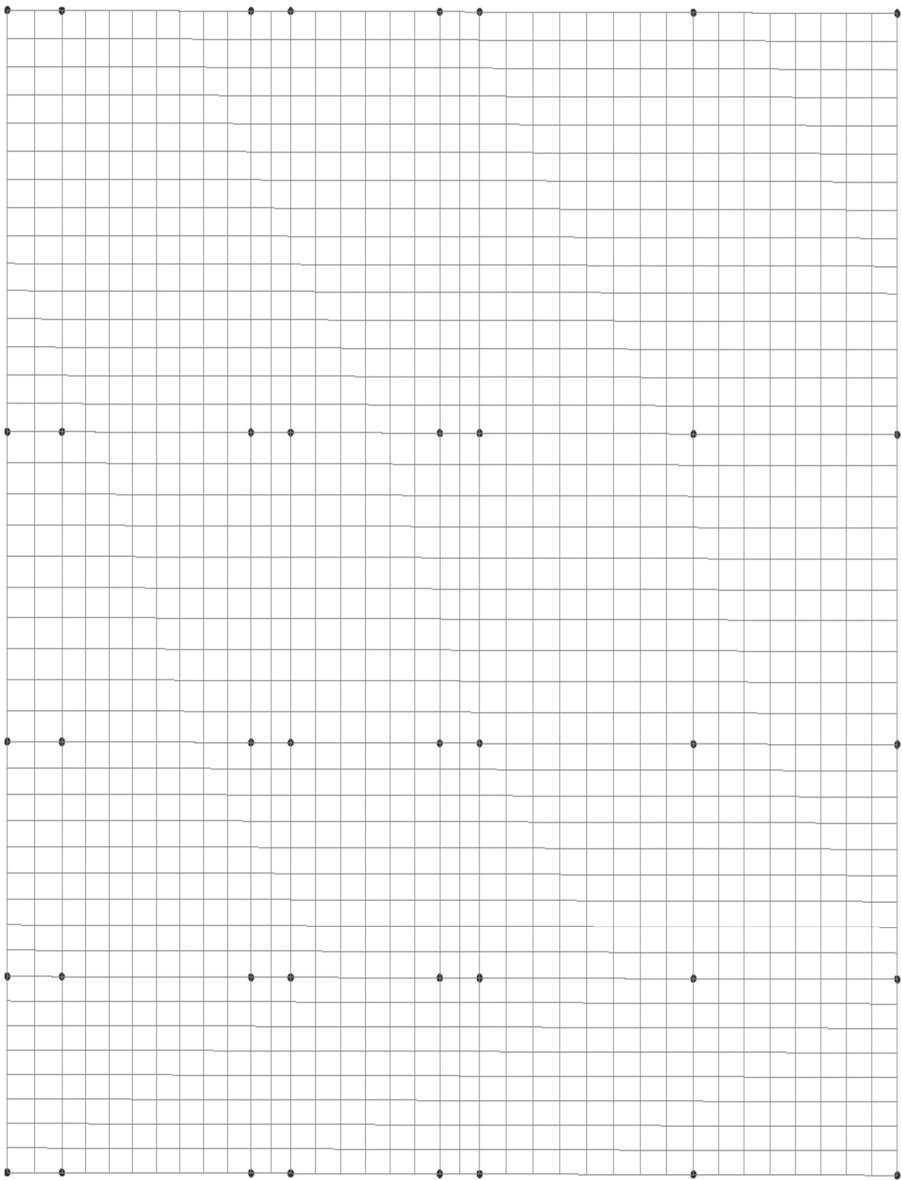
	Hydropower plant 1 (200 MW)	Status :	Page : 56
		Date :	Created :

Slab 3 – level +66.85.:



	Hydropower plant 1 (200 MW)	Status :	Page : 57
		Date :	Created :

Exterior wall 1 - northern wall :



Exterior wall 1:4

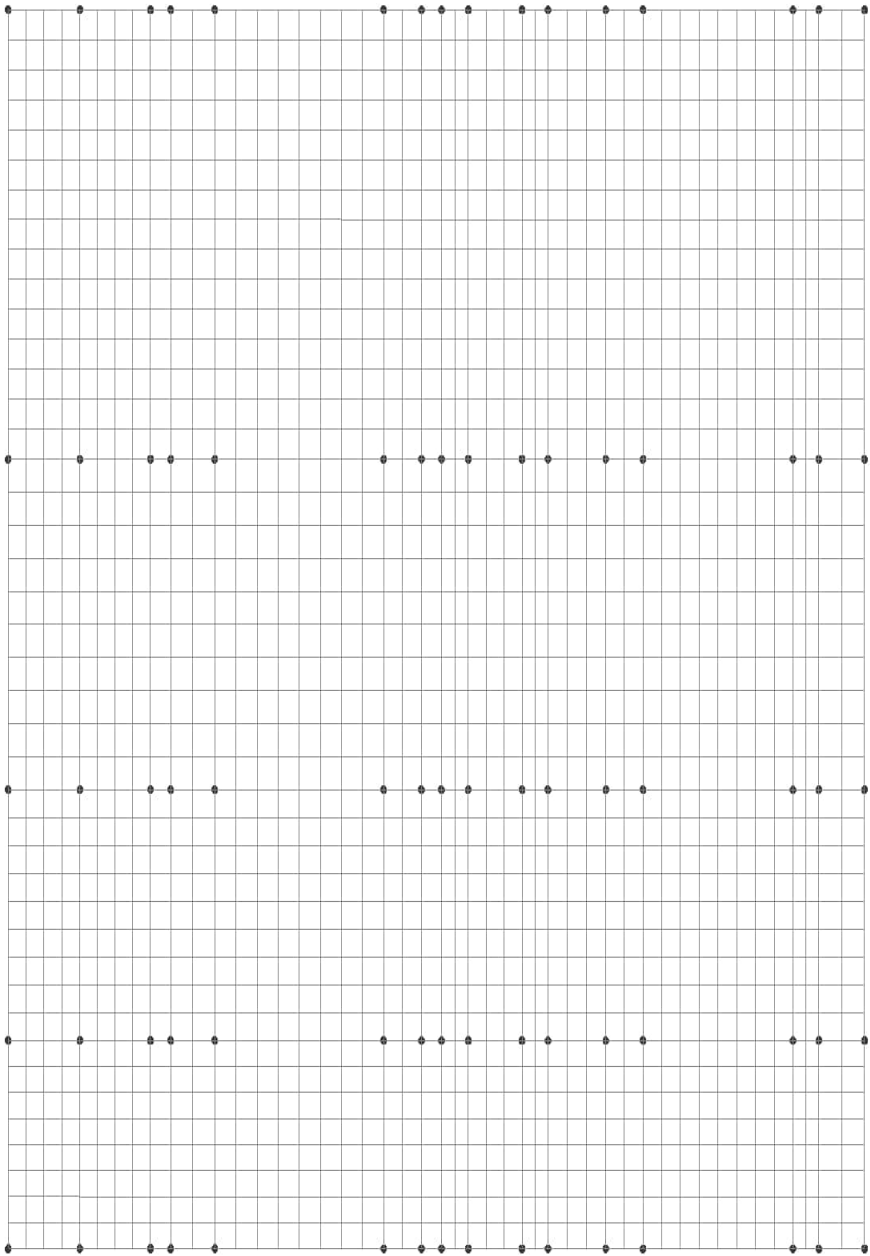
Exterior wall 1:3

Exterior wall 1:2

Exterior wall 1:1

	Hydropower plant 1 (200 MW)	Status :	Page : 58
		Date :	Created :

Exterior wall 2 - eastern wall :



Exterior wall 2:4

Exterior wall 2:3

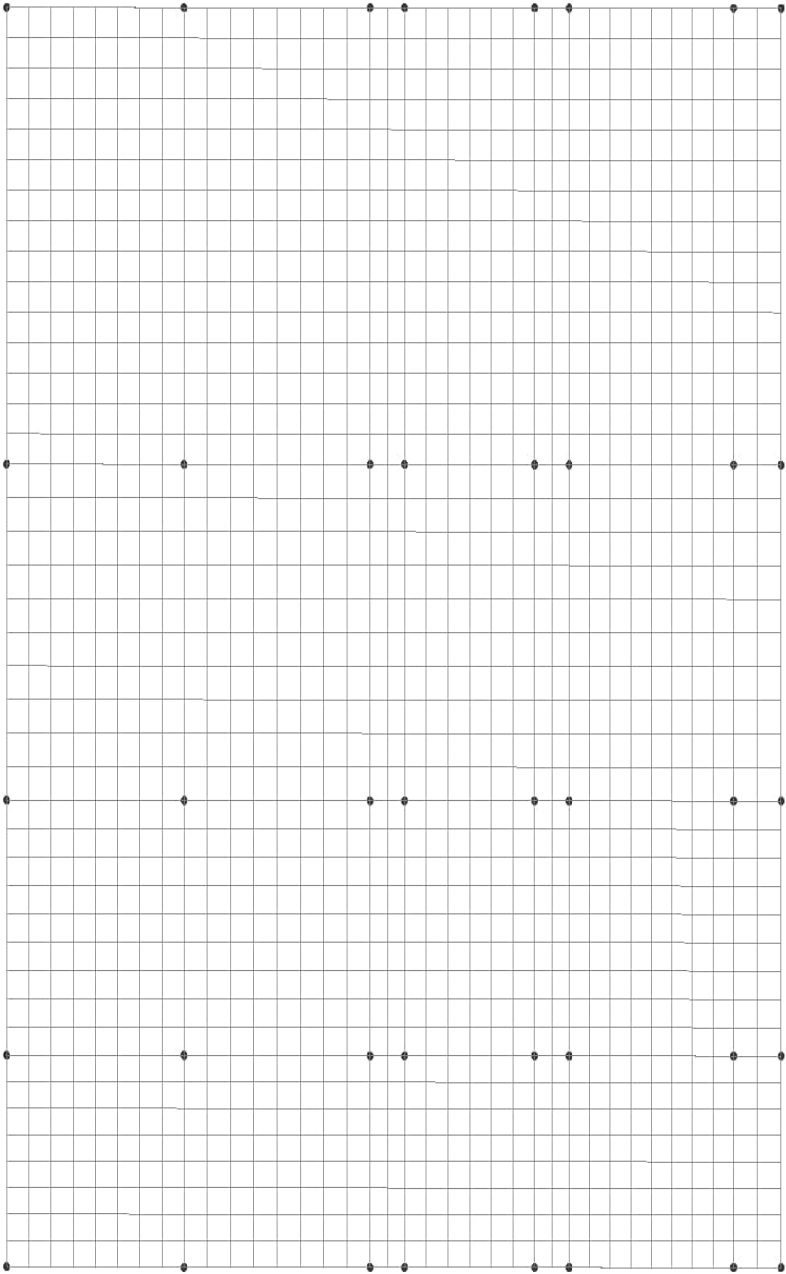
Exterior wall 2:2

Exterior wall 2:1

	Hydropower plant 1 (200 MW)	Status :	Page : 59
		Date :	Created :

Exterior wall 3 - southern wall :

■



Exterior wall 3:4

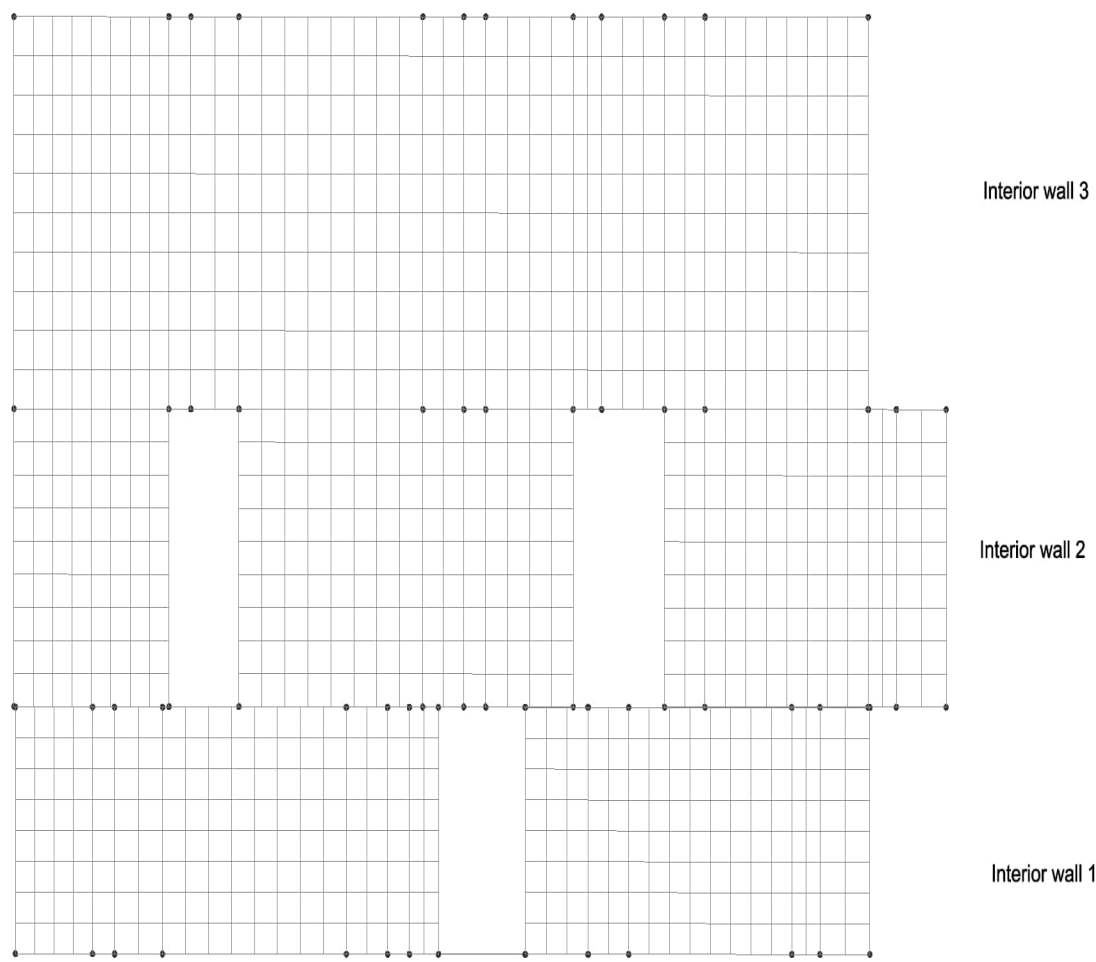
Exterior wall 3:3

Exterior wall 3:2

Exterior wall 3:1

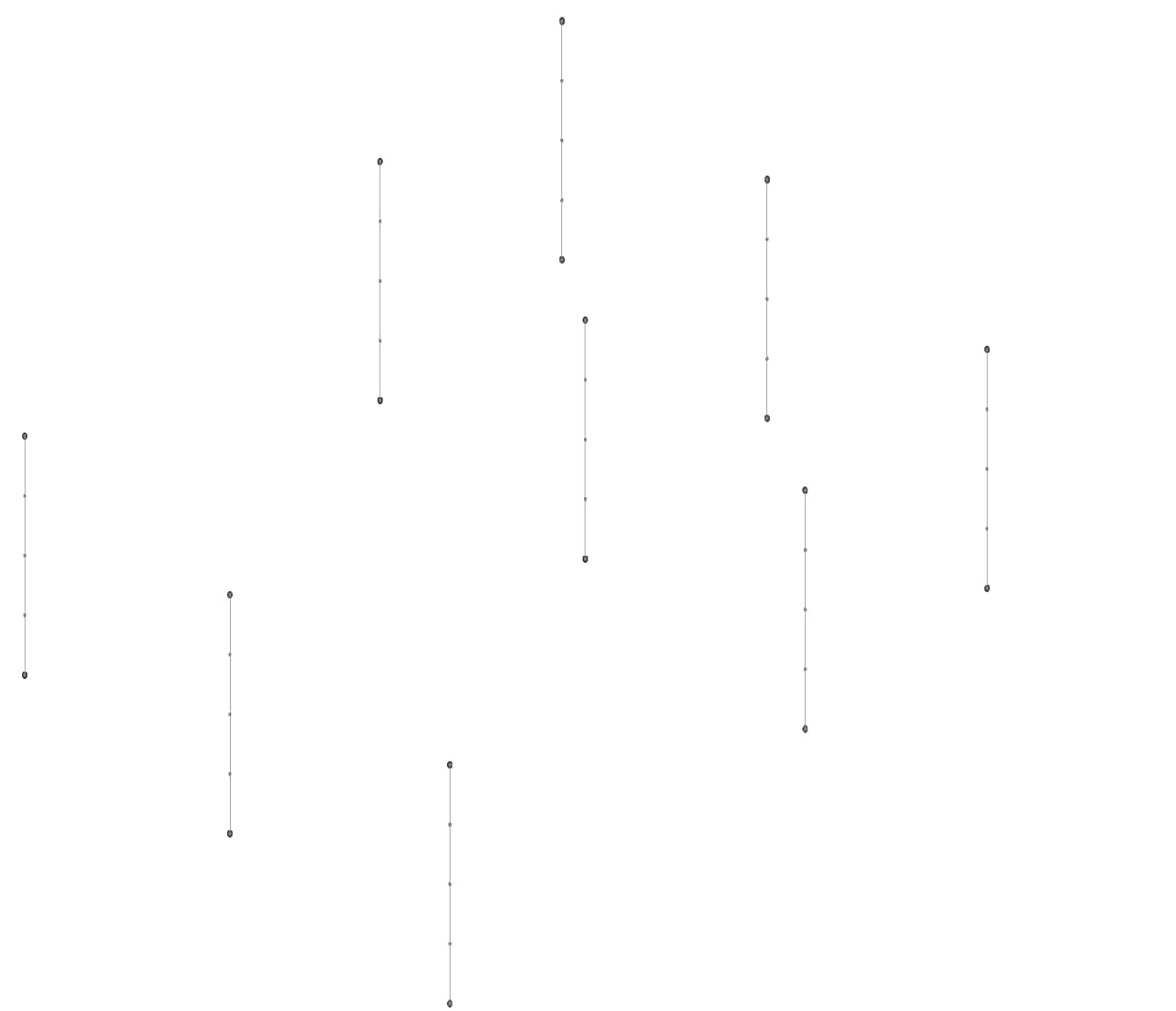
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		Date :	Created :

Interior wall 1..3 :



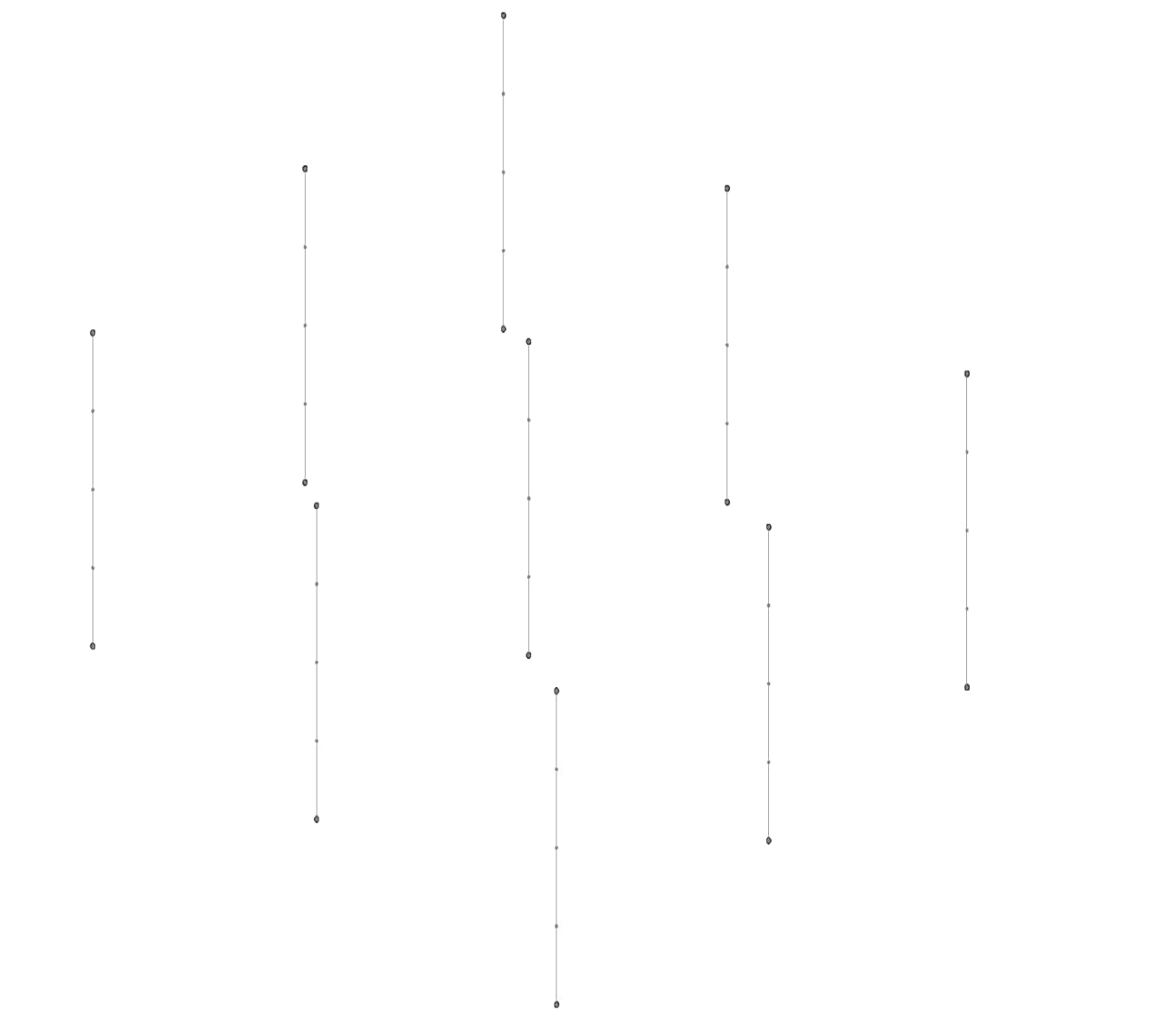
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		Date :	Created :

Columns 1:



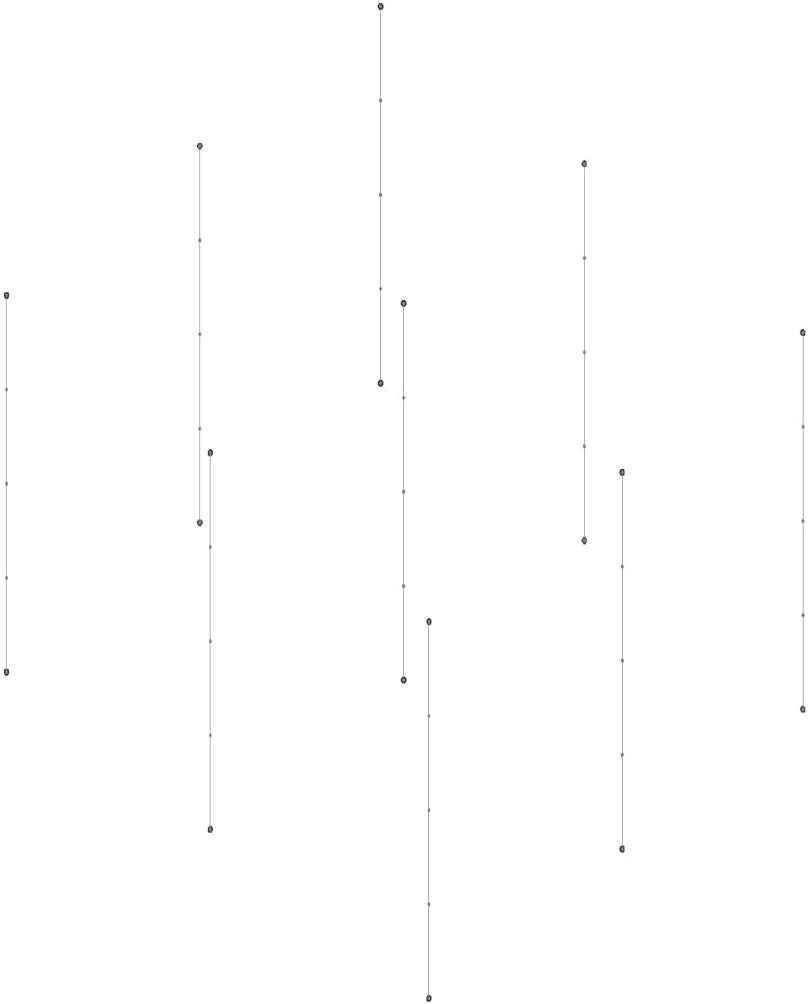
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		Date :	Created :

Columns 2:



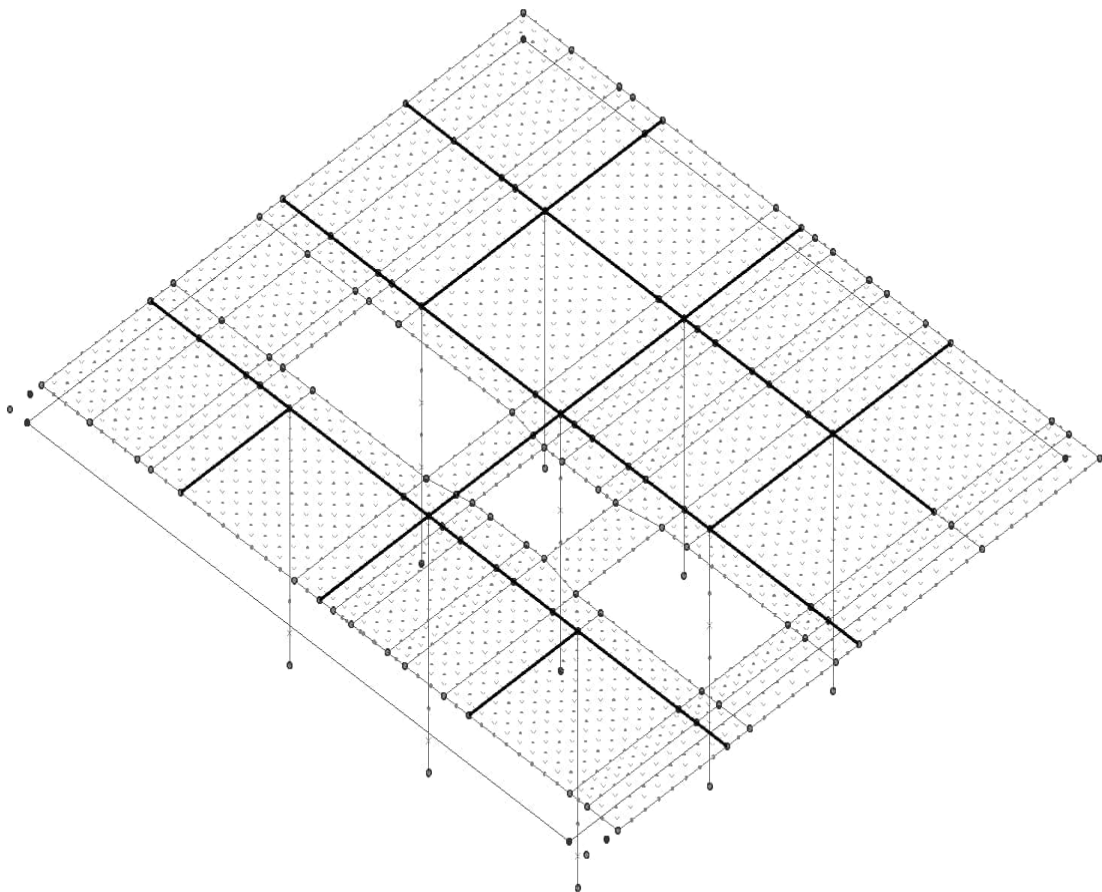
	Hydropower plant 1 (200 MW)	Status :	Page : 63
		Date :	Created :

Columns 3 :



	Hydropower plant 1 (200 MW)	Status :	Page : 64
		Date :	Created :

Beams 1X..3X / Beams 1Y..3Y :

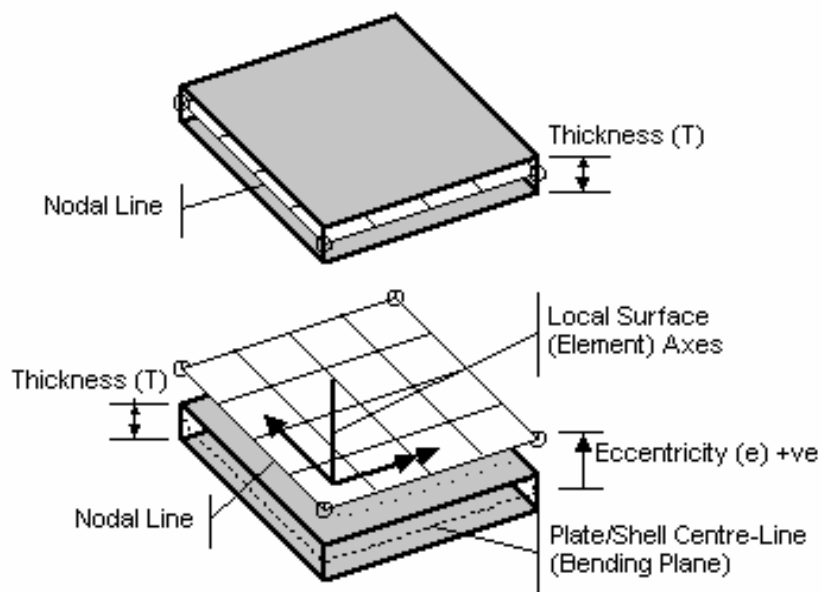


	Hydropower plant 1 (200 MW)	Status :	Page : 65
		Date :	Created :

2.3 CROSSECTION PROPERTIES

The structure is modelled with Shell elements ("Thick shell" / QTS4) or as 3D thick beam elements ("Thick beam" / BMS3) .

2.3.1 Shell elements ("Thick shell" / QTS4)

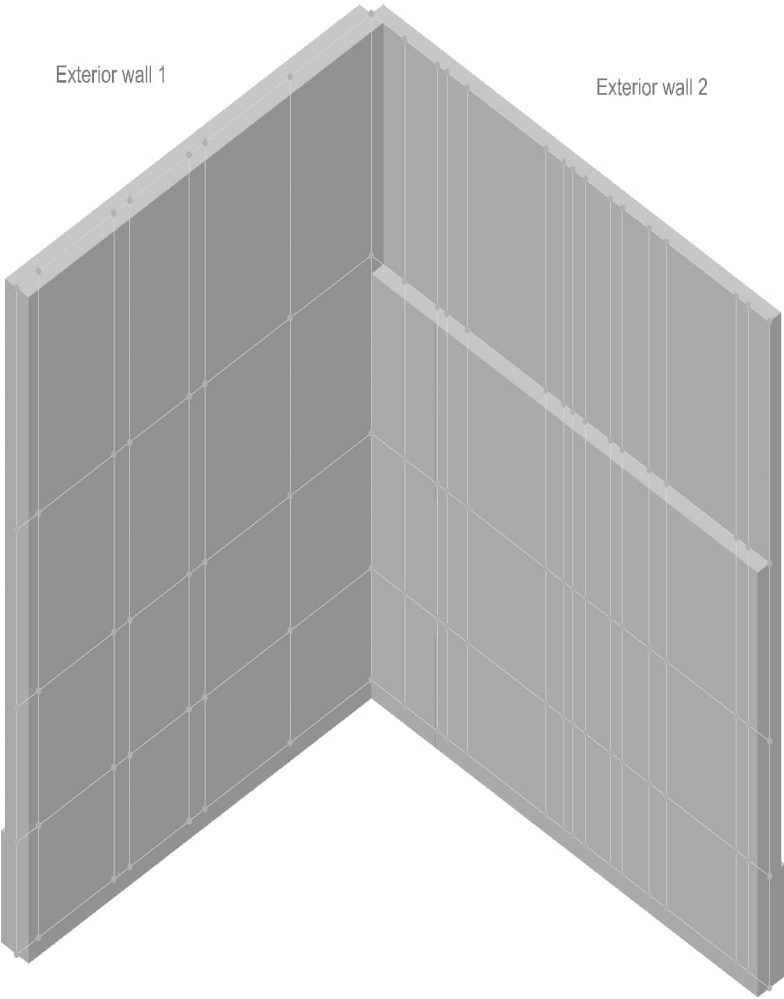


Geometry	t	e_z	Remark
Skiva t=1.4m	1.40	-0.10	Exterior wall 1:1..1:3
Skiva t =0.8 m	0.80	0	Exterior wall 4:3
Skiva t = 0.7 m	0.70	0	Slab 1..3
Skiva t = 1.2 m	1.20	0	Exterior wall 2:1..2:3, 3:1..3:3, 4:2, 4:3
Skiva t = 0.5 m	0.50	0	Interior wall 2..3
Skiva t = 0.6 m	0.60	-0.30	Exterior wall 4:3
-	m	m	-

	Hydropower plant 1 (200 MW)	Status :	Page : 66
		Date :	Created :

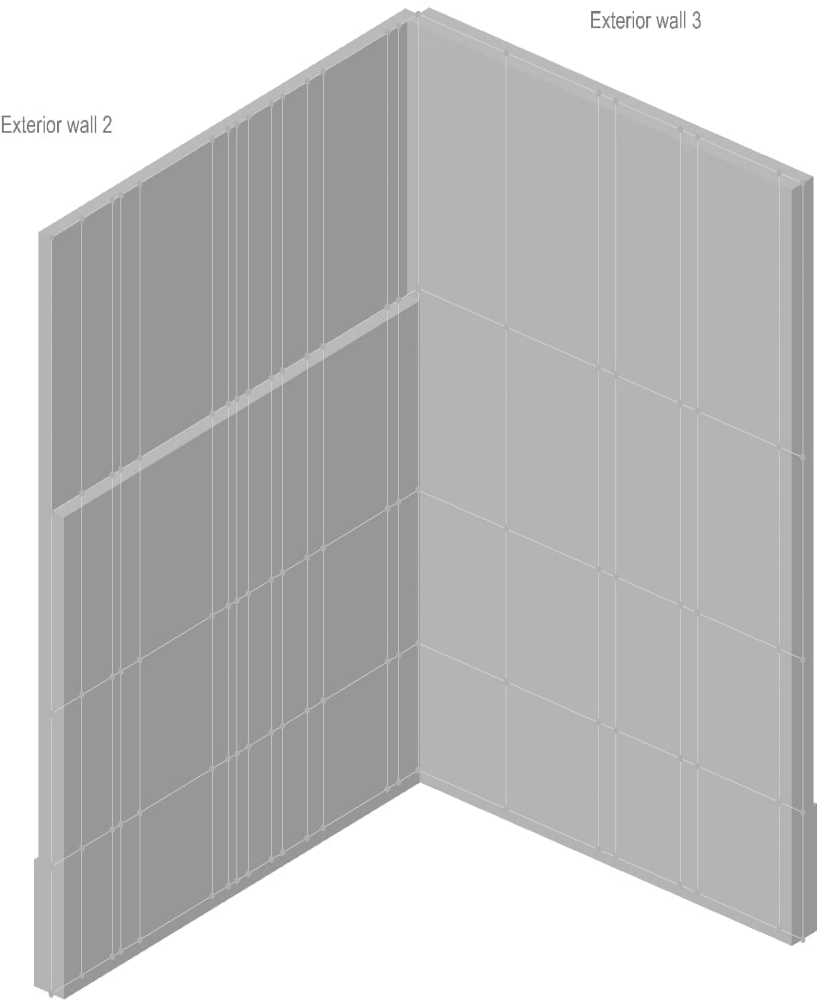
View – Exterior wall 1 / Exterior wall 2..:

-



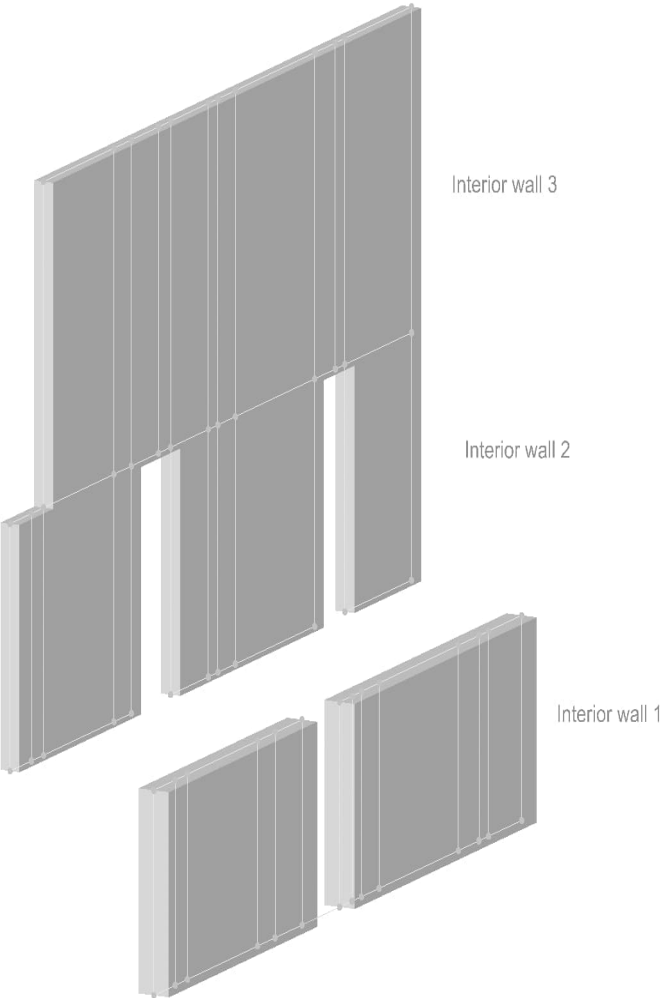
	Hydropower plant 1 (200 MW)	Status :	Page : 67
		Date :	Created :

View – Exterior wall 2 / Exterior wall 3 .:



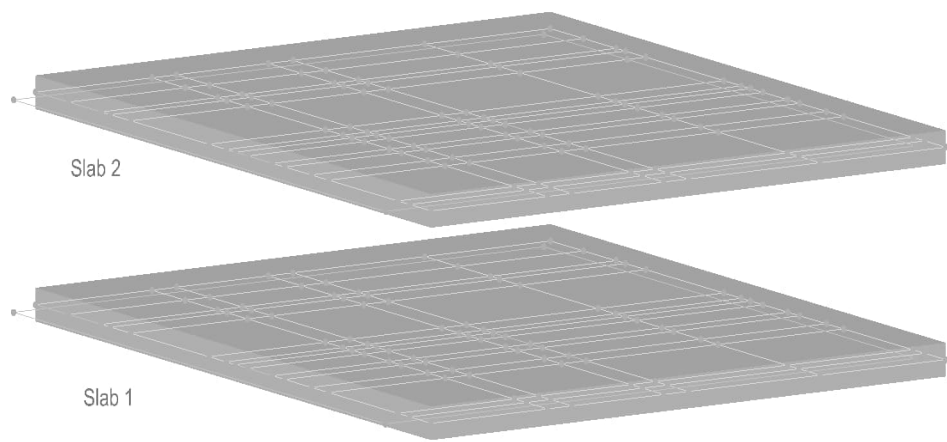
	Hydropower plant 1 (200 MW)	Status :	Page : 68
		Date :	Created :

View – Interior wall 1..3..:



	Hydropower plant 1 (200 MW)	Status :	Page : 69
		Date :	Created :

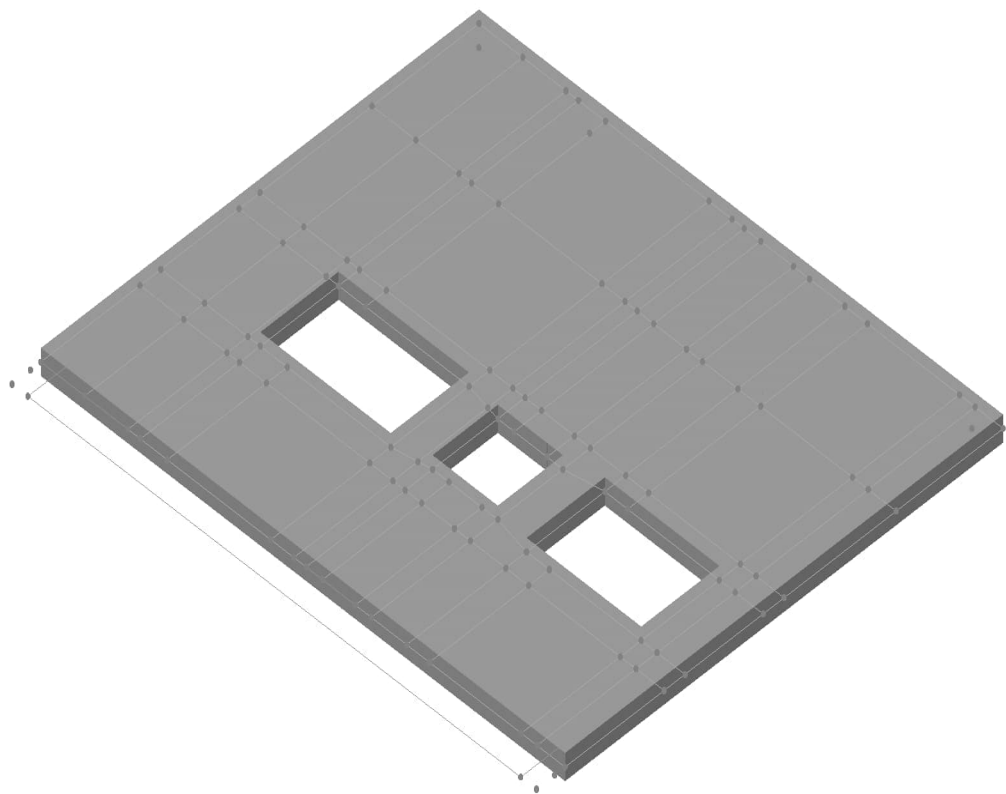
View – Slab 1/ Slab 2 :



-

	Hydropower plant 1 (200 MW)	Status :	Page : 70
		Date :	Created :

View – Slab 3 :

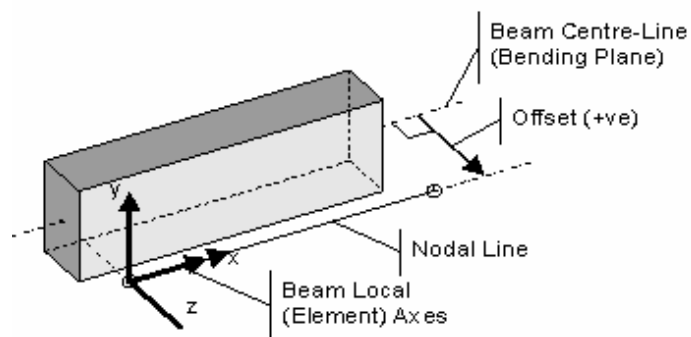


	Hydropower plant 1 (200 MW)	Status :	Page : 71
		Date :	Created :

2.3.2 3D- beam element ("Thick beam" / BMS3)

Cross section properties are calculated with *Section Property Calculator*.

When introducing beam elements into structure an Offset as seen below can be used.



	Hydropower plant 1 (200 MW)	Status :	Page : 72
		Date :	Created :

2.3.2.1 Columns

Usage

3D Thick Beam

Definition

From Library

Rotate through 90°

Enter Properties

	Value
Cross sectional area (A)	0.64
Second moment of area about y axis (Iyy)	0.0341333
Second moment of area about z axis (Izz)	0.0341333
Product moment of area (Iyz)	0.0
Torsion constant (Jxx)	0.0576853
Effective shear area in y direction (Asy)	0.533333
Effective shear area in z direction (Asz)	0.533333
Offset in y direction (Ry)	0.0
Offset in z direction (Rz)	0.0

Visualise...

Tapering >>

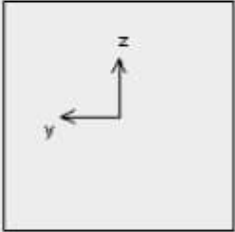
Cross section...

Plastic properties...

User Sections

Local

Column 800x800



Attribute

Column 800x800

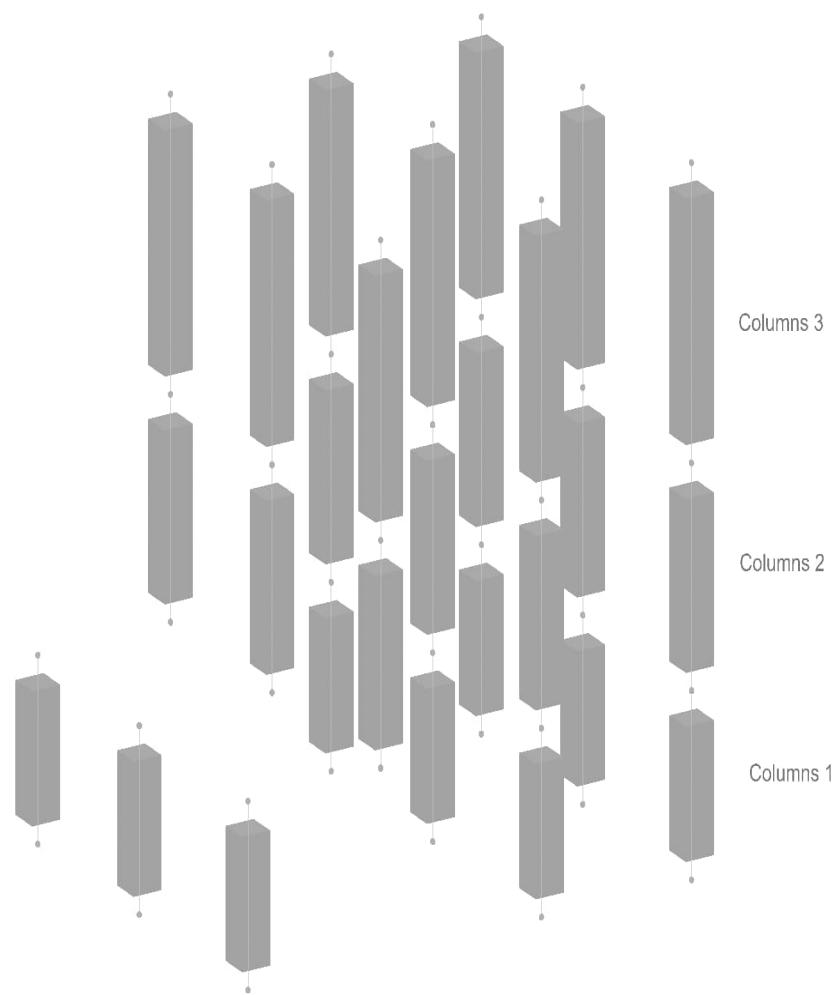
 (2)

Offset vertical direction : 0

Offset horizontal direction : 0

	Hydropower plant 1 (200 MW)	Status :	Page : 73
		Date :	Created :

View – Columns 1..3 :



	Hydropower plant 1 (200 MW)	Status :	Page : 74
		Date :	Created :

2.3.2.2 Beams 1X..3X / 1Y..3Y (∴ level of slab 3)

Usage

3D Thick Beam

Definition

From Library

☐ Rotate through 90°

Enter Properties

Cross sectional area (A)
Second moment of area about y axis (Iyy)
Second moment of area about z axis (Izz)
Product moment of area (Iyz)
Torsion constant (Jxx)
Effective shear area in y direction (Asy)
Effective shear area in z direction (Asz)
Offset in y direction (Ry)
Offset in z direction (Rz)

Value
0.4
8.33333E-3
0.0213333
0.0
0.0203752
0.333333
0.333333
0.0
0.6

Visualise...Tapering >>

Cross section...Plastic properties...

Attribute

Beam 0.8 m x 0.5 m

(8)

Offset vertical direction : 0.6 m

Offset horizontal direction : 0

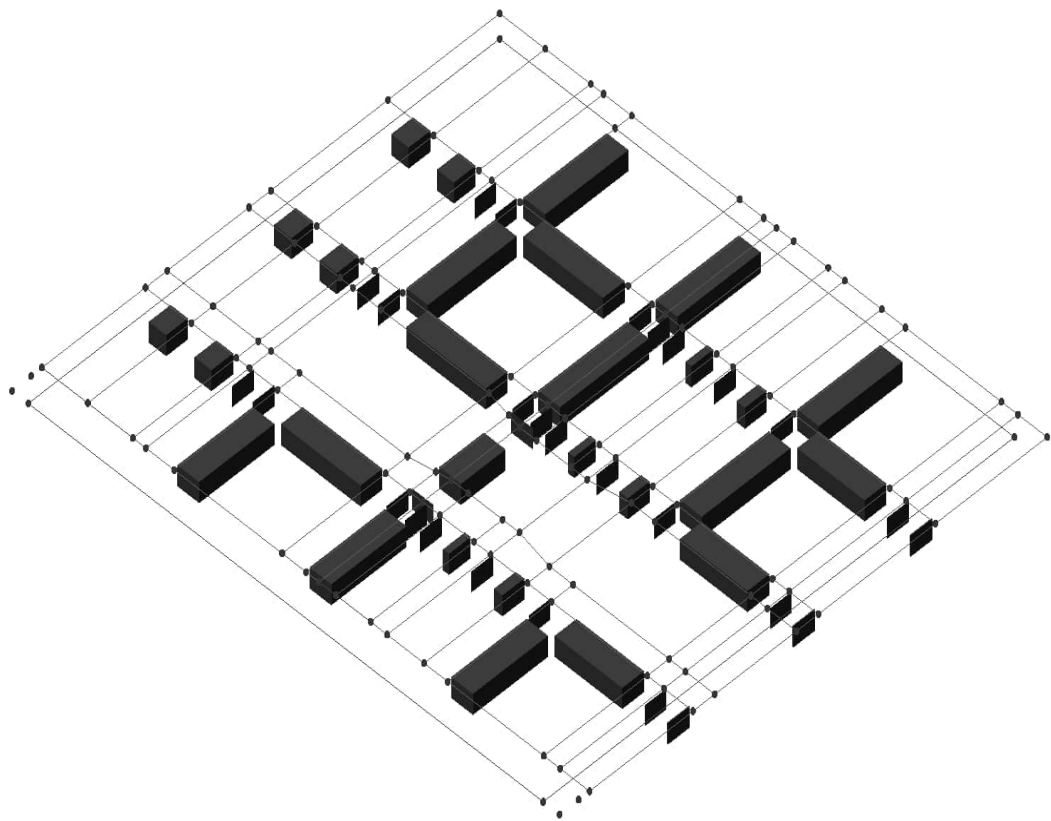
File : Hydro power plant 1

Datum : 2026-08-13

Tid : 18:39

	Hydropower plant 1 (200 MW)	Status :	Page : 75
		Date :	Created :

View – Beams 1X..3X / 1Y..3Y :



	Hydropower plant 1 (200 MW)	Status :	Page : 76
		Date :	Created :

2.4 MATERIAL

Concrete : $E_{ck} = 30 \text{ GPa}$

Material	Värde
E	$30 \cdot 10^6 \text{ kPa}$
ν	0.2 *
ρ	2400 kg/m^3

* = According to general engineering recommendation $\nu = 0$ can be applied. However in the analysis $\nu = 0.002$ is inserted.

	Hydropower plant 1 (200 MW)	Status :	Page : 77
		Date :	Created :

2.5 BOUNDARY CONDITIONS

The structure is modeled with two different boundry conditions used to describe either the foundation or the connection to the powerstation at baseline 2 .

2.5.1 Boundry at foundation : “Fixed”

		Free	Fixed	Spring stiffness	
Translation in	X	☐	☒	☐	
	Y	☐	☒	☐	
	Z	☐	☒	☐	
Rotation about	X	☐	☒	☐	
	Y	☐	☒	☐	
	Z	☐	☒	☐	
Hinge rotation		☒	☐	☐	
Pore pressure		☒	☐	☐	

Spring stiffness distribution
☒ Stiffness
☐ Stiffness/unit length
☐ Stiffness/unit area

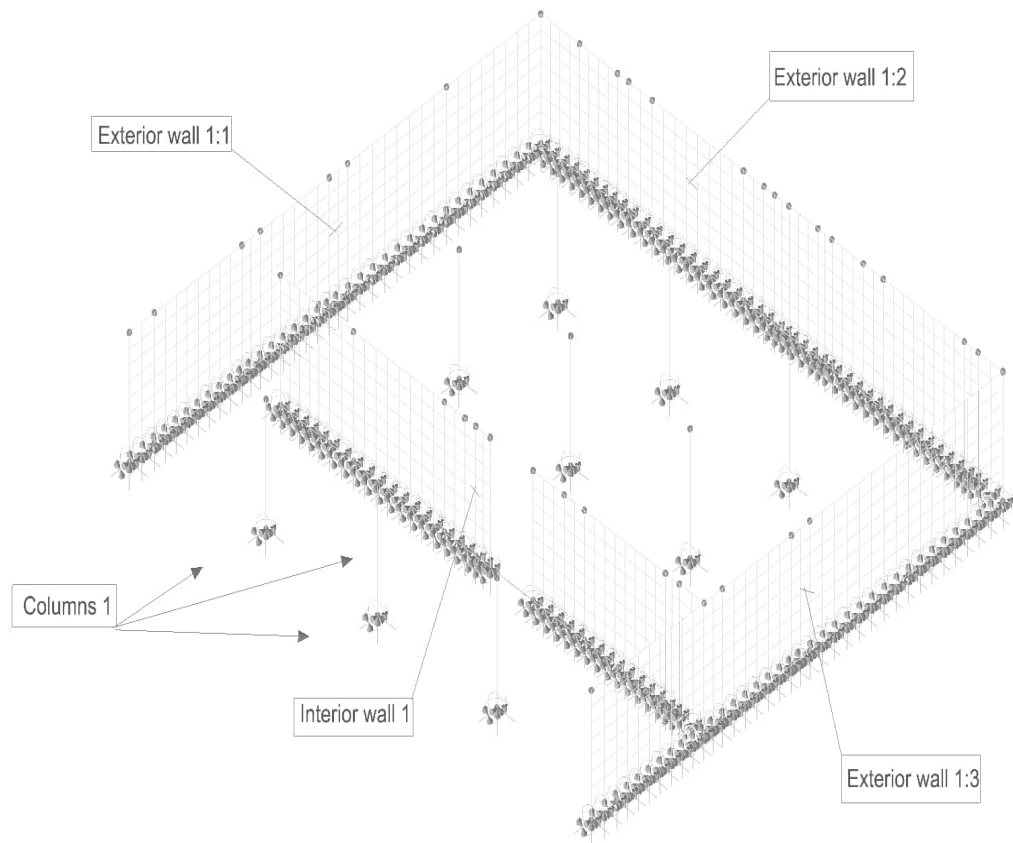
Attribute

(1)

	Hydropower plant 1 (200 MW)	Status :	Page : 78
		Date :	Created :

View – “Point: fixed”

Support Point : Fixed



Stiffness	Value
$C_{\Delta, x}$	Fixed
$C_{\Delta, y}$	Fixed
$C_{\Delta, z}$	Fixed
$C_{\varphi, x-x}$	Fixed
$C_{\varphi, y-y}$	Fixed
$C_{\varphi, z-z}$	Fixed

	Hydropower plant 1 (200 MW)	Status :	Page : 79
		Date :	Created :

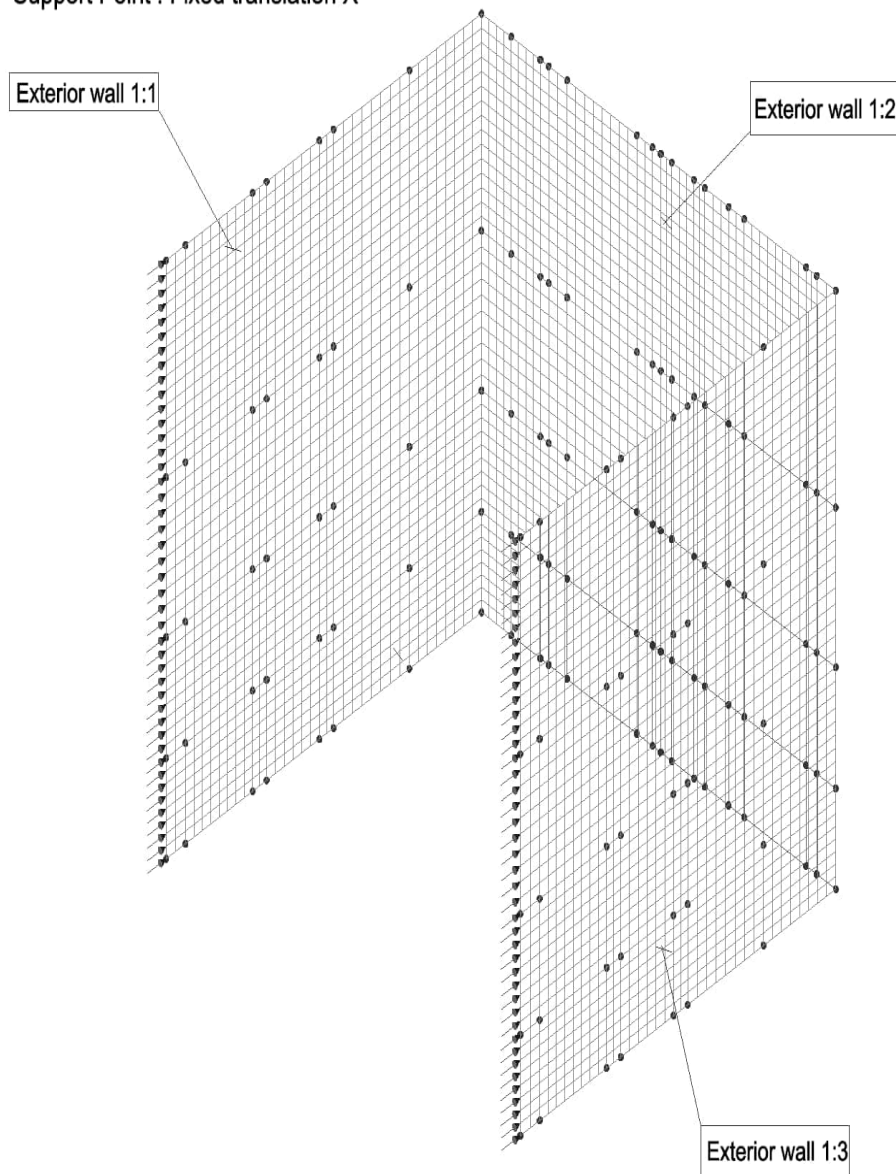
2.5.2 Boundry at baseline 2 : “Fixed in translation X”

		Free	Fixed	Spring stiffness	
Translation in	X	☐	☒	☐	
	Y	☒	☐	☐	
	Z	☒	☐	☐	
Rotation about	X	☒	☐	☐	
	Y	☒	☐	☐	
	Z	☒	☐	☐	
Hinge rotation		☒	☐	☐	
Pore pressure		☒	☐	☐	
Spring stiffness distribution					
☒ Stiffness ☐ Stiffness/unit length ☐ Stiffness/unit area					
Attribute Point : Fixed translation in X (2)					

	Hydropower plant 1 (200 MW)	Status :	Page : 80
		Date :	Created :

View – “Point: fixed in translation X”

Support Point : Fixed translation X



Stiffness	Value
$C_{\Delta, x}$	Fixed
$C_{\Delta, y}$	Free
$C_{\Delta, z}$	Free
$C_{\varphi, x-x}$	Free
$C_{\varphi, y-y}$	Free
$C_{\varphi, z-z}$	Free

	Hydropower plant 1 (200 MW)	Status :	Page : 81
		Date :	Created :

2.6 SEARCH AREA

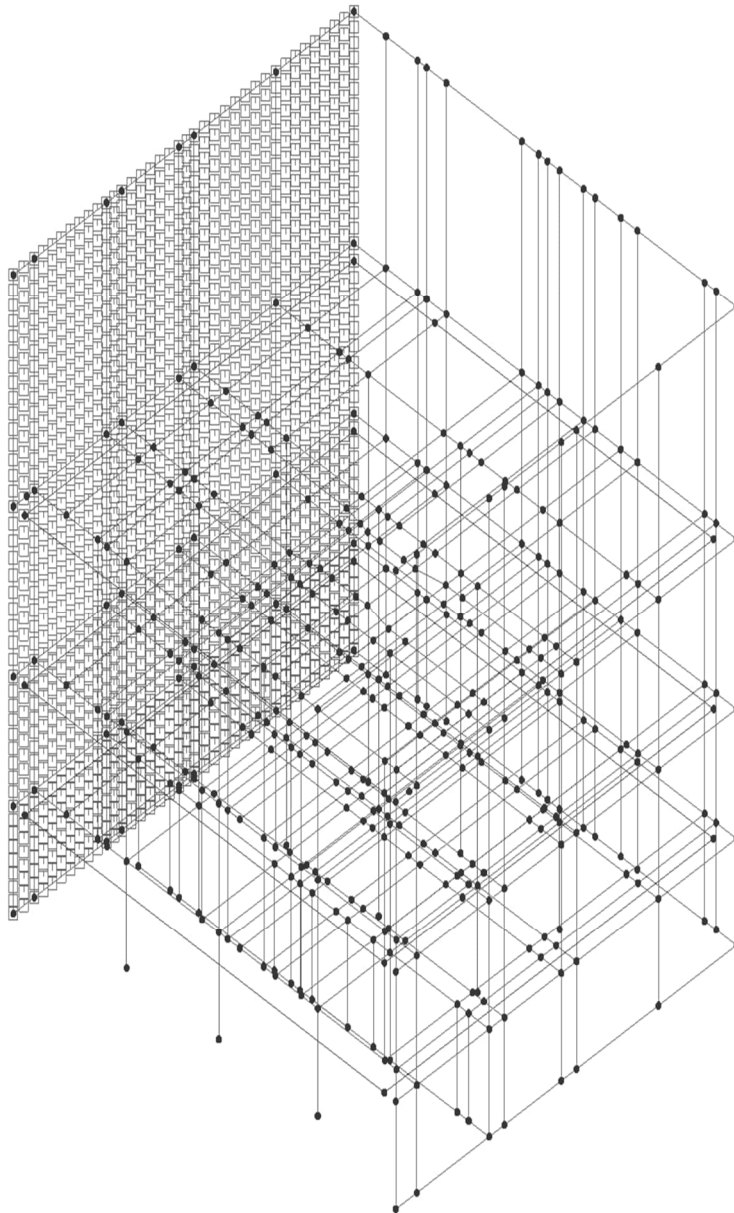
Discrete loads are applied to various load areas. These are termed *Search Area*.

For the analysis 6 *Search Area*'s are defined consisting om structural elements.

	Hydropower plant 1 (200 MW)	Status :	Page : 82
		Date :	Created :

2.6.1 Search area : Exterior wall 1

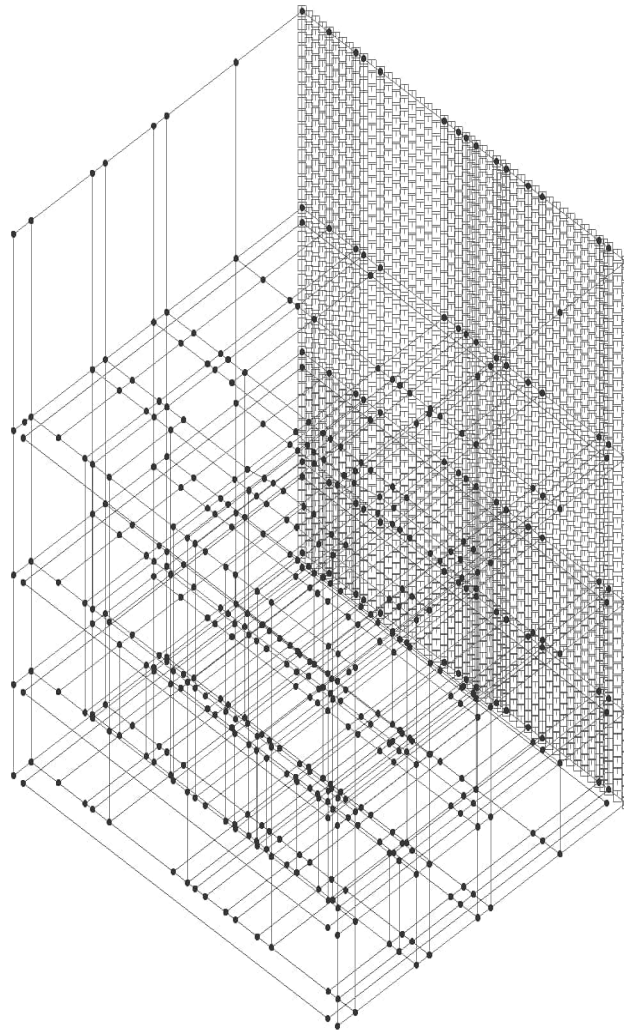
Structural elements : Exterior wall 1:1 / Exterior wall 1:2 / Exterior wall 1:3 / Exterior wall 1:4



	Hydropower plant 1 (200 MW)	Status :	Page : 83
		Date :	Created :

3.7.2 Search area : Exterior wall 2

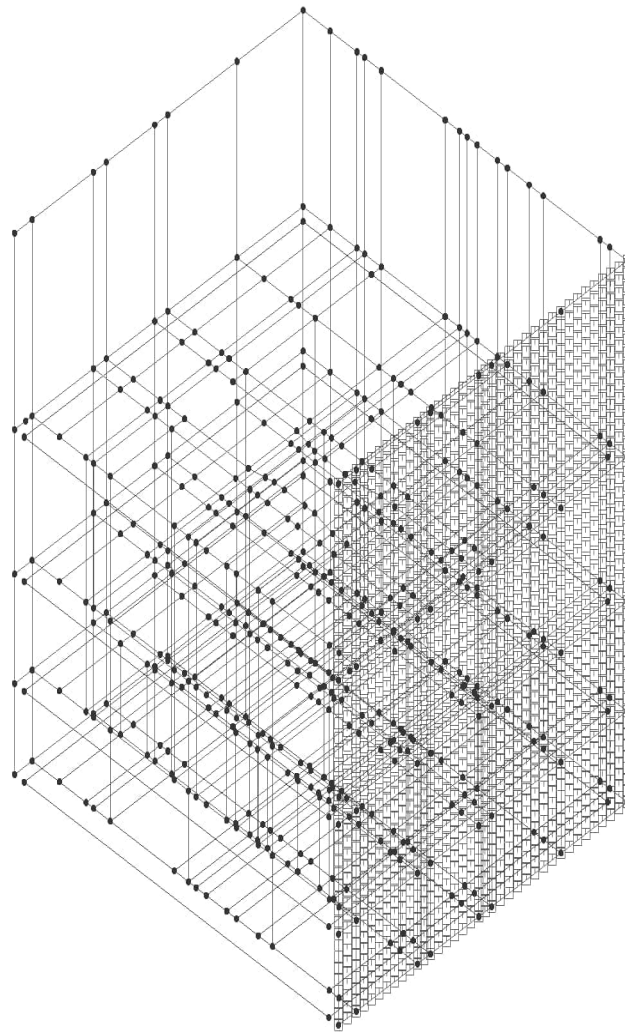
Structural elements : Exterior wall 2:1 / Exterior wall 2:2 / Exterior wall 2:3 / Exterior wall 2:4



	Hydropower plant 1 (200 MW)	Status :	Page : 84
		Date :	Created :

2.6.3 Search area : Exterior wall 3

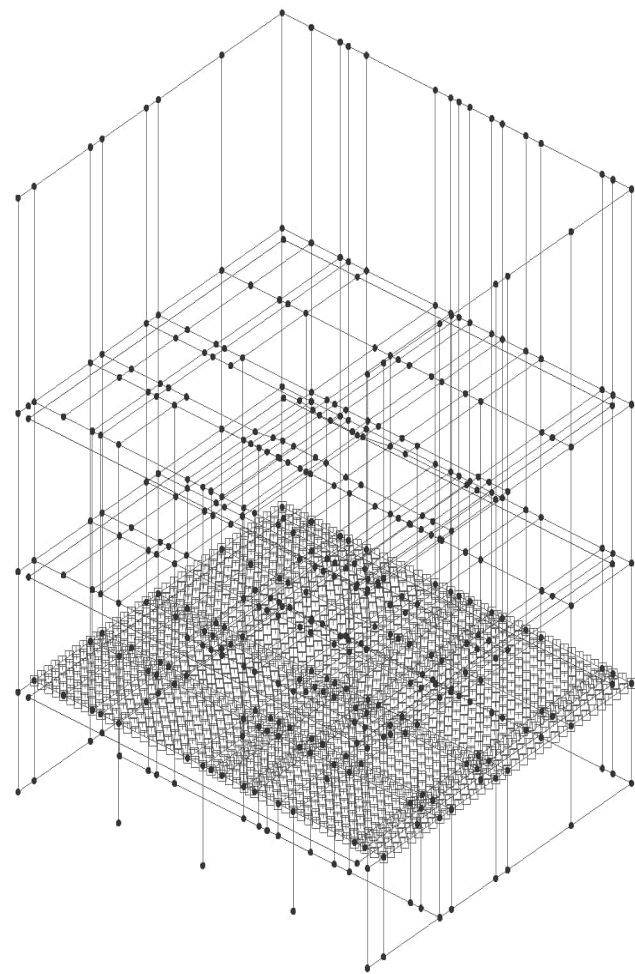
Structural elements : Exterior wall 3:1 / Exterior wall 3:2 / Exterior wall 3:3 / Exterior wall 3:4



	Hydropower plant 1 (200 MW)	Status :	Page : 85
		Date :	Created :

2.6.4 Search area : Slab level +56.65

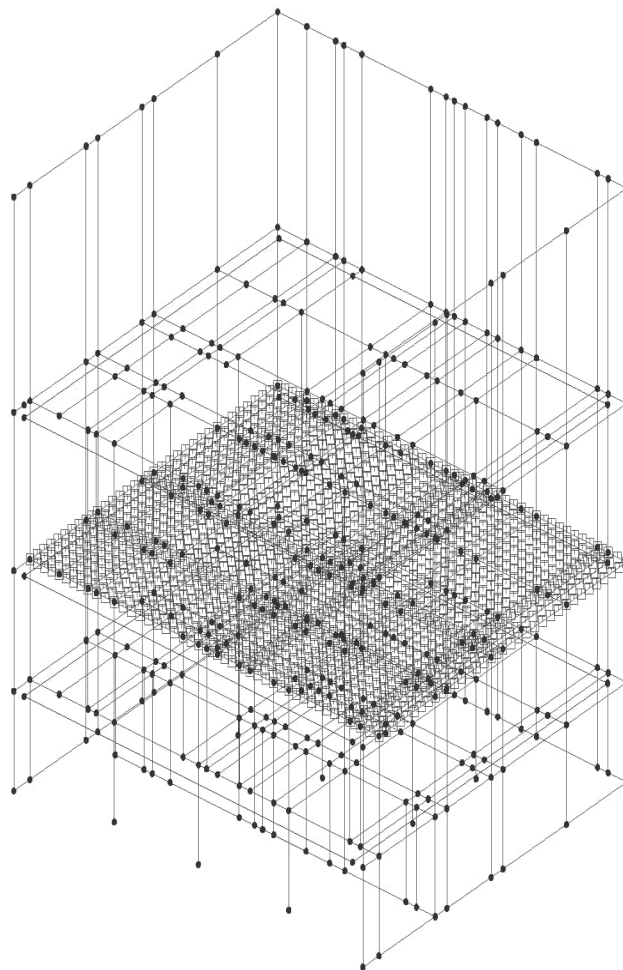
Structural elements : Slab 1



	Hydropower plant 1 (200 MW)	Status :	Page : 86
		Date :	Created :

3.7.5 Search area : Slab level +61.05

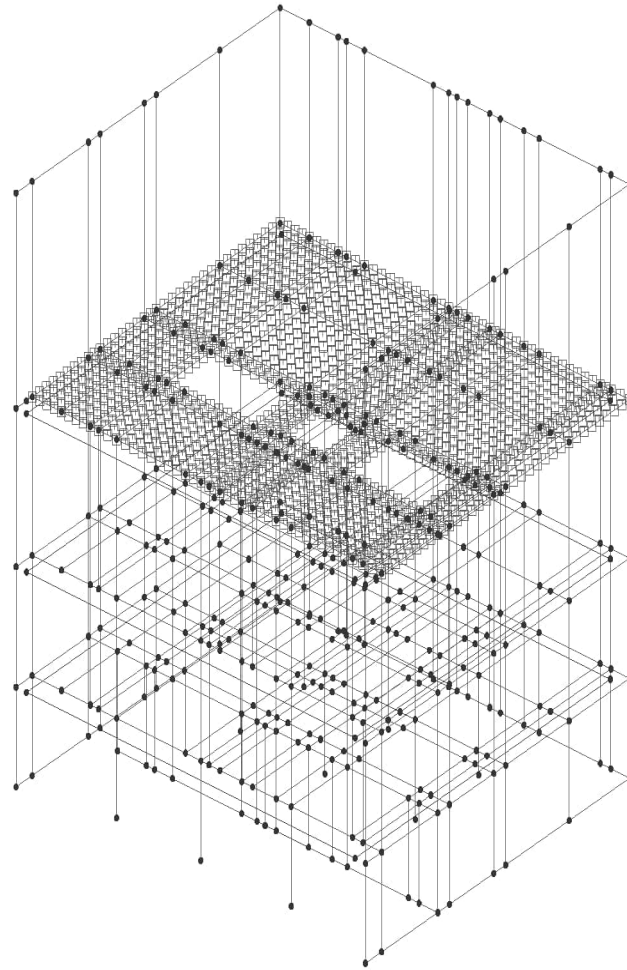
Search area consists of surfaces : Slab 2



	Hydropower plant 1 (200 MW)	Status :	Page : 87
		Date :	Created :

2.6.6 Search area : Slab level +66.85

Search area consists of surfaces : Slab 3



-

	Hydropower plant 1 (200 MW)	Status :	Page : 88
		Date :	Created :

3. LOADS

3.1	DEAD WEIGHT	page 88-97
3.2	WATERLOAD	page 98-113
3.3	EARTH PRESSURE	page 114-124
3.5	SURCHARGE	page 125-132
3.4	LIVE SURFACE LOAD	page 133-137
3.6	CRANE LOAD	page 138-143
3.7	MACHINE LOAD	page 144-164
3.8	WIND LOAD	page 165
3.9	EARTHQUAKE LOAD	page 166-169
3.10	LOADCOMBINATIONS	page 170-174

	Hydropower plant 1 (200 MW)	Status :	Page : 89
		Date :	Created :

3.1 DEAD WEIGHT

3.1.1 Reinforced concrete

$\gamma_{btg} = 24 \frac{kN}{m^3}$

Loadcase : Dead weight 1

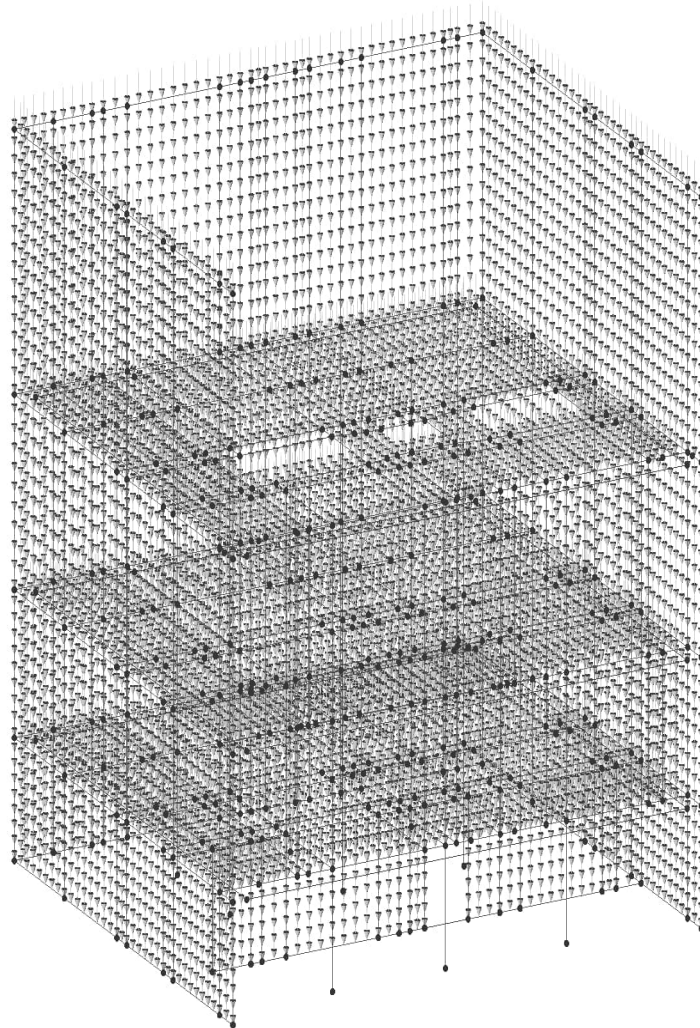
Structural loading : Body force

Acceleration in z direction (a_z) : $-10 \frac{m}{s^2}$

Component	Value
Linear acceleration in X	0.0
Linear acceleration in Y	0.0
Linear acceleration in Z	-10.0
Angular velocity about X axis	0.0
Angular velocity about Y axis	0.0
Angular velocity about Z axis	0.0
Angular acceleration about X axis	0.0
Angular acceleration about Y axis	0.0
Angular acceleration about Z axis	0.0

Attribute (1)

	Hydropower plant 1 (200 MW)	Status :	Page : 90
		Date :	Created :



Shell elements : $q = a_z \cdot t \cdot \rho_{btg}$

Beam elements : $p = a_z \cdot A \cdot \rho_{btg}$

Remark Load intensity is found by applying density and geometric properties to all LINES/SURFACES.

	Hydropower plant 1 (200 MW)	Status :	Page : 91
		Date :	Created :

3.1.2 Steel structure

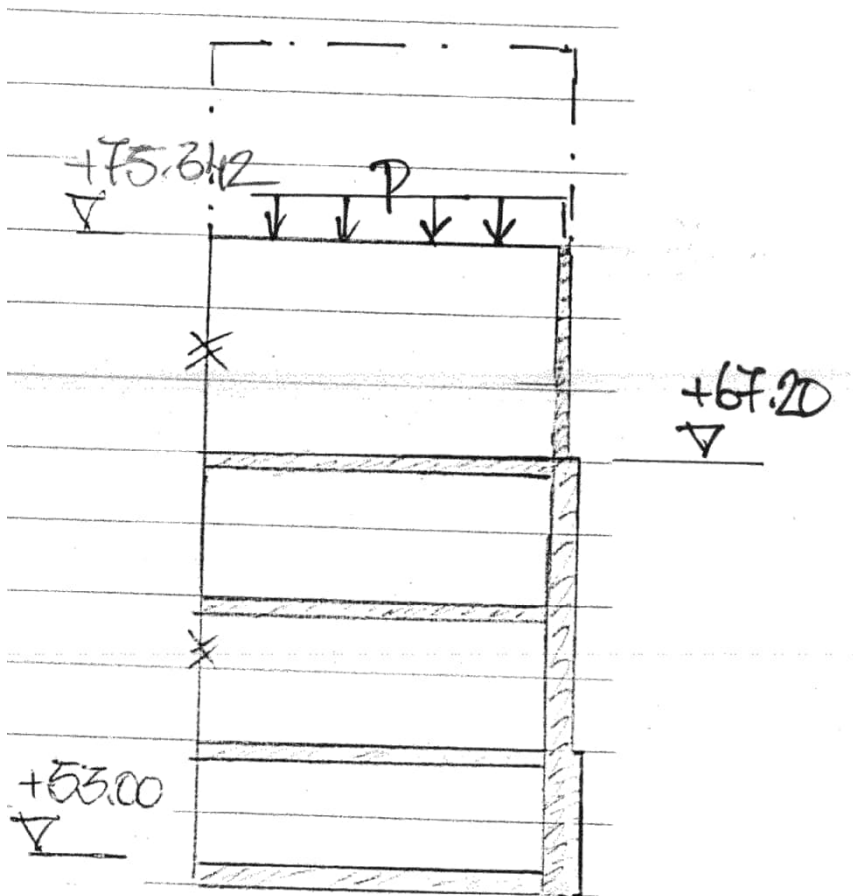
The load is an approximation of the steel structure above level +75.342.

The load intensity is set to 1 kPa and distributed along concrete walls I X-direction.

$$A = b \cdot l = 18.7m \cdot 21.7m = 406m^2$$

$$P_{tot} = A \cdot 1kPa = 406kN$$

$$p = \frac{P_{tot}}{2l'} = \frac{406kN}{2 \cdot 17.9m} = 11.3 \frac{kN}{m}$$



	Hydropower plant 1 (200 MW)	Status :	Page : 92
		Date :	Created :

Loadcase : Dead weight 2

Structural loading : Global distributed

Force type : Per unit length

Component z direction : $-11.3 \frac{kN}{m}$

☐ Total

☒ Per unit length

☐ Per unit area

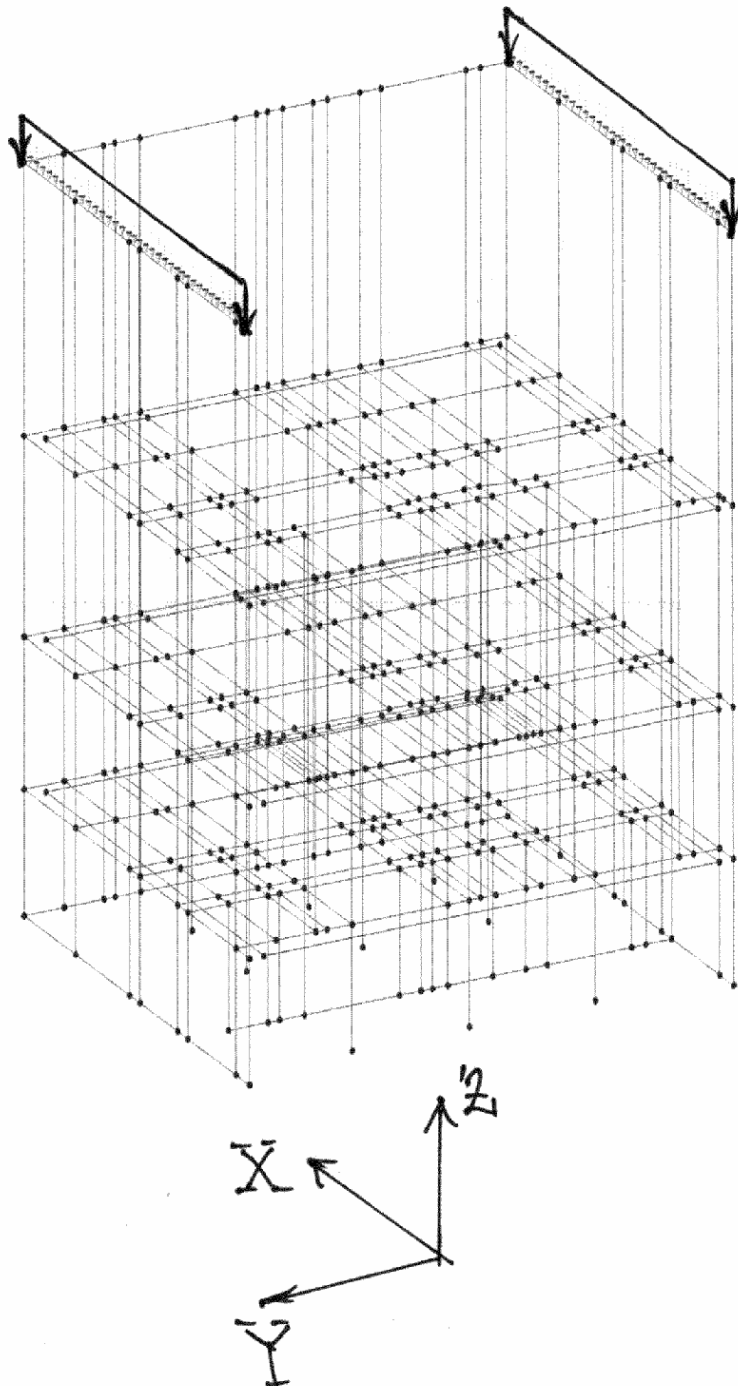
Component	Value
X Direction	0.0
Y Direction	0.0
Z Direction	-11.3
Moment about X axis	0.0
Moment about Y axis	0.0
Moment about Z axis	0.0
Moment about hinge nodes	0.0

Attribute

Dead weight 2

 (2)

	Hydropower plant 1 (200 MW)	Status :	Page : 93
		Date :	Created :



	Hydropower plant 1 (200 MW)	Status :	Page : 94
		Date :	Created :

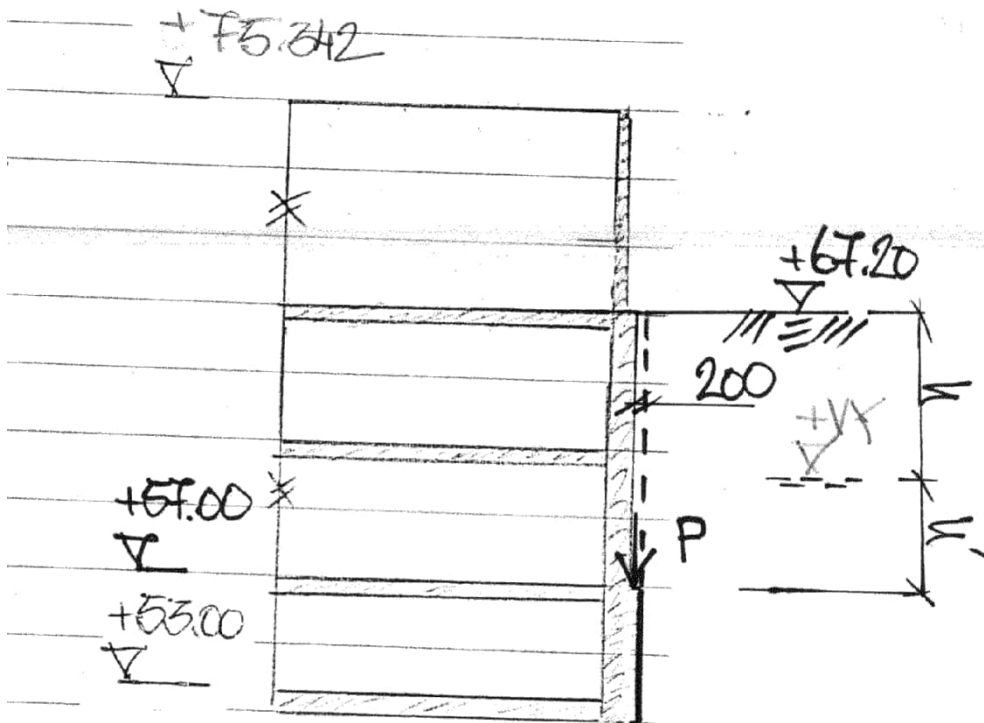
3.1.3 Earth filling

Load is introduced at level +57.00 due to an increase of wall thickness by 200 mm.

The load is comparatively low. For this reason the load is modelled with intensity of water level LLW. The effect of water level HHW is considered using a reduced load coefficient.

$$\text{LLW} = +53.53 \quad \Rightarrow h = (67.20 - 57.00) = 10.20 \text{ m} \quad ; h' = 0 \text{ m}$$

$$\text{HHW} = +62.94 \quad \Rightarrow h = (67.20 - 62.94) = 4.26 \text{ m} \quad ; h' = 10.20 - 4.26 = 5.94 \text{ m}$$



$$p_{LLW} = 0.2m \cdot (\gamma \cdot h + \gamma' \cdot h') = 0.2m \cdot \left(18 \frac{kN}{m^3} \cdot 10.20m + 11 \frac{kN}{m^3} \cdot 0m\right) = 37 \frac{kN}{m}$$

$$p_{HHW} = 0.2m \cdot (\gamma \cdot h + \gamma' \cdot h') = 0.2m \cdot \left(18 \frac{kN}{m^3} \cdot 4.26m + 11 \frac{kN}{m^3} \cdot 5.94m\right) = 28 \frac{kN}{m}$$

$$\Rightarrow \frac{q_{HHE}}{q_{LLW}} = 0.76$$

Remark The effect of water at top is neglected since is balanced with same force at bottom of slab +53.00 when designing the studied structure.

	Hydropower plant 1 (200 MW)	Status :	Page : 95
		Date :	Created :

Loadcase : Dead weight 3

Structural loading : Global distributed

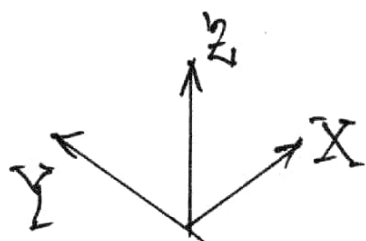
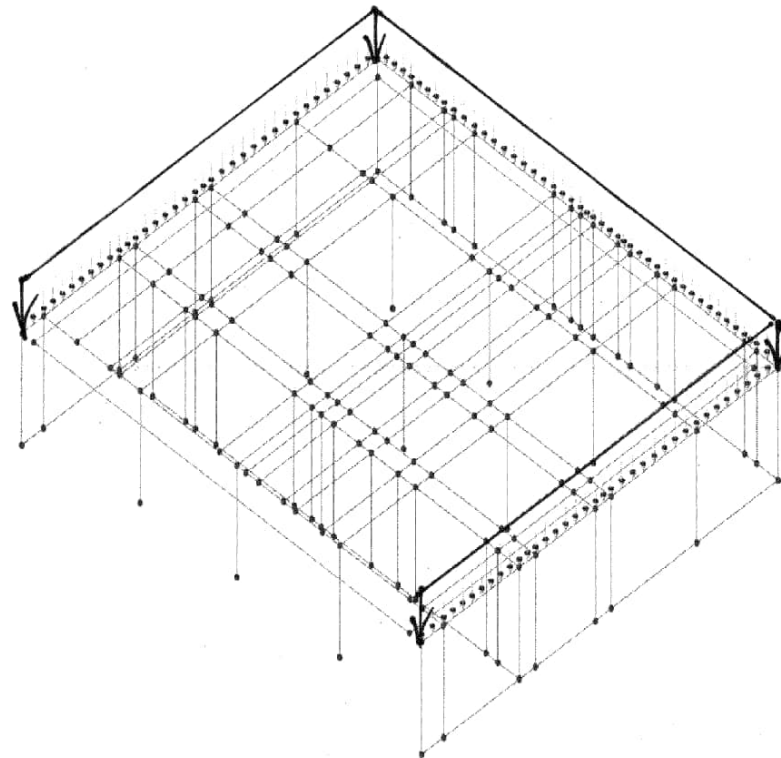
Force type : Per unit length

Component z direction : $-37 \frac{kN}{m}$

☐ Total ☒ Per unit length ☐ Per unit area	
Component	Value
X Direction	0.0
Y Direction	0.0
Z Direction	-37.0
Moment about X axis	0.0
Moment about Y axis	0.0
Moment about Z axis	0.0
Moment about hinge nodes	0.0

Attribute (58)

	Hydropower plant 1 (200 MW)	Status :	Page : 96
		Date :	Created :



	Hydropower plant 1 (200 MW)	Status :	Page : 97
		Date :	Created :

3.1.4 Load combinations

Load combination smart : *Dead weight*

Loadcase	Permanent factor	Variable factor
Dead weight 1	1.00	0
Dead weight 2	1.00	0
Dead weight 3	0.76	0.24

	Hydropower plant 1 (200 MW)	Status :	Page : 98
		Date :	Created :

3.2 WATER LOAD

Waterflow varies between +53.63 to +62.94(+64.50) as seen in table listed bellow.

Level	Flow	Remark
+62.94	8110	10000 year
+61.62	5859	1000 year
+55.10	240	Design flow*
+53.63	13.4	Ecological flow
m	m ³ /s	-

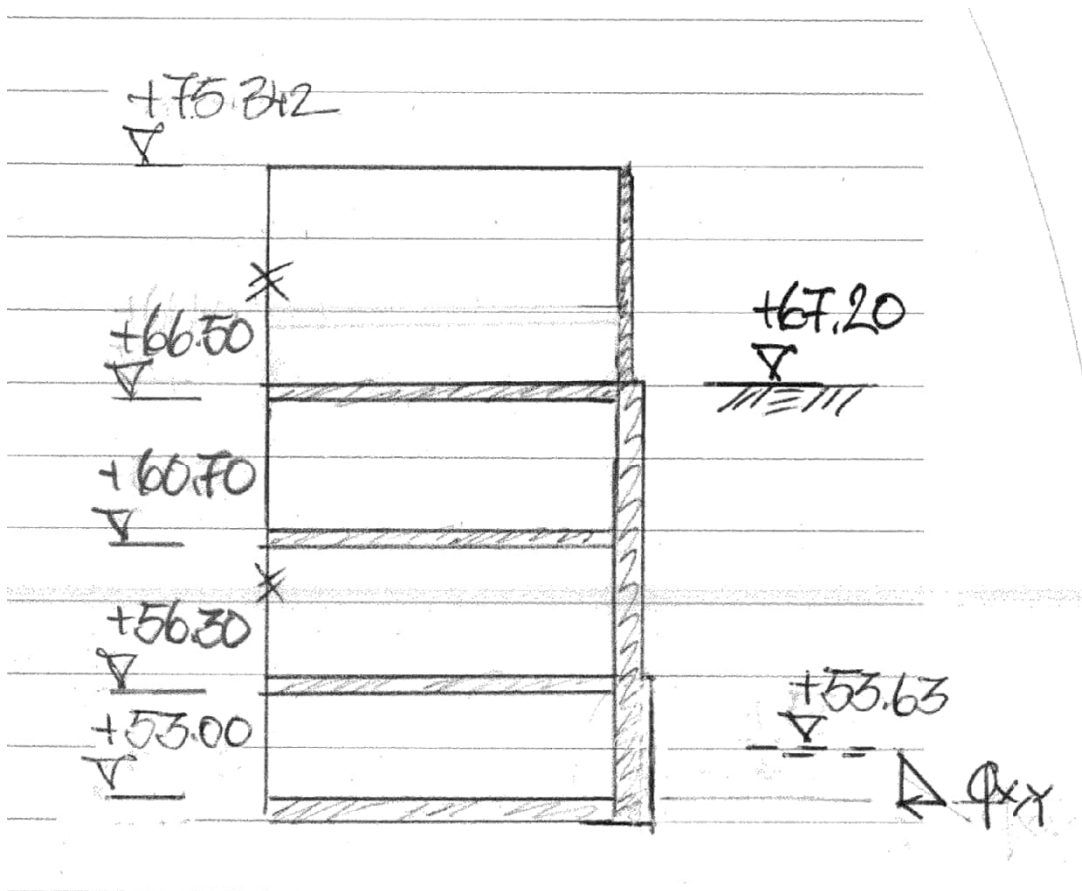
* = Corresponds to 100 year flow

	Hydropower plant 1 (200 MW)	Status :	Page : 99
		Date :	Created :

3.2.1 “Low” water level

Level +53.63 corresponding to ecological flow is used.

$$q_{x,y} = (53.63m - 53.00m) \cdot 1.0 \cdot 10 \frac{kN}{m^3} = 6.3kPa$$



	Hydropower plant 1 (200 MW)	Status :	Page : 100
		Date :	Created :

Loadcase : Water LLW qx1

Structural loading : Discrete patch load

Search area : Exterior wall 2

Force type : Per unit area

Component x direction : -6.3 kPa

Options for load outside search area : Exclude All Load

Patch type

☐ 8 node patch
☒ 4 node patch
☐ Straight line
☐ Curve

Untransformed load direction

☒ X
☐ Z

☐ Y
☐ Surface normal

Projection vector

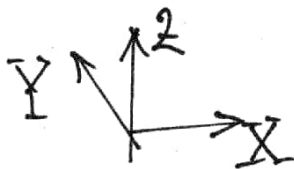
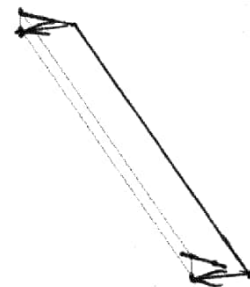
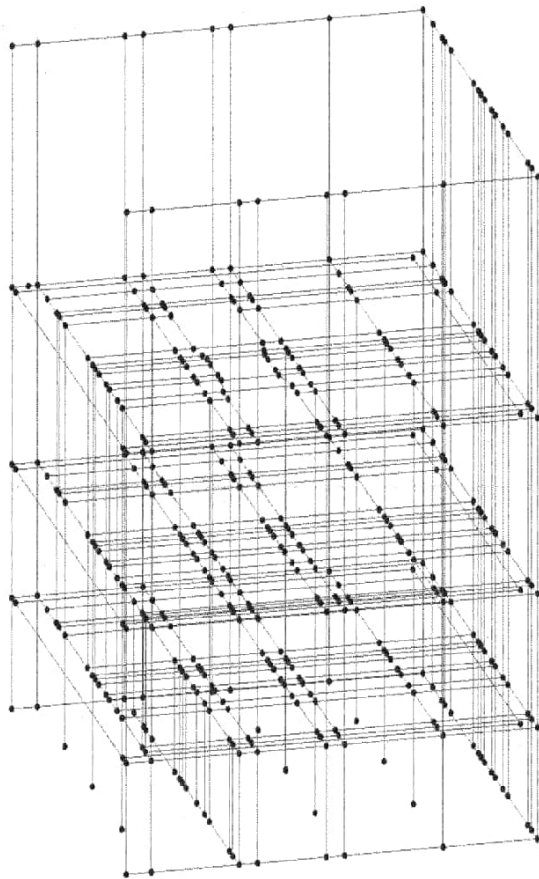
☐ Project in load direction

X component
Y component
Z component

	X Coordinate	Y Coordinate	Z Coordinate	Load
1	31.0	-15.0	53.63	0.0
2	31.0	-15.0	53.0	-6.3
3	31.0	15.0	53.0	-6.3
4	31.0	15.0	53.63	0.0

Attribute
(5)

	Hydropower plant 1 (200 MW)	Status :	Page : 101
		Date :	Created :



	Hydropower plant 1 (200 MW)	Status :	Page : 102
		Date :	Created :

Loadcase : Water LLW qy1

Structural loading : Discrete patch load

Search area : Exterior wall 1

Force type : Per unit area

Component y direction : -6.3 kPa

Patch type

☐ 8 node patch
☒ 4 node patch
☐ Straight line
☐ Curve

Untransformed load direction

☐ X
☐ Z
☒ Y
☐ Surface normal

Projection vector

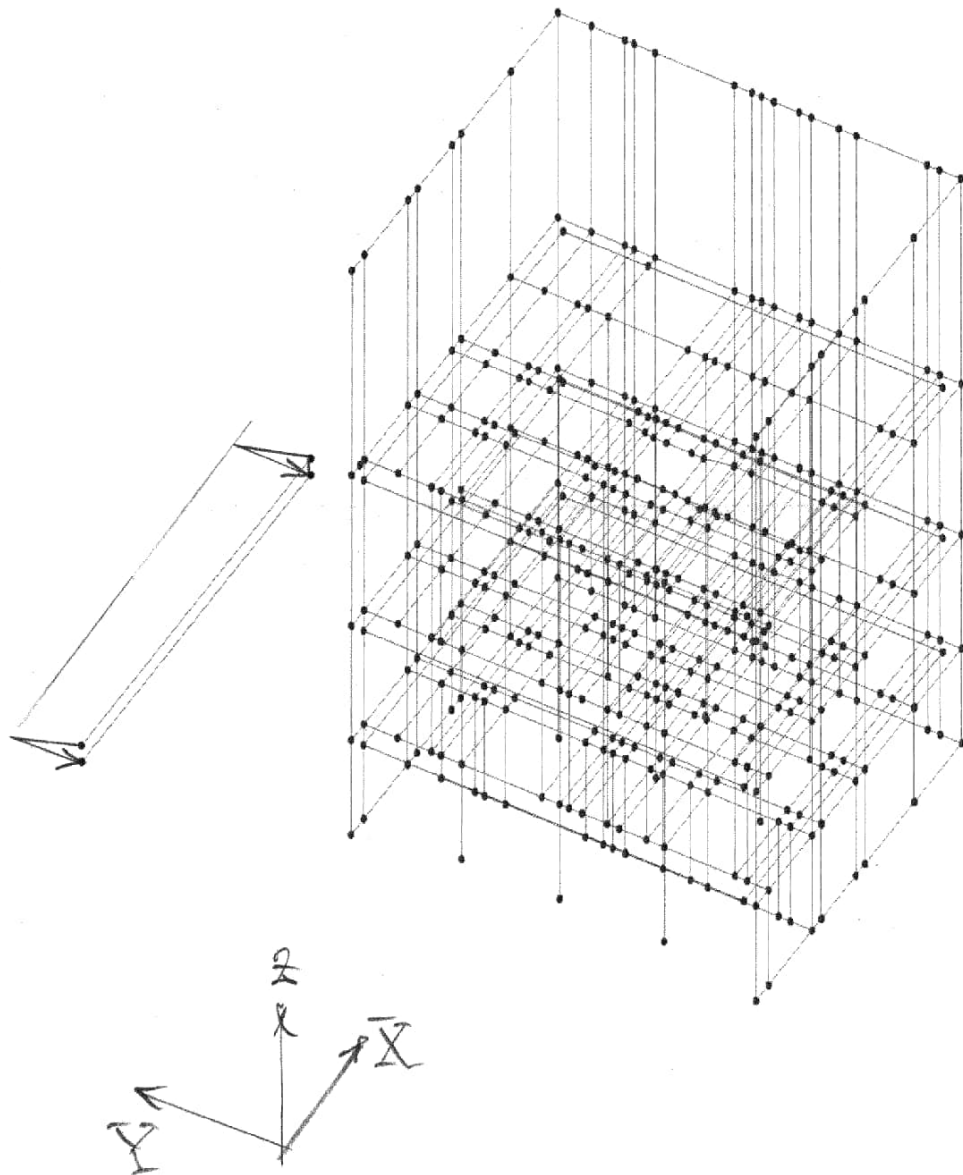
☐ Project in load direction

X component
Y component
Z component

	X Coordinate	Y Coordinate	Z Coordinate	Load
1	-2.0	21.0	53.63	0.0
2	18.0	21.0	53.63	0.0
3	18.0	21.0	53.0	-6.3
4	-2.0	21.0	53.0	-6.3

Attribute (6)

	Hydropower plant 1 (200 MW)	Status :	Page : 103
		Date :	Created :



	Hydropower plant 1 (200 MW)	Status :	Page : 104
		Date :	Created :

Loadcase : Water LLW qy2

Structural loading : Discrete patch load

Search area : Exterior wall 3

Force type : Per unit area

Component y direction : +6.3 kPa

Options for load outside search area : Exclude All Load

Patch type

☐ 8 node patch

☒ 4 node patch

☐ Straight line

☐ Curve

Untransformed load direction

☐ X

☐ Z

☒ Y

☐ Surface normal

Projection vector

☐ Project in load direction

X component

Y component

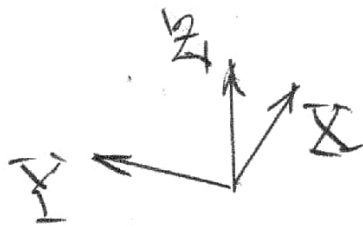
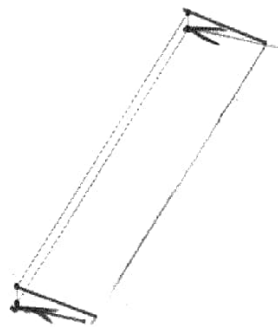
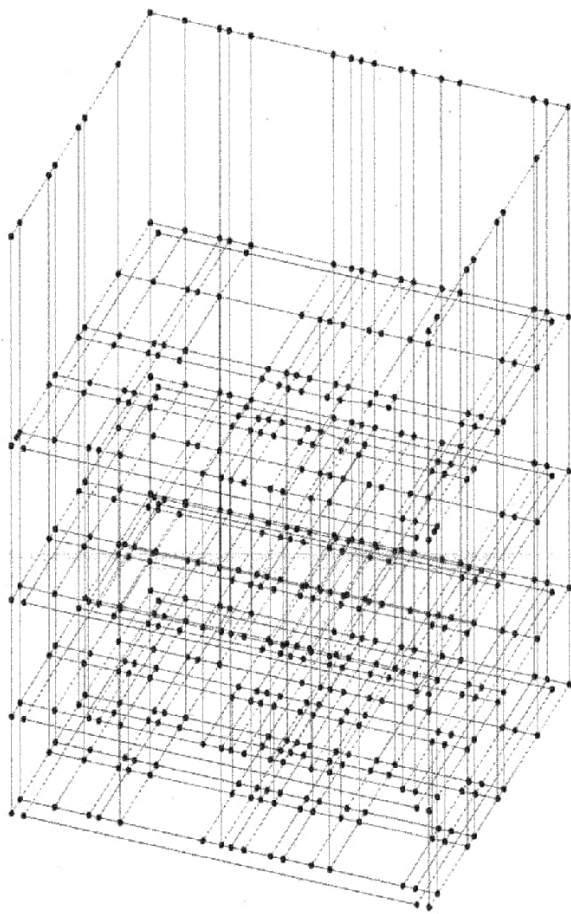
Z component

Attribute

Water LLW' qy2

(3)

	Hydropower plant 1 (200 MW)	Status :	Page : 105
		Date :	Created :

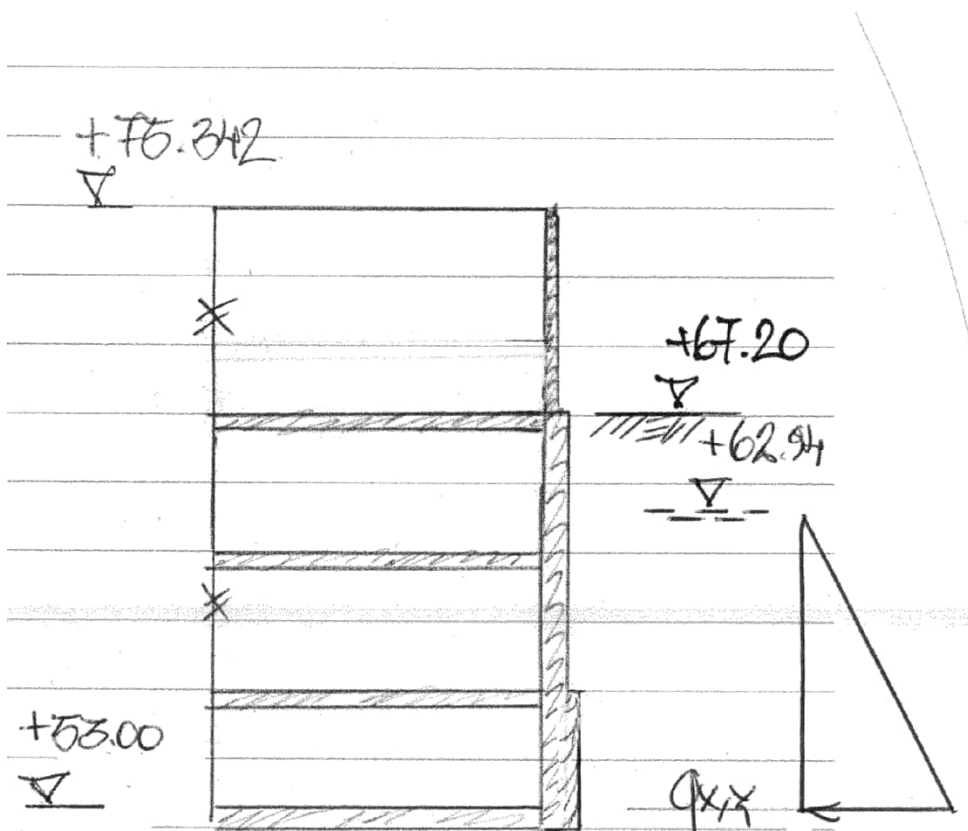


	Hydropower plant 1 (200 MW)	Status :	Page : 106
		Date :	Created :

3.2.2 “High” water level

Level +62.94 corresponding to 10000 year flow is used.

$$q_{x,y} = (62.94m - 53.00m) \cdot 1.0 \cdot 10 \frac{kN}{m^3} = 99.4kPa$$



	Hydropower plant 1 (200 MW)	Status :	Page : 107
		Date :	Created :

Loadcase : Water HHW qx1

Structural loading : Discrete patch load

Search area : Exterior wall 2

Force type : Per unit area

Component x direction : -99.4 kPa

Options for load outside search area : Exclude All Load

Patch type

☐ 8 node patch

☒ 4 node patch

☐ Straight line

☐ Curve

Untransformed load direction

☒ X

☐ Z

☐ Y

☐ Surface normal

Projection vector

☐ Project in load direction

X component

0.0

Y component

0.0

Z component

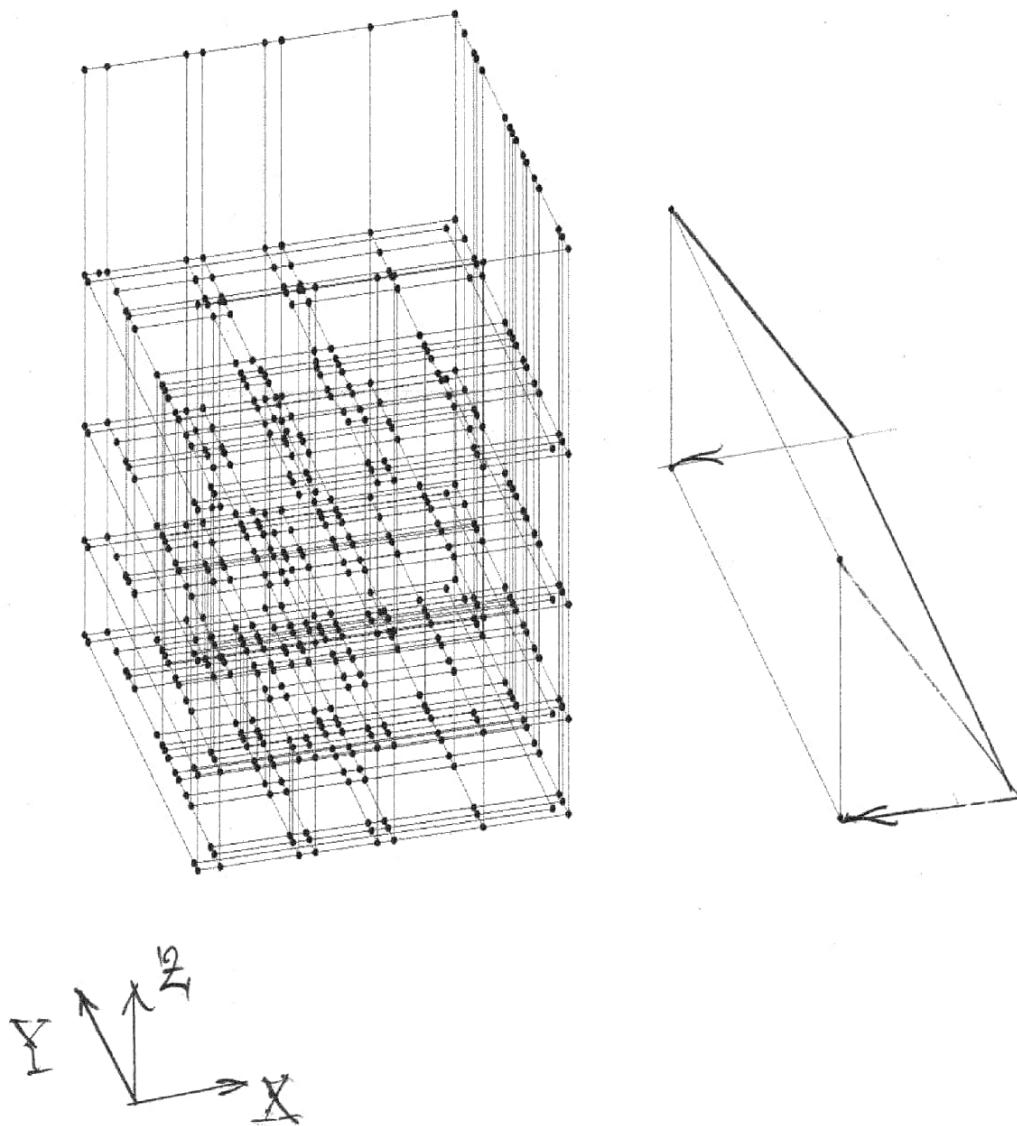
1.0

Attribute

Water HHW qx1

(4)

	Hydropower plant 1 (200 MW)	Status :	Page : 108
		Date :	Created :



	Hydropower plant 1 (200 MW)	Status :	Page : 109
		Date :	Created :

Loadcase : Water HHW.qy1

Structural loading : Discrete patch load

Search area : Exterior wall 1

Force type : Per unit area

Component y direction : -99.4 kPa

Options for load outside search area : Exclude All Load

Patch type

☐ 8 node patch
☒ 4 node patch
☐ Straight line
☐ Curve

Untransformed load direction

☐ X
☐ Z

☒ Y
☐ Surface normal

Projection vector
☐ Project in load direction

X component

Y component

Z component

0.0

0.0

1.0

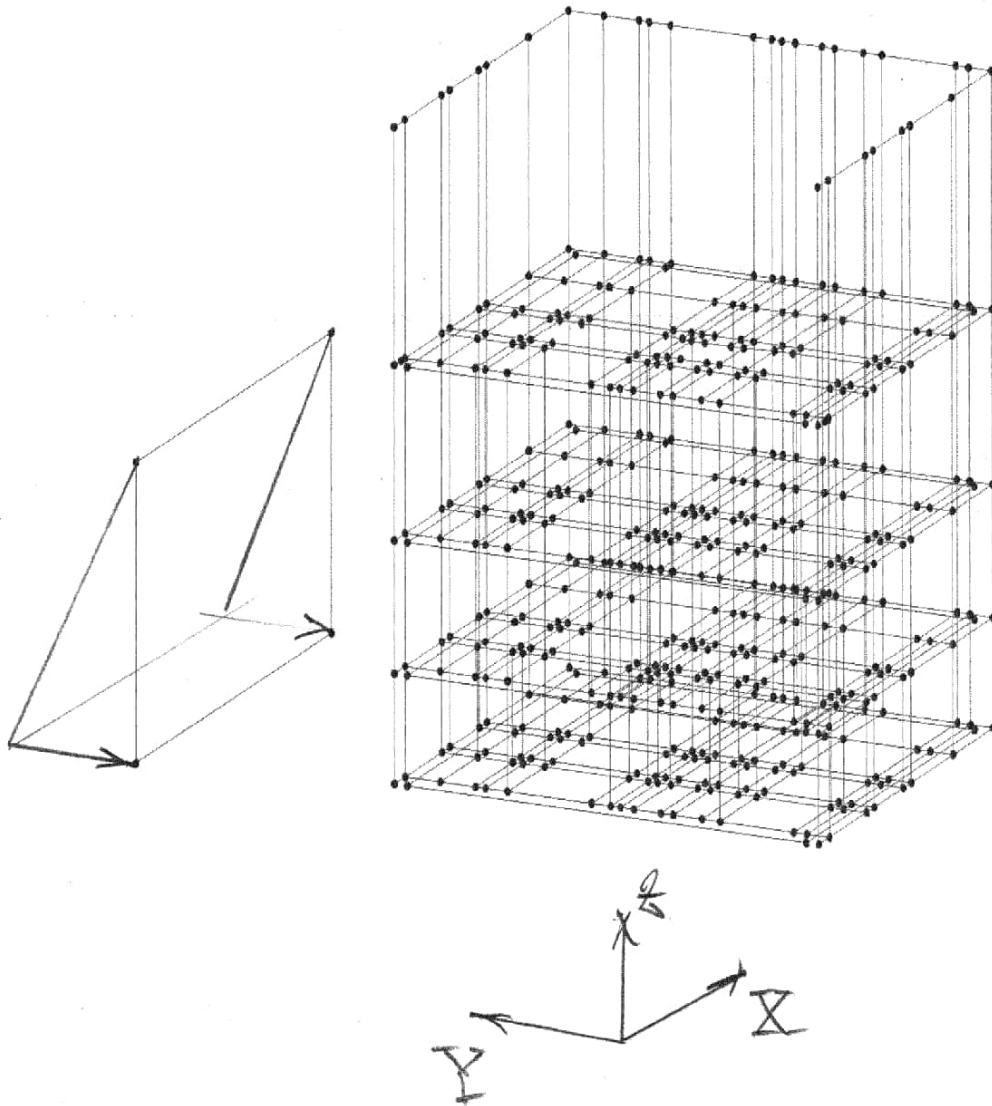
	X Coordinate	Y Coordinate	Z Coordinate	Load
1	-2.0	20.0	53.0	-99.4
2	18.0	20.0	53.0	-99.4
3	18.0	20.0	62.94	0.0
4	-2.0	20.0	62.94	0.0

Attribute

Water HHW.qy1

(7)

	Hydropower plant 1 (200 MW)	Status :	Page : 110
		Date :	Created :



	Hydropower plant 1 (200 MW)	Status :	Page : 111
		Date :	Created :

Loadcase : Water HHW.qy2

Structural loading : Discrete patch load

Search area : Exterior wall 3

Force type : Per unit area

Component y direction : +99.4 kPa

Options for load outside search area : Exclude All Load

Patch type

☐ 8 node patch

☒ 4 node patch

☐ Straight line

☐ Curve

Untransformed load direction

☐ X

☐ Z

☒ Y

☐ Surface normal

Projection vector

☐ Project in load direction

X component

0.0

Y component

0.0

Z component

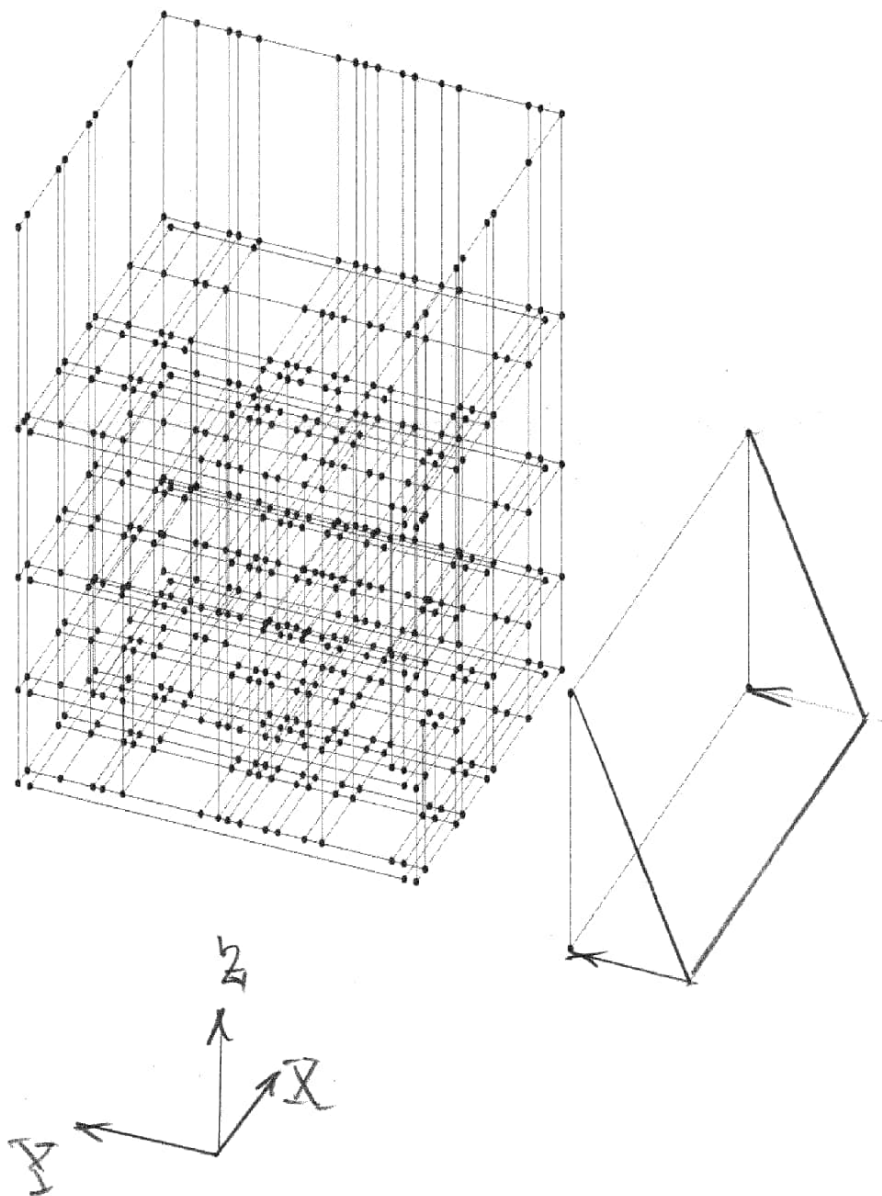
1.0

Attribute

Water HHW.qy2

(8)

	Hydropower plant 1 (200 MW)	Status :	Page : 112
		Date :	Created :



	Hydropower plant 1 (200 MW)	Status :	Page : 113
		Date :	Created :

3.2.3 Load combinations

Loadcombination basic : Water LLW

Loadcase	Factor
<i>Water LLW qx1</i>	1.00
<i>Water LLW qy1</i>	1.00
<i>Water LLW qy2</i>	1.00

Loadcombination basic : Water HHW

Loadcase	Factor
<i>Water HHW qx1</i>	1.00
<i>Water HHW qy1</i>	1.00
<i>Water HHW qy2</i>	1.00

	Hydropower plant 1 (200 MW)	Status :	Page : 114
		Date :	Created :

3.3 EARTH PRESSURE

Earth properties listed bellow are used in the design.

$$K_0 = \sin 40^\circ = 0.38$$

$$\gamma = 18 \frac{kN}{m^3}$$

$$\gamma' = 11 \frac{kN}{m^3}$$

Water level varies between LLW=+53.53 and HHW=+62.94. Both levels are studied.

$$q_{x,y}^{unreduced} = K_0 \cdot h \cdot \gamma \quad : \text{unreduced earth pressure}$$

$$q_{x,y}^{reduction} = K_0 \cdot h_w \cdot (\gamma - \gamma') : \text{reduction due to reduced density beneath water}$$

$$q_{x,y} = q_{x,y}^{unreduced} - q_{x,y}^{reduction} : \text{reduced earth pressure}$$



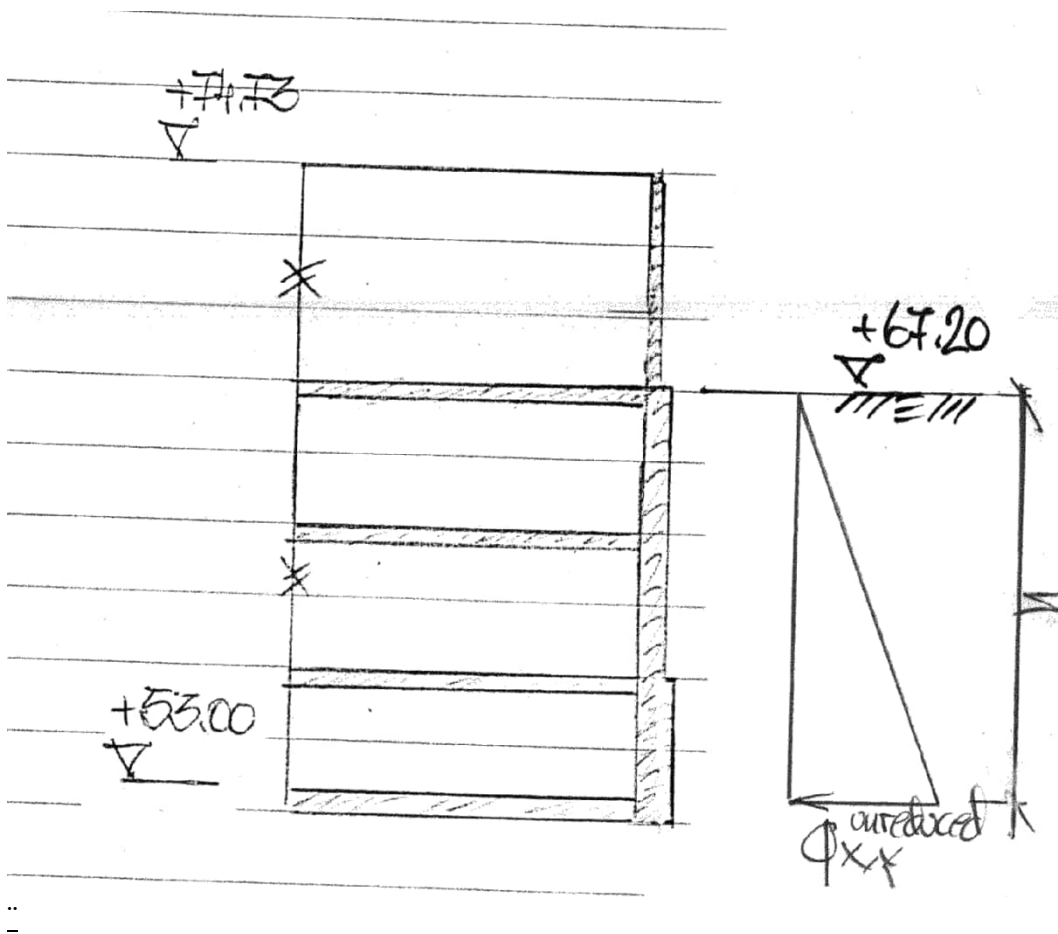
	Hydropower plant 1 (200 MW)	Status :	Page : 115
		Date :	Created :

3.3.1 Earth pressure unreduced

Unreduced earth pressure bellow assumes a water level below +53.00.

$$h = 67.20 - 53.00 = 14.20m$$

$$q_{x,y}^{unreduced} = 0.38 \cdot 14.2m \cdot 18 \frac{kN}{m^3} = 97kPa$$



	Hydropower plant 1 (200 MW)	Status :	Page : 116
		Date :	Created :

Loadcase : Earth pressure unreduced qx1

Structural loading : Discrete patch load

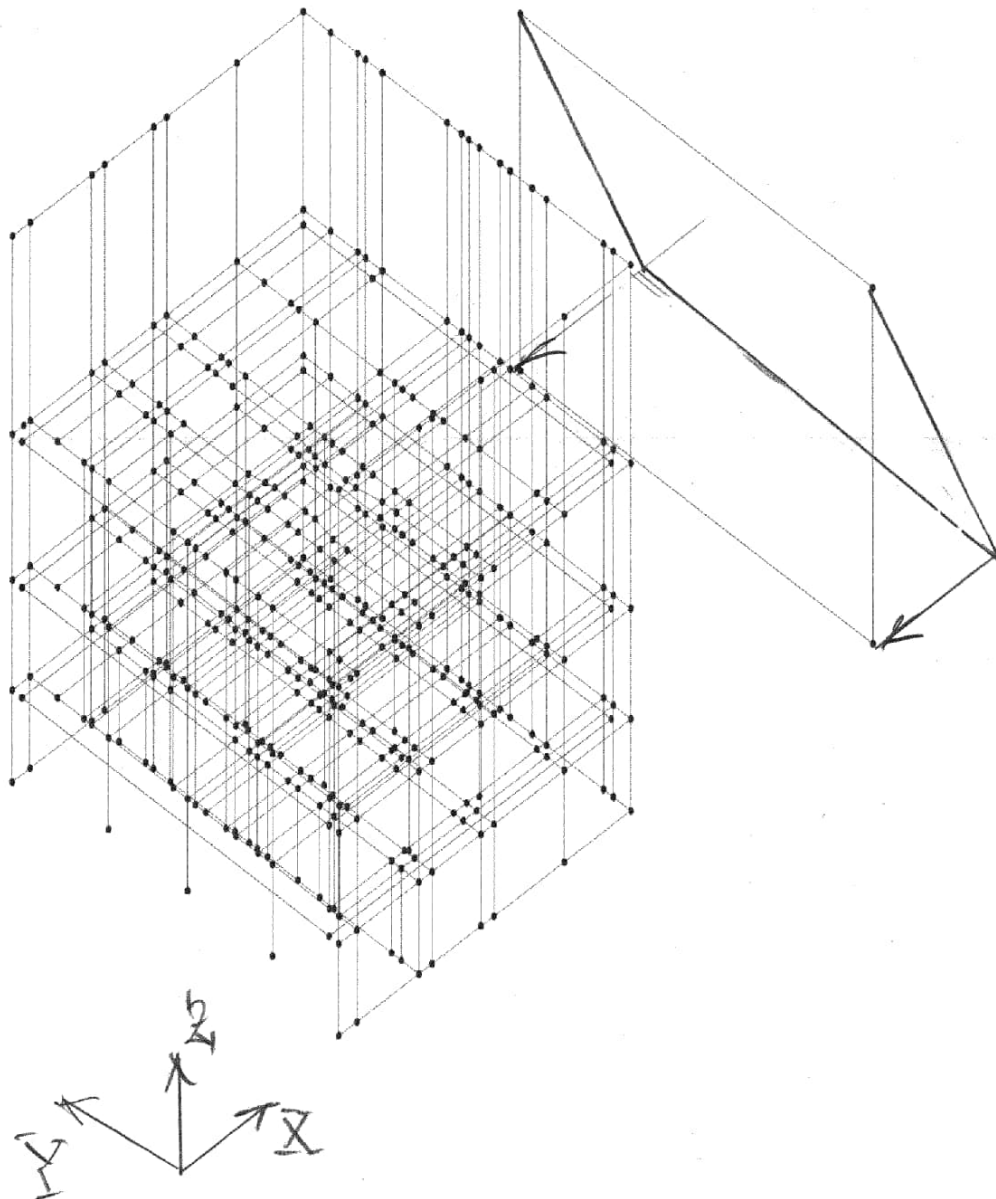
Search area : Exterior wall 2

Force type : Per unit area

Component x direction : { 0 -97 } kPa

Options for load outside search area : Exclude All Load

	Hydropower plant 1 (200 MW)	Status :	Page : 117
		Date :	Created :



	Hydropower plant 1 (200 MW)	Status :	Page : 118
		Date :	Created :

Loadcase : Earth pressure unreduced qv1

Structural loading : Discrete patch load

Search area : Exterior wall 1

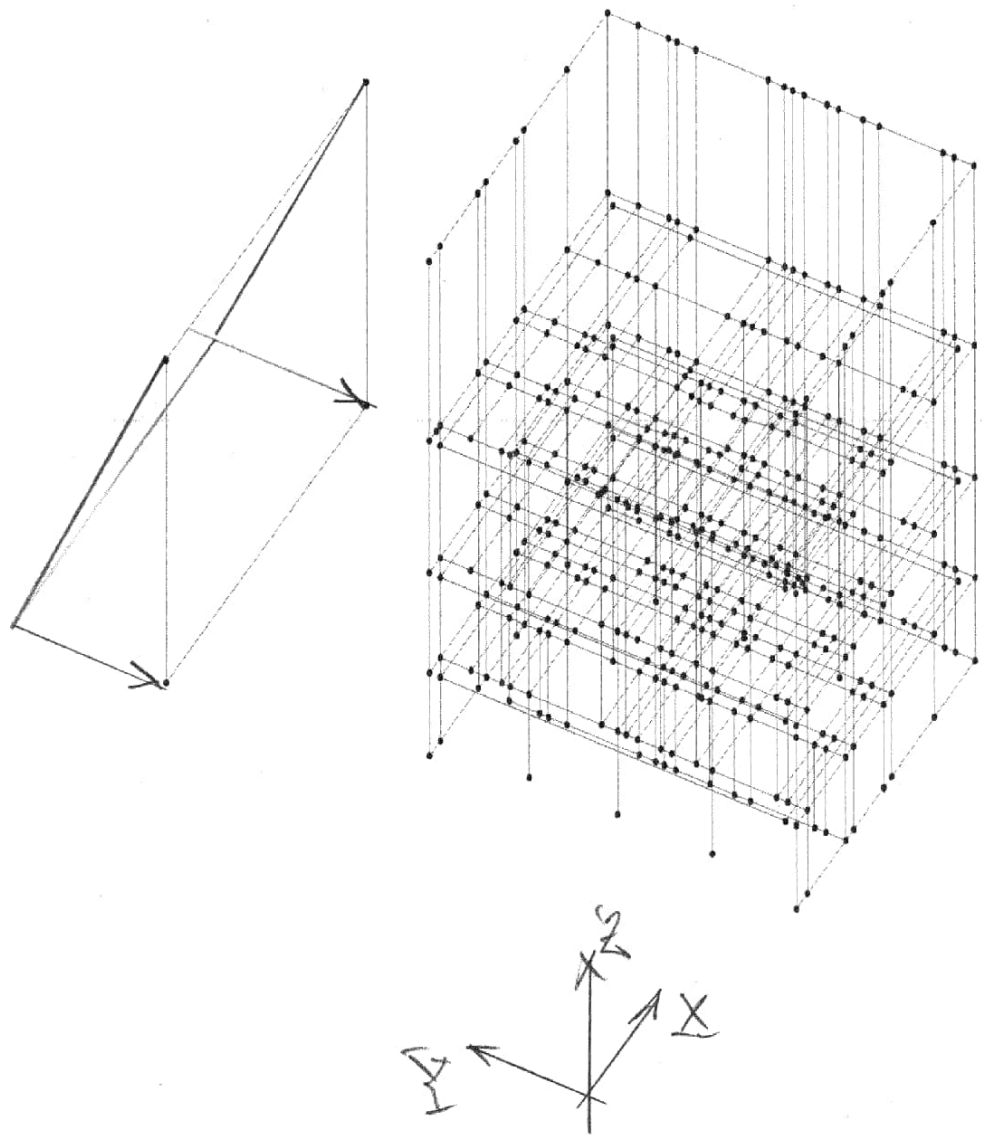
Force type : Per unit area

Component y direction : { 0 -97 } kPa

Options for load outside search area : Exclude All Load

Patch type				
☐ 8 node patch ☒ 4 node patch ☐ Straight line ☐ Curve				
Untransformed load direction			Projection vector	
☐ X ☐ Z ☒ Y ☐ Surface normal			☐ Project in load direction X component 0.0 Y component 0.0 Z component 1.0	
	X Coordinate	Y Coordinate	Z Coordinate	Load
1	32.0	-12.2	53.0	-97.0
2	32.0	9.5	53.0	-97.0
3	32.0	9.5	67.2	0.0
4	32.0	-12.2	67.2	0.0
Attribute Earth pressure unreduced qx1 (61)				

	Hydropower plant 1 (200 MW)	Status :	Page : 119
		Date :	Created :



	Hydropower plant 1 (200 MW)	Status :	Page : 120
		Date :	Created :

Loadcase : Earth pressure unreduced qy2

Structural loading : Discrete patch load

Search area : Exterior wall 3

Force type : Per unit area

Component y direction : { 0 +97 } kPa

Options for load outside search area : Exclude All Load

Patch type

☐ 8 node patch
☒ 4 node patch
☐ Straight line
☐ Curve

Untransformed load direction

☐ X
☐ Z
☒ Y
☐ Surface normal

Projection vector

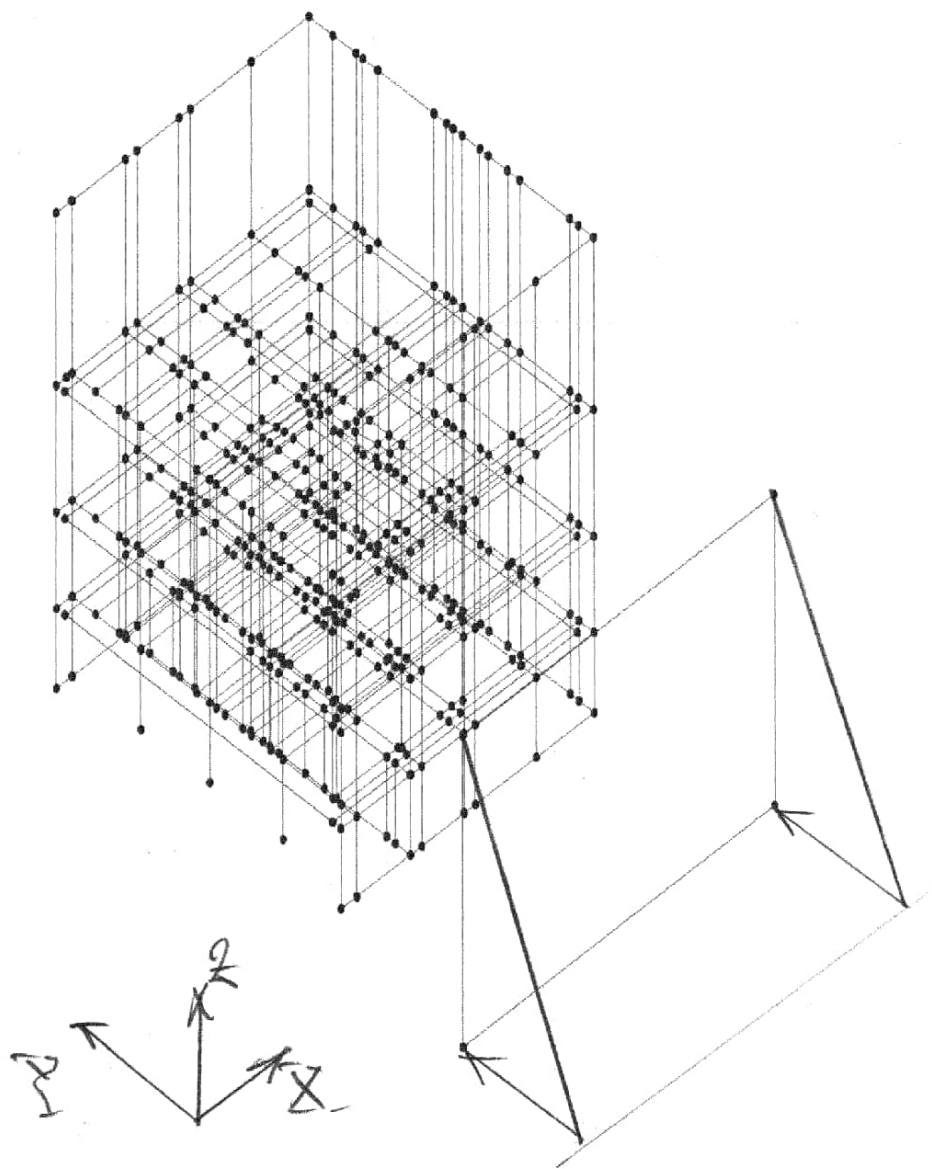
☐ Project in load direction

X component
Y component
Z component

	X Coordinate	Y Coordinate	Z Coordinate	Load
1	20.0	-22.0	53.0	97.0
2	-2.0	-22.0	53.0	97.0
3	-2.0	-22.0	67.2	0.0
4	20.0	-22.0	67.2	0.0

Attribute (60)

	Hydropower plant 1 (200 MW)	Status :	Page : 121
		Date :	Created :



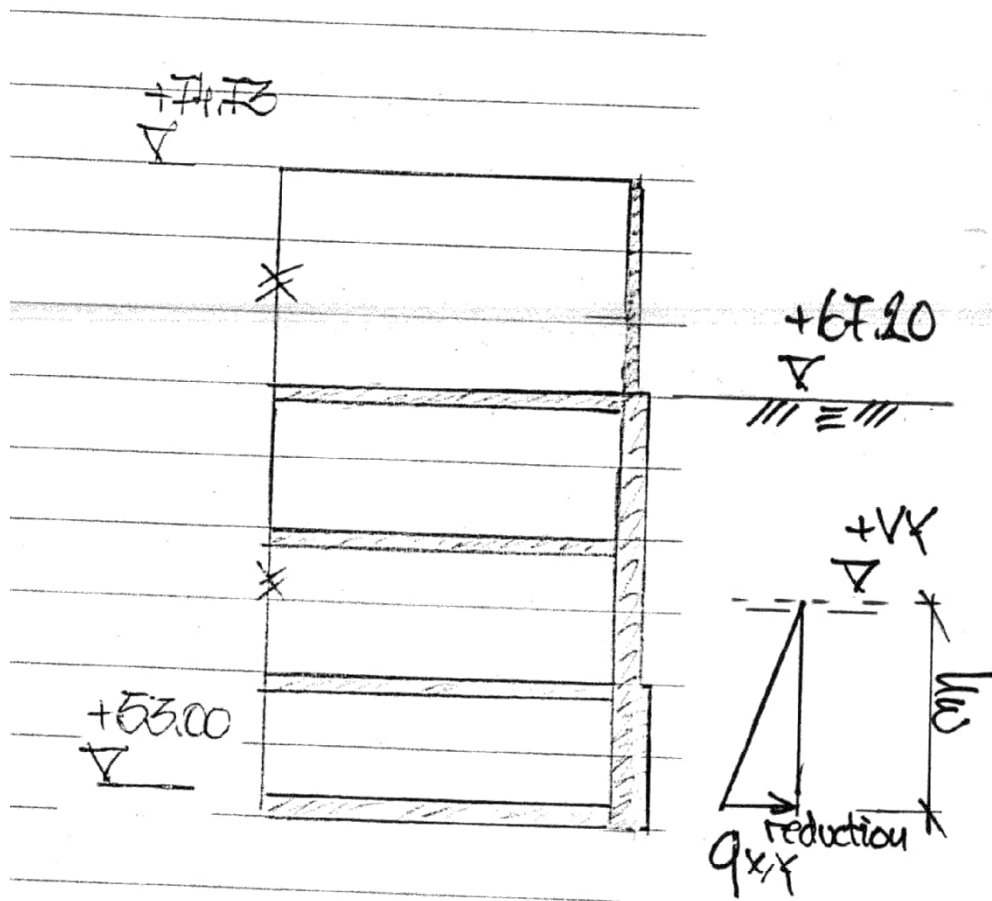
	Hydropower plant 1 (200 MW)	Status :	Page : 122
		Date :	Created :

3.3.2 Reduction of earth pressure due to water level LLW

Reduction due to water level +53.63.

$$h_w = 53.63 - 53.00 = 0.63m$$

$$q_{x,y}^{reduction} = 0.38 \cdot 0.63m \cdot \left(18 \frac{kN}{m^3} - 11 \frac{kN}{m^3}\right) = 1.7kPa$$



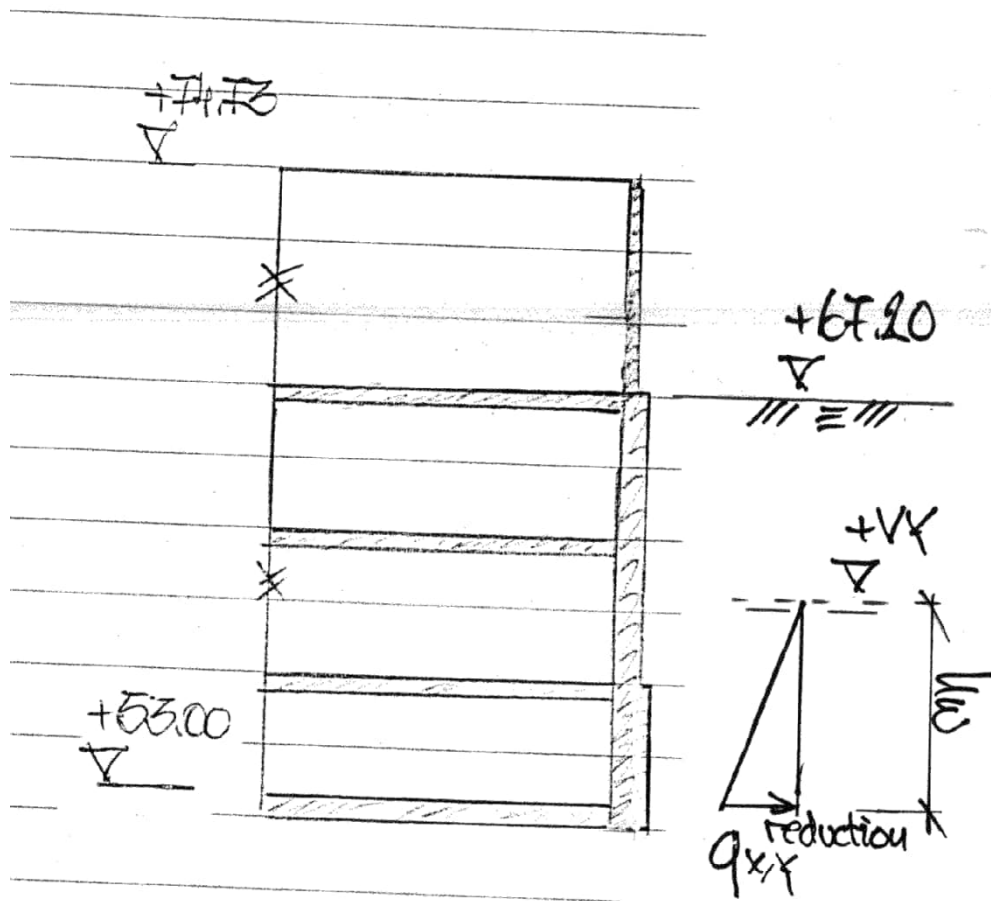
	Hydropower plant 1 (200 MW)	Status :	Page : 123
		Date :	Created :

3.3.3 Reduction of earth pressure due to water level HHW

Reduction due to water level +62.94.

$$h_w = 62.94 - 53.00 = 9.94m$$

$$q_{x,y}^{reduction} = 0.38 \cdot 9.94m \cdot \left(18 \frac{kN}{m^3} - 11 \frac{kN}{m^3}\right) = 24.5kPa$$



	Hydropower plant 1 (200 MW)	Status :	Page : 124
		Date :	Created :

3.3.4 Load combinations

Load combination basic : Earth pressure LLW

..

Loadcase	Factor
Water LLW qx1	-0.27*
Water LLW qy1	-0.27*
Water LLW qy2	-0.27*
Earth pressure unreduced qx1	1.00
Earth pressure unreduced qy1	1.00
Earth pressure unreduced qy2	1.00

$$* = \frac{-1.7kPa}{+6.3kPa} = -0.27$$

Load combination basic : Earth pressure HHW

Loadcase	Factor
Water HHW qx1	-0.25**
Water HHW qy1	-0.25**
Water HHW qy2	-0.25**
Earth pressure unreduced qx1	1.00
Earth pressure unreduced qy1	1.00
Earth pressure unreduced qy2	1.00

$$** = \frac{-24.4kPa}{+99.4kPa} = -0.25$$

	Hydropower plant 1 (200 MW)	Status :	Page : 125
		Date :	Created :

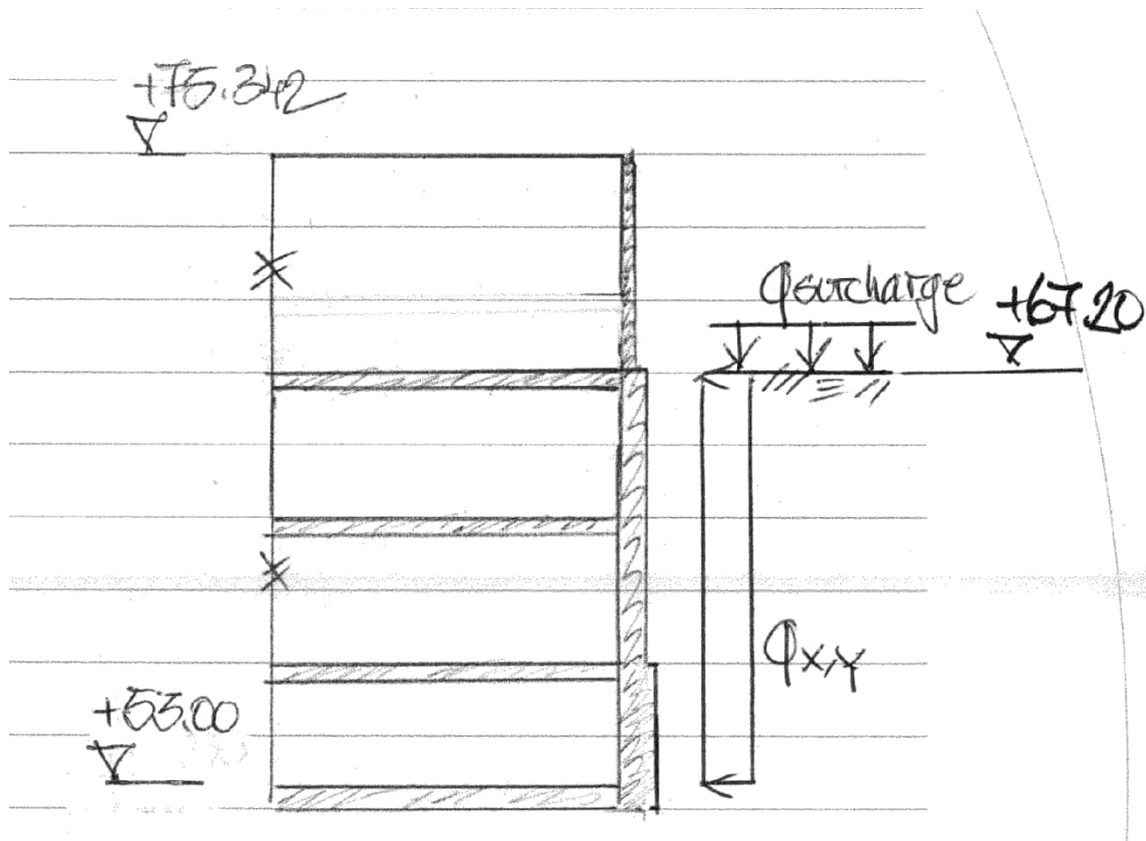
3.4 SURCHARGE

Earth properties listed bellow are used in the design.

$$K_0 = 0.38$$

$$q_{surcharge} = 10kPa$$

$$q_{x,y} = K_0 \cdot q_{surcharge} = 3.8kPa$$



	Hydropower plant 1 (200 MW)	Status :	Page : 126
		Date :	Created :

Loadcase : Surcharge qx1

Structural loading : Discrete patch load

Search area : Exterior wall 2

Force type : Per unit area

Component x direction : -3.8 kPa

Options for load outside search area : Exclude All Load

Patch type

☐ 8 node patch

☒ 4 node patch

☐ Straight line

☐ Curve

Untransformed load direction

☒ X

☐ Z

☐ Y

☐ Surface normal

Projection vector

☐ Project in load direction

X component

0.0

Y component

0.0

Z component

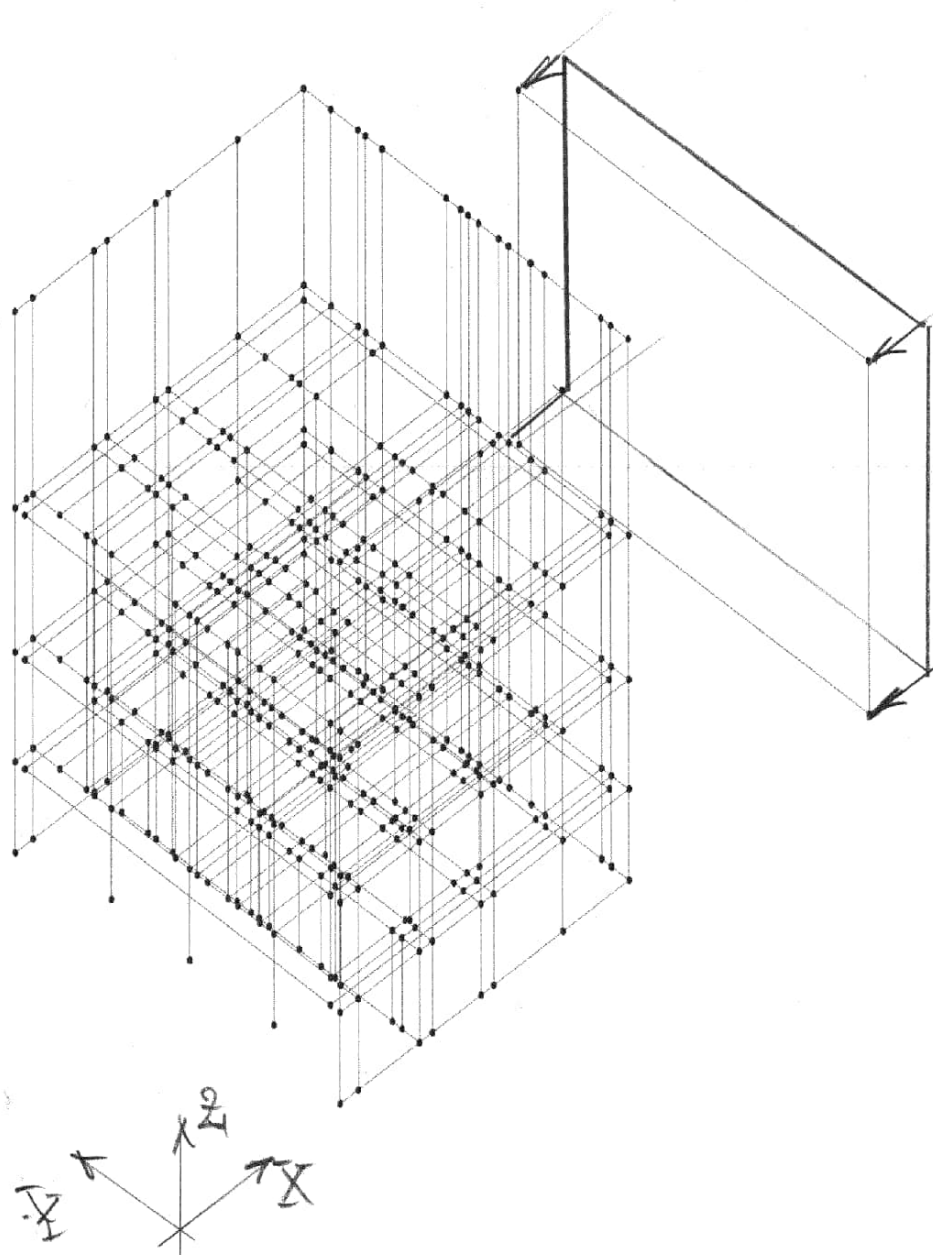
1.0

Attribute

Surcharge qx1

(62)

	Hydropower plant 1 (200 MW)	Status :	Page : 127
		Date :	Created :



	Hydropower plant 1 (200 MW)	Status :	Page : 128
		Date :	Created :

Loadcase : Surcharge qy1

Structural loading : Discrete patch load

Search area : Exterior wall 1

Force type : Per unit area

Component y direction : -3.8 kPa

Options for load outside search area : Exclude All Load

Patch type
☐ 8 node patch ☒ 4 node patch ☐ Straight line ☐ Curve

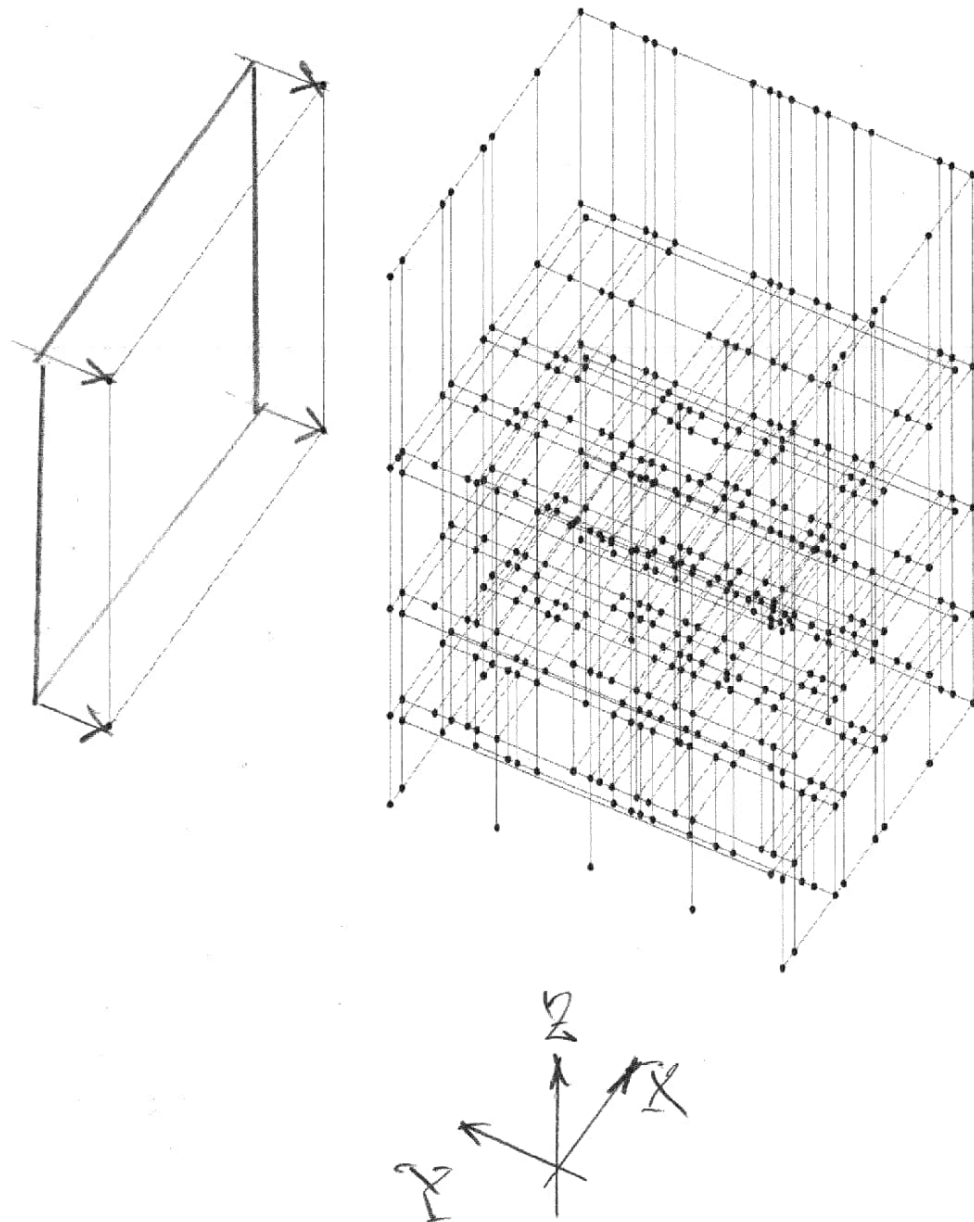
Untransformed load direction
☐ X ☐ Z
☒ Y ☐ Surface normal

Projection vector
☐ Project in load direction
X component
Y component
Z component

	X Coordinate	Y Coordinate	Z Coordinate	Load
1	18.0	22.0	53.0	-3.8
2	-2.0	22.0	53.0	-3.8
3	-2.0	22.0	67.2	-3.8
4	18.0	22.0	67.2	-3.8

Attribute (63)

	Hydropower plant 1 (200 MW)	Status :	Page : 129
		Date :	Created :



	Hydropower plant 1 (200 MW)	Status :	Page : 130
		Date :	Created :

Loadcase : Surcharge qy2

Structural loading : Discrete patch load

Search area : Exterior wall 3

Force type : Per unit area

Component y direction : +3.8 kPa

Options for load outside search area : Exclude All Load

Patch type

☐ 8 node patch

☒ 4 node patch

☐ Straight line

☐ Curve

Untransformed load direction

☐ X

☐ Z

☒ Y

☐ Surface normal

Projection vector

☐ Project in load direction

X component

0.0

Y component

0.0

Z component

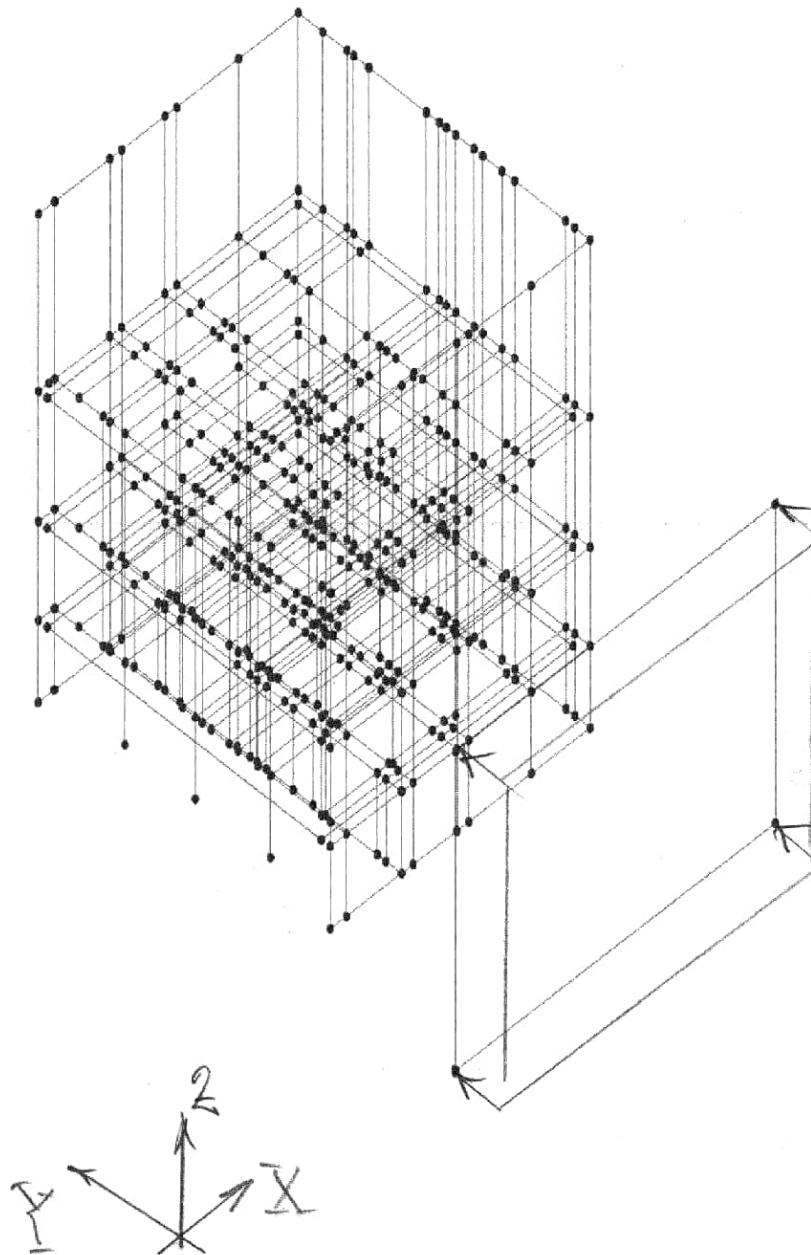
1.0

Attribute

Surcharge qy2

(64)

	Hydropower plant 1 (200 MW)	Status :	Page : 131
		Date :	Created :



	Hydropower plant 1 (200 MW)	Status :	Page : 132
		Date :	Created :

-

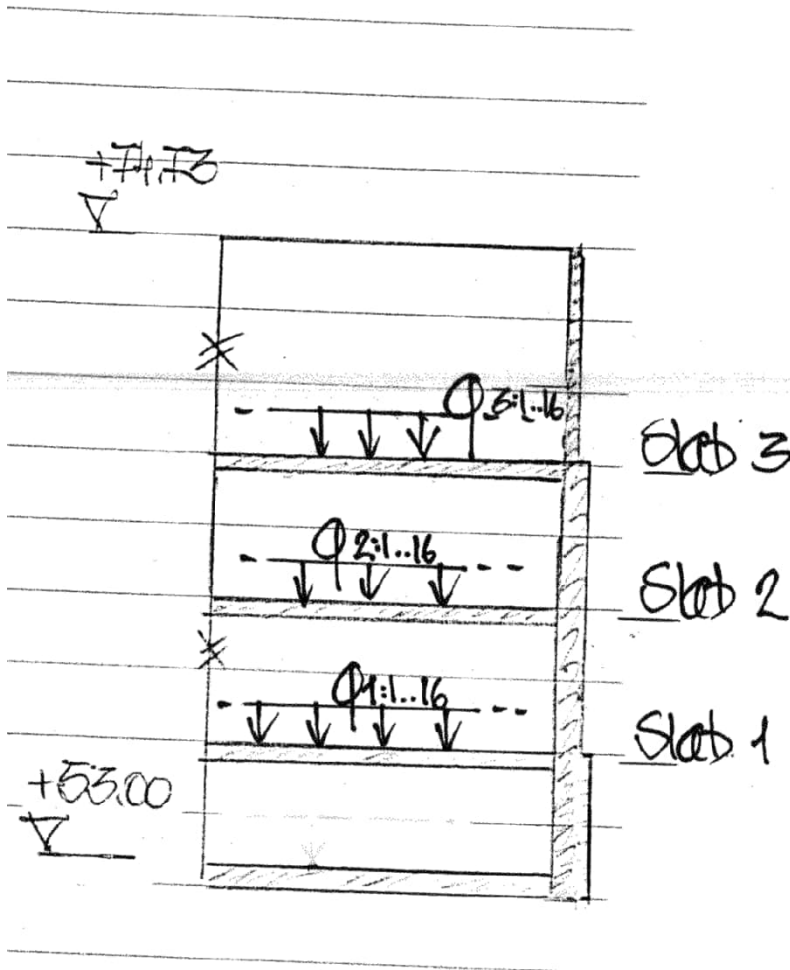
Load combination smart : *Surcharge*

Loadcase	Permanent factor	Variable factor
Surcharge qx1	0	1.00
Surcharge qy1	0	1.00
Surcharge qy2	0	1.00

	Hydropower plant 1 (200 MW)	Status :	Page : 133
		Date :	Created :

3.5 LIVE SURFACE LOAD

Slabs 1-3 are designed to handle live surface load corresponding to 10 kPa.



	Hydropower plant 1 (200 MW)	Status :	Page : 134
		Date :	Created :

3.5.1 Load on slab 1

Loadcases : Surface 1:1-1:16

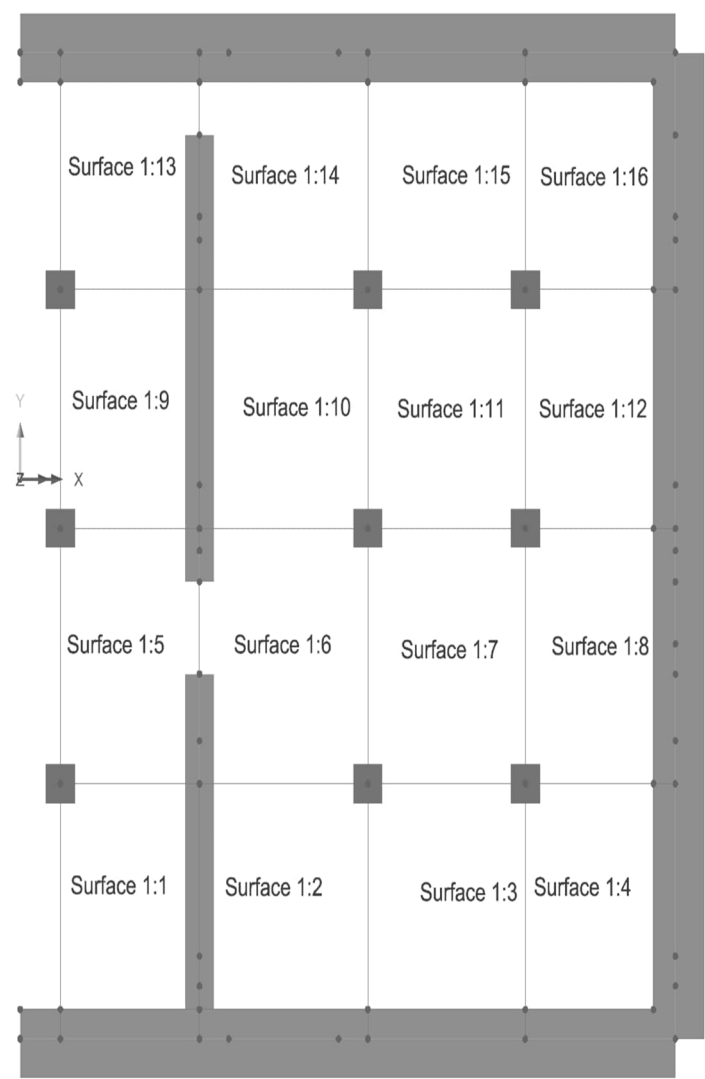
Structural loading : Discrete patch load

Search area : Slab 1

Force type : Per unit area

Component z direction :-10 kPa

Options for load outside search area : Exclude All Load



	Hydropower plant 1 (200 MW)	Status :	Page : 135
		Date :	Created :

3.5.2 Load on slab 2

Loadcases : Surface 2:1-2:16

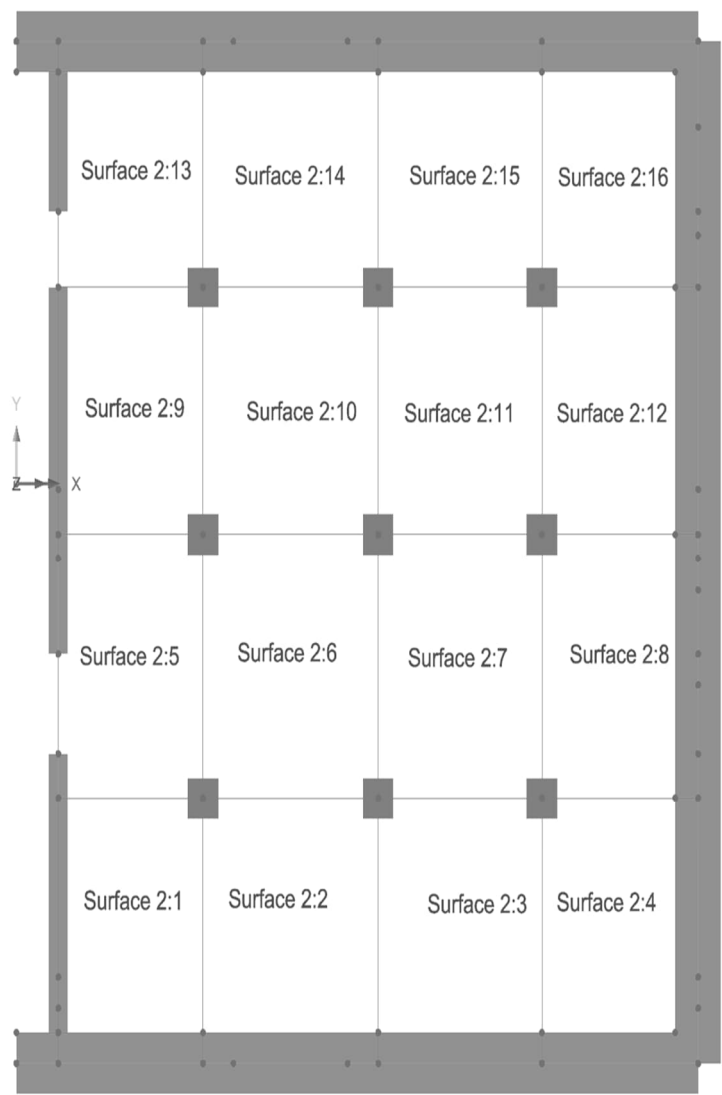
Structural loading : Discrete patch load

Search area : Slab 2

Force type : Per unit area

Component z direction :-10 kPa

Options for load outside search area : Exclude All Load



Remark Coordinate table of surface load see Appendix 1.

	Hydropower plant 1 (200 MW)	Status :	Page : 136
		Date :	Created :

3.5.3 Load on slab 3

Loadcases : Surface 3:1-3:16

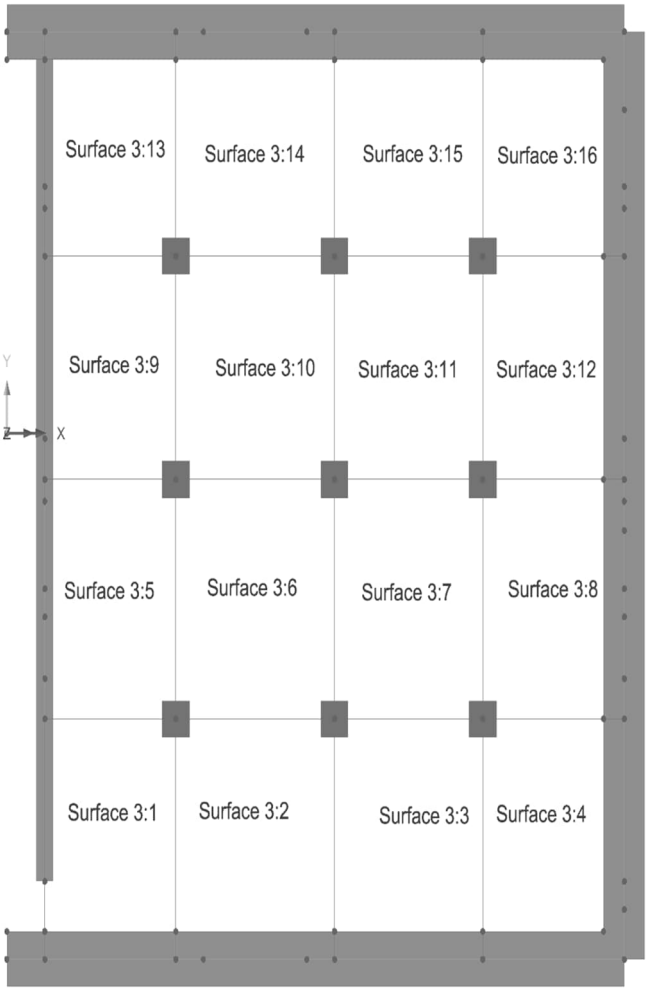
Structural loading : Discrete patch load

Search area : Slab 3

Force type : Per unit area

Component z direction :-10 kPa

Options for load outside search area : Exclude All Load



Remark Coordinate table of surface load see Appendix 1.

	Hydropower plant 1 (200 MW)	Status :	Page : 137
		Date :	Created :

3.5.4 Load combinations

Smart loadcombination : Surface load

Loadcase	Permanent factor	Variable factor
Surface 1:1...1:16	0	1.00
Surface 2:1...2:16	0	1.00
Surface 3:1...3:16	0	1.00

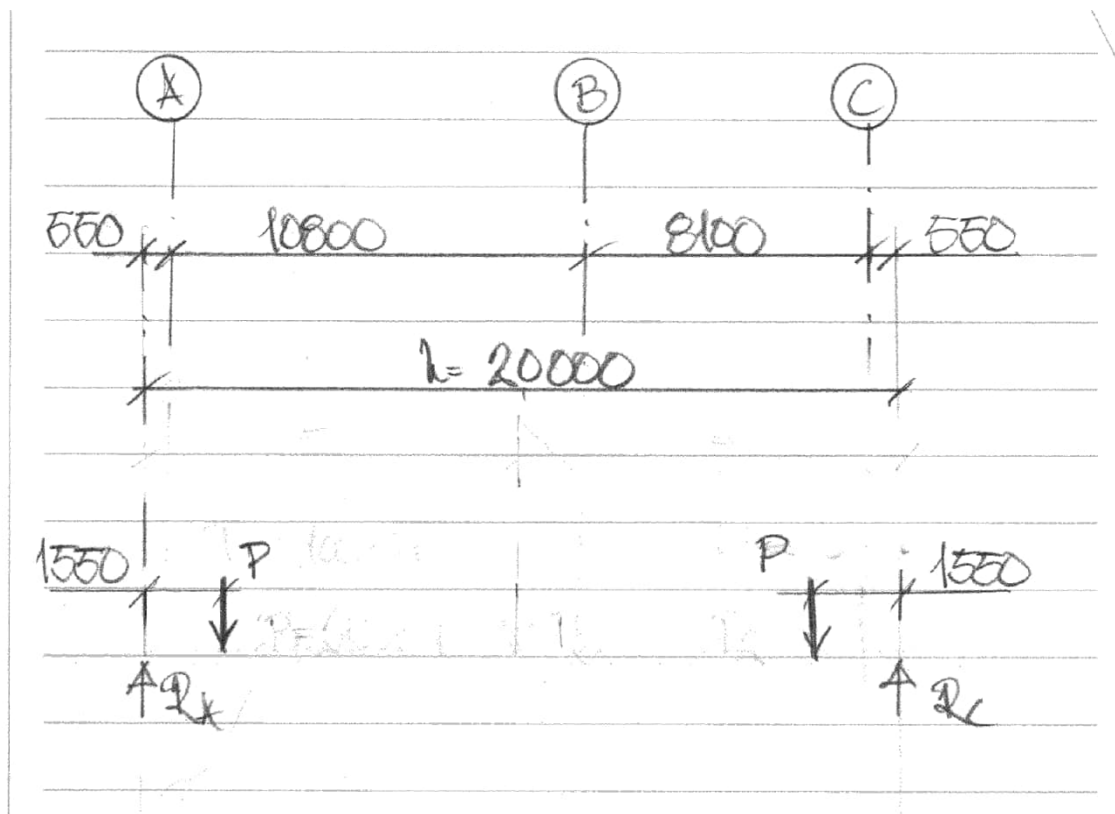
	Hydropower plant 1 (200 MW)	Status :	Page : 138
		Date :	Created :

3.6 CRANE LOAD

The crane load is chosen to be the same as the capacity of crane.

There are two hooks one main ($\therefore$ 2100 kN) and one auxillary ($\therefore$ 150 kN). Only the main hook is considered due to its higher capacity.

The most dangerous position arises when hook main hook is positioned 1000 mm from baseline A or baseline C.

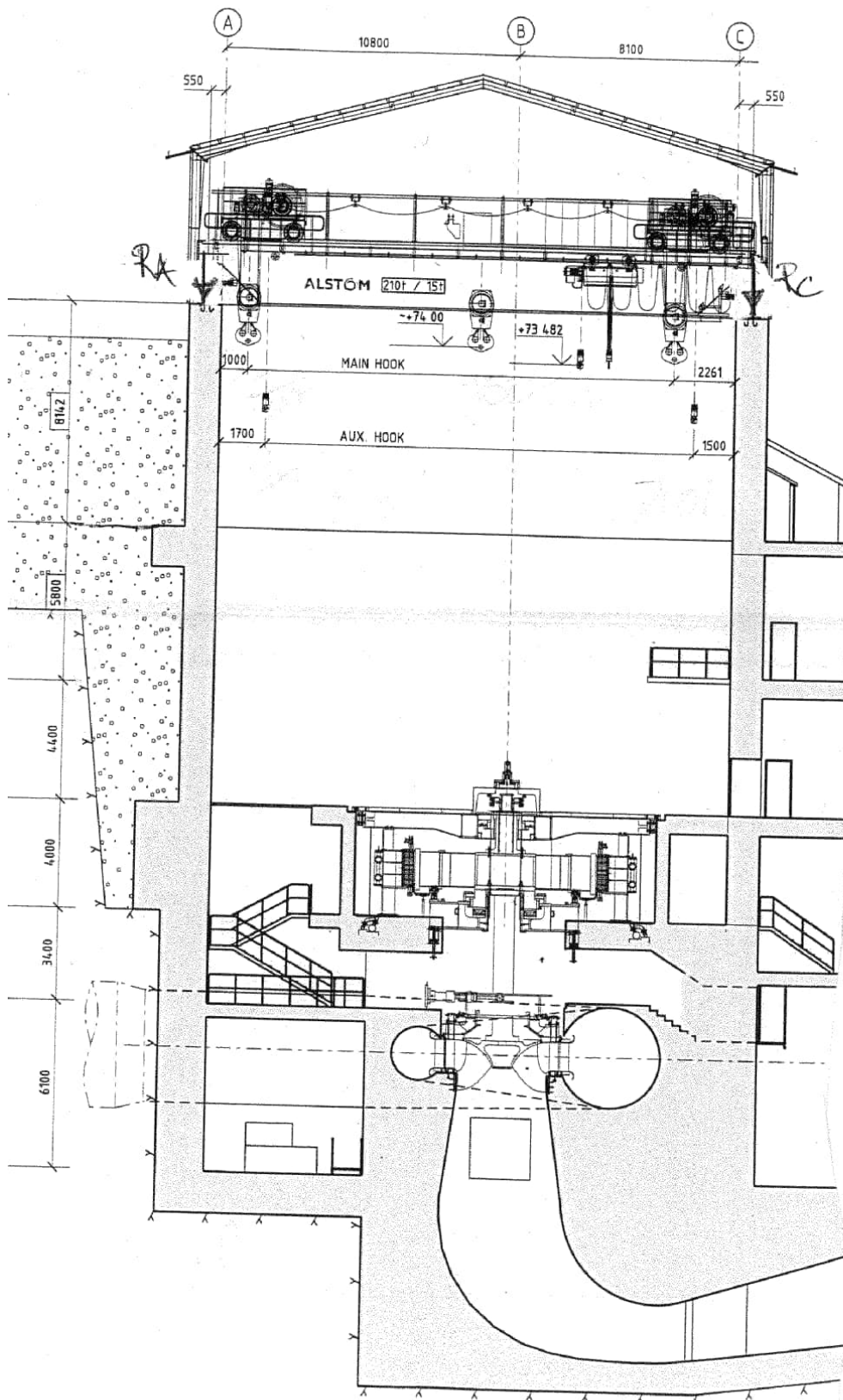


$$P = 2100kN$$

$$R_A = R_C = P \cdot \frac{L - 1.55m}{L} = 2100kN \cdot \frac{20.0m - 1.55m}{20.0m} = 1937kN$$

Remark The effect of breaking/friction and excentric load positioning is neglected since it is considered marginal when designing the studied structure.

	Hydropower plant 1 (200 MW)	Status :	Page : 139
		Date :	Created :



	Hydropower plant 1 (200 MW)	Status :	Page : 140
		Date :	Created :

Structural load : Crain.

Component	Value
Concentrated load in X Dir	0.0
Concentrated load in Y Dir	0.0
Concentrated load in Z Dir	-1.937E3
Moment about X axis	0.0
Moment about Y axis	0.0
Moment about Z axis	0.0
Moment about hinge nodes	0.0
Pore pressure	0.0

	Hydropower plant 1 (200 MW)	Status :	Page : 141
		Date :	Created :

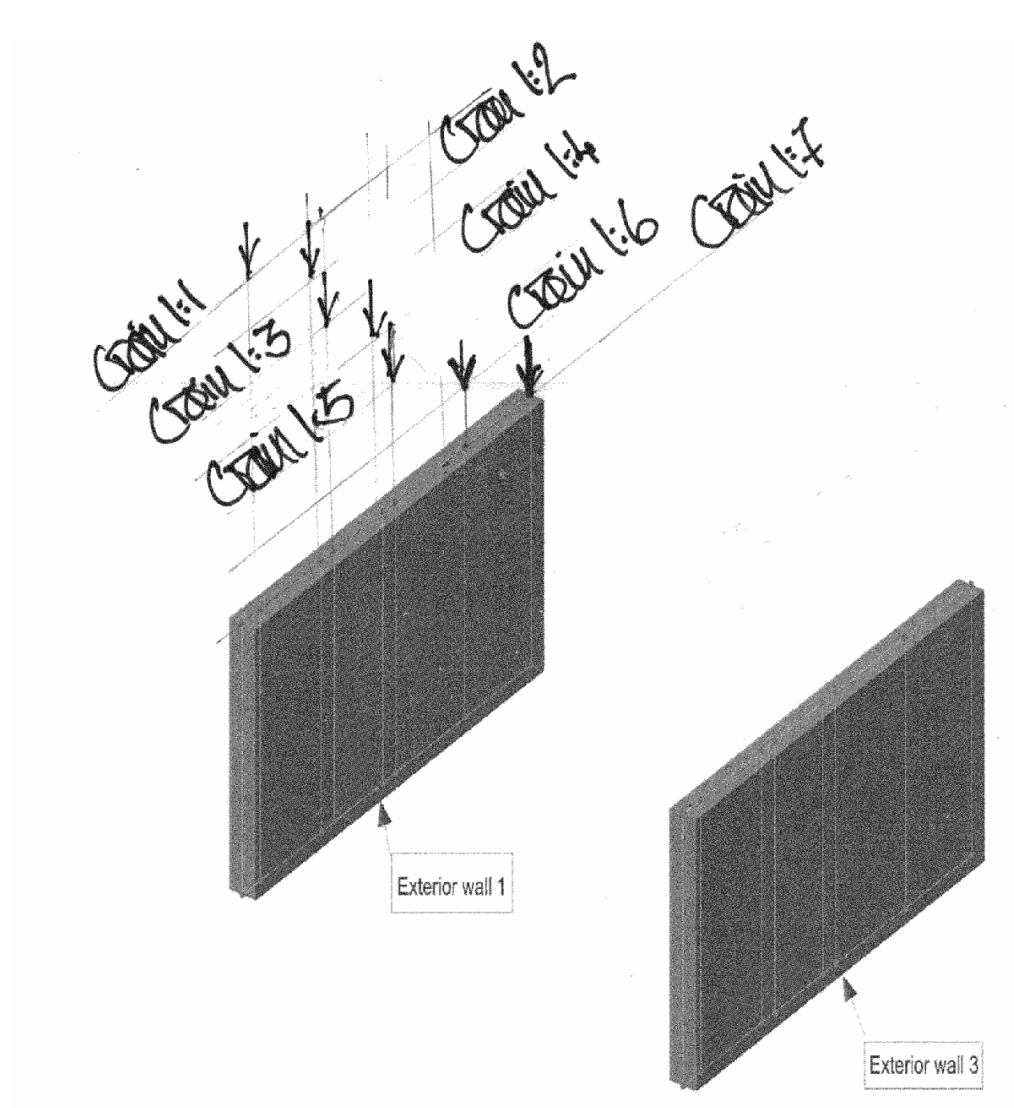
3.6.1 Load on exterior wall 1

Loadcase : Crain 1:1-1:7

Structural loading : Global distributed

Structural load : Crain

Load type : Concentrated load



	Hydropower plant 1 (200 MW)	Status :	Page : 142
		Date :	Created :

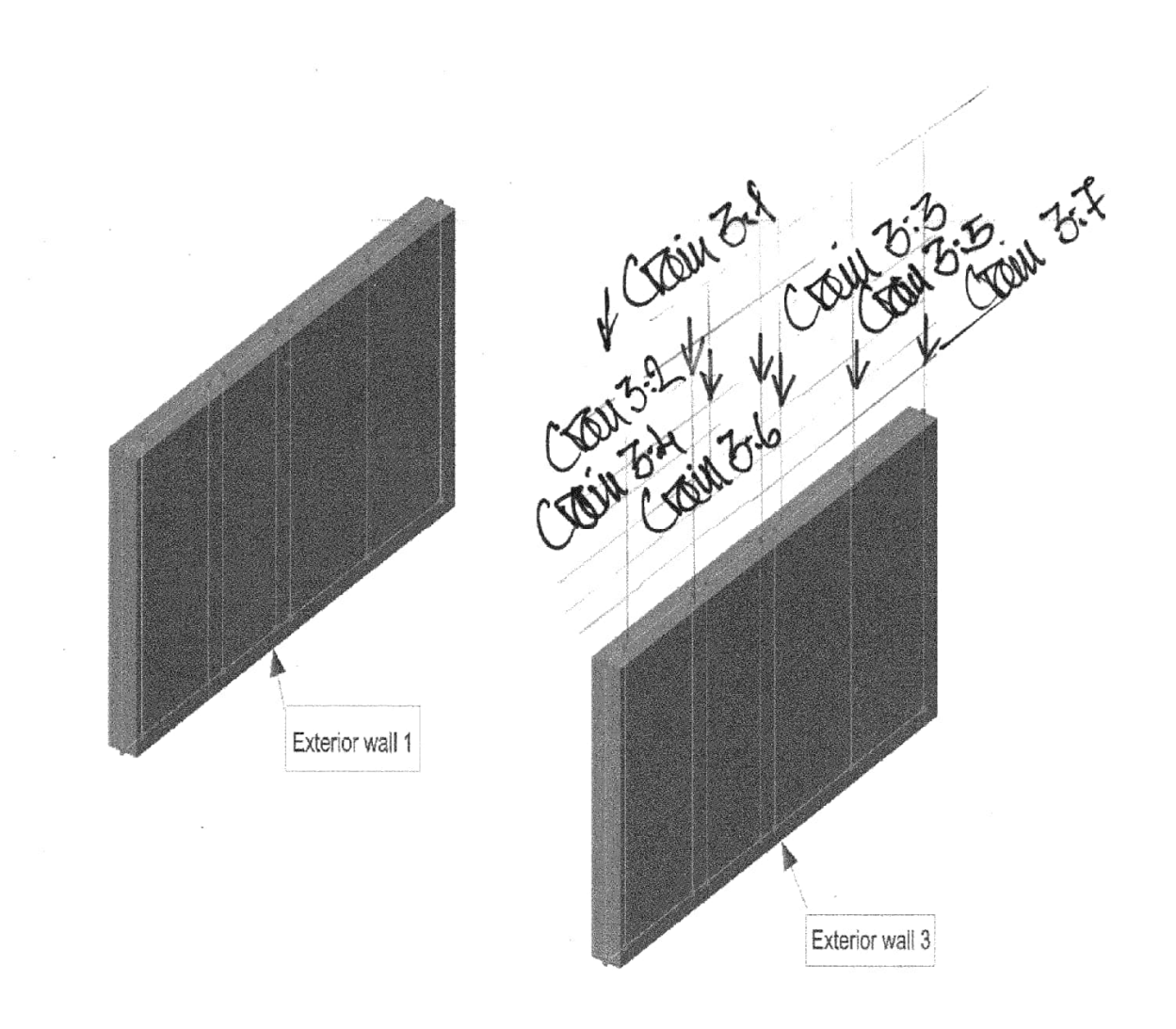
3.6.2
Load on exterior wall 3

Loadcase : Crain 3:1-3:7

Structural loading : Global distributed

Structural load : Crain

Load type : Concentrated load



	Hydropower plant 1 (200 MW)	Status :	Page : 143
		Date :	Created :

3.6.3 Envelope

Envelope : *Crain load*

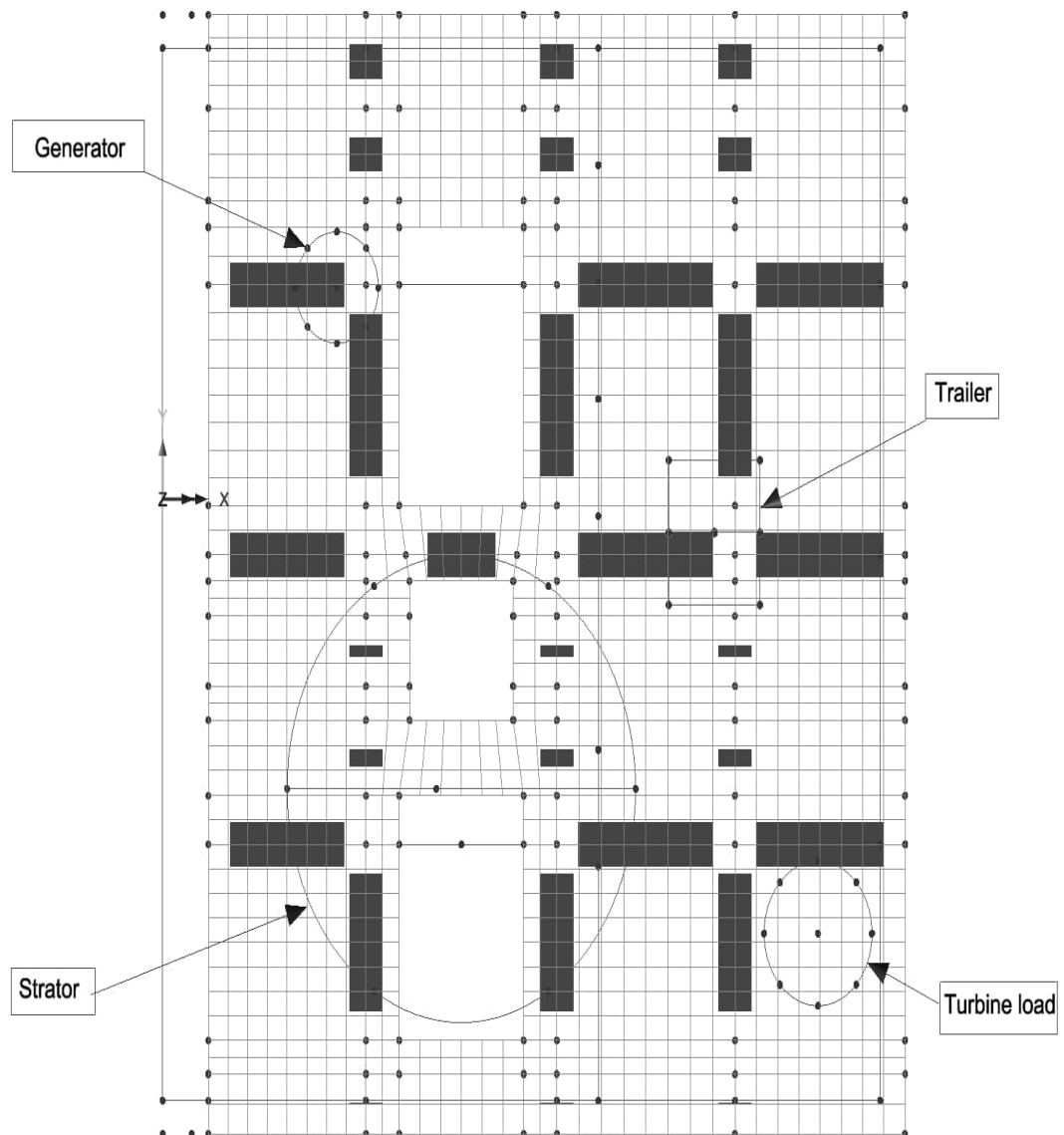
Loadcase	Factor
Crain 1:1...1:7	1
Crain 3:1...3:7	1

	Hydropower plant 1 (200 MW)	Status :	Page : 144
		Date :	Created :

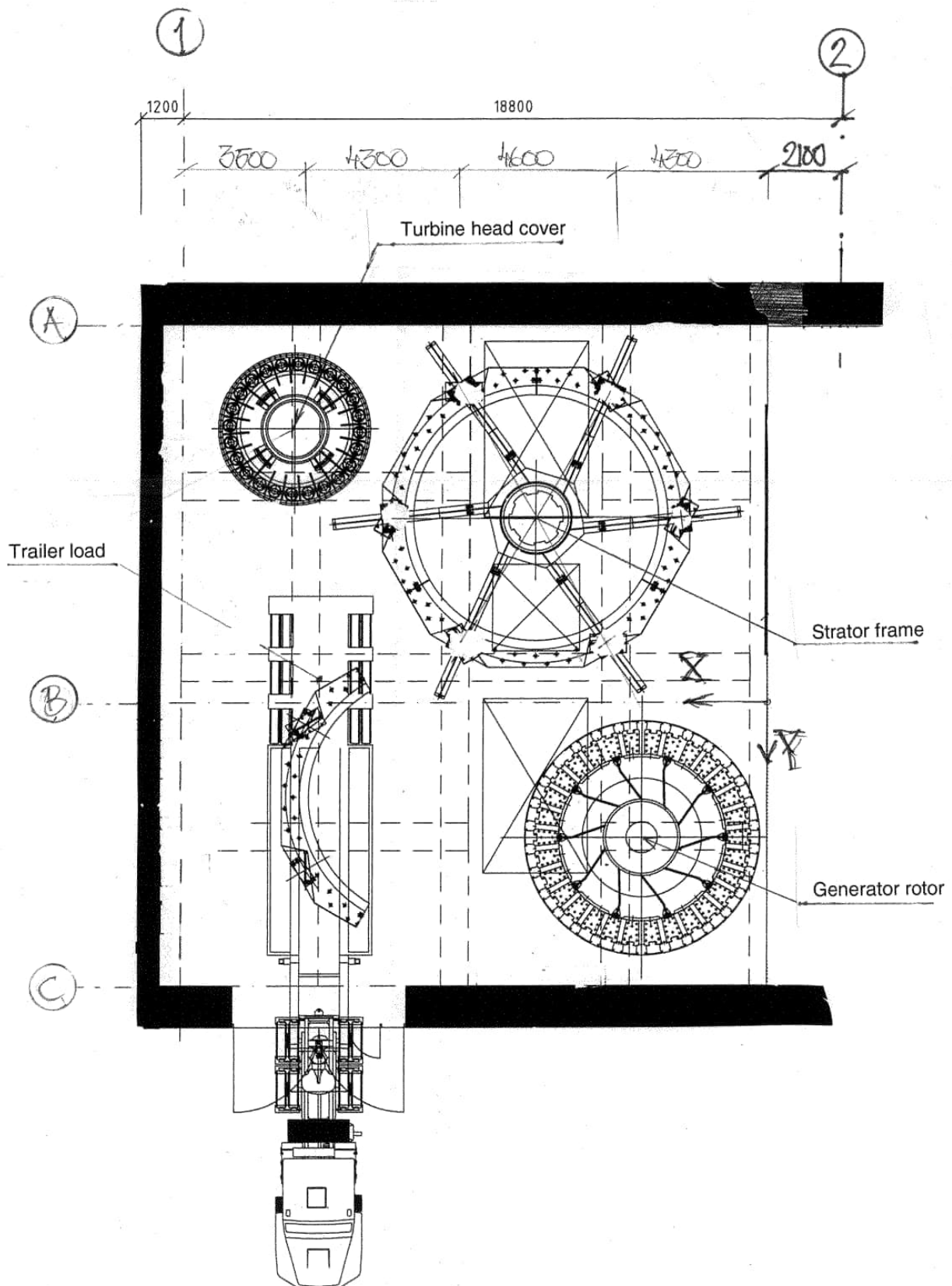
3.7 MACHINE LOAD

The repair bay floor +67.20 is loaded with the following machine loads during assembly.

- Turbine head cover (line load) : 130 kN
- Stator frame (point loads) : 1200kN
- Generator rotor (line load) : 2000 kN
- Trailer load (point load) : 130 kN

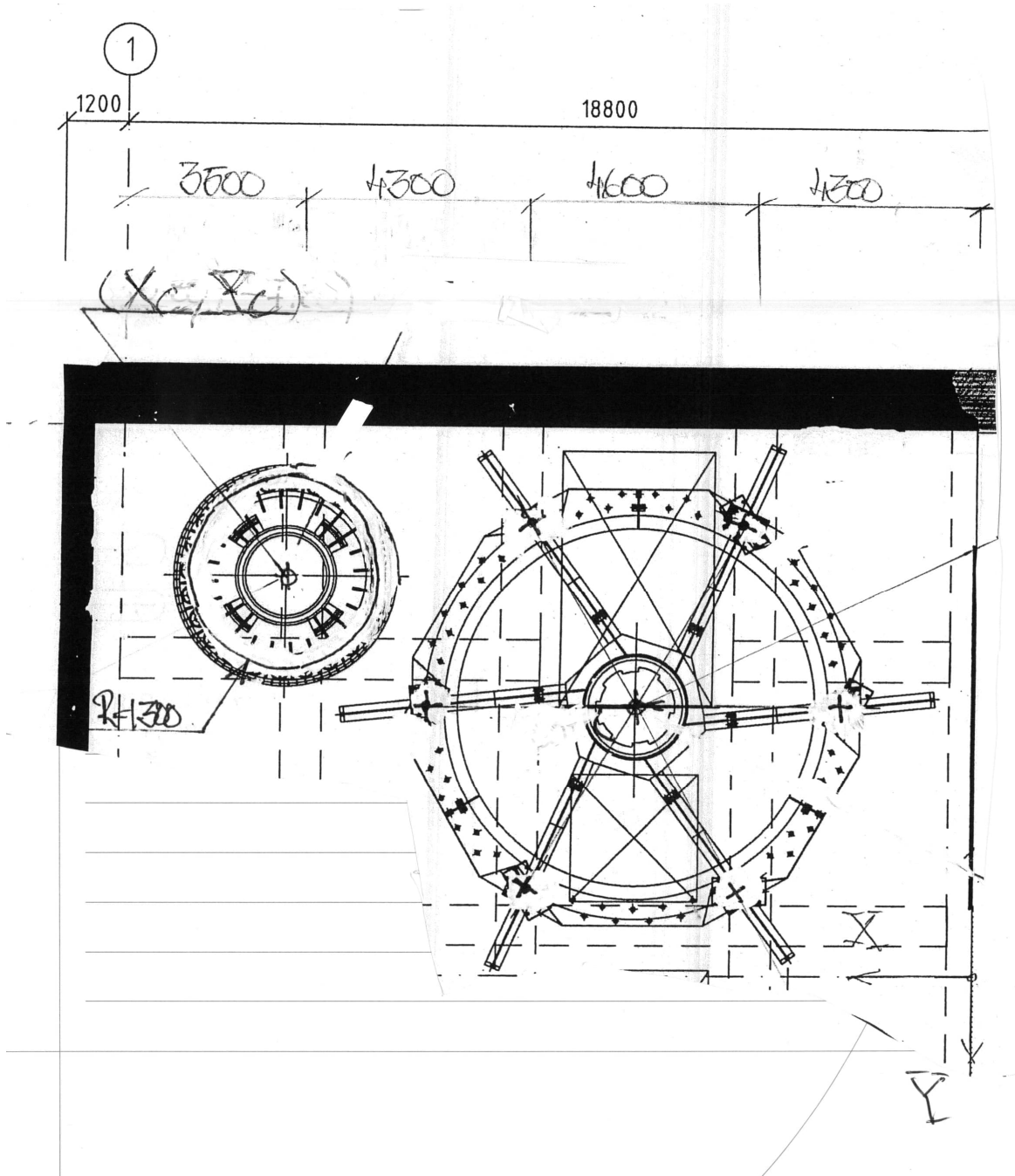


	Hydropower plant 1 (200 MW)	Status :	Page : 145
		Date :	Created :



	Hydropower plant 1 (200 MW)	Status :	Page : 146
		Date :	Created :

3.7.1 Turbine head cover



$X_c = +15.80 \text{ m}$

$Y_c = -7.80 \text{ m}$

	Hydropower plant 1 (200 MW)	Status :	Page : 147
		Date :	Created :

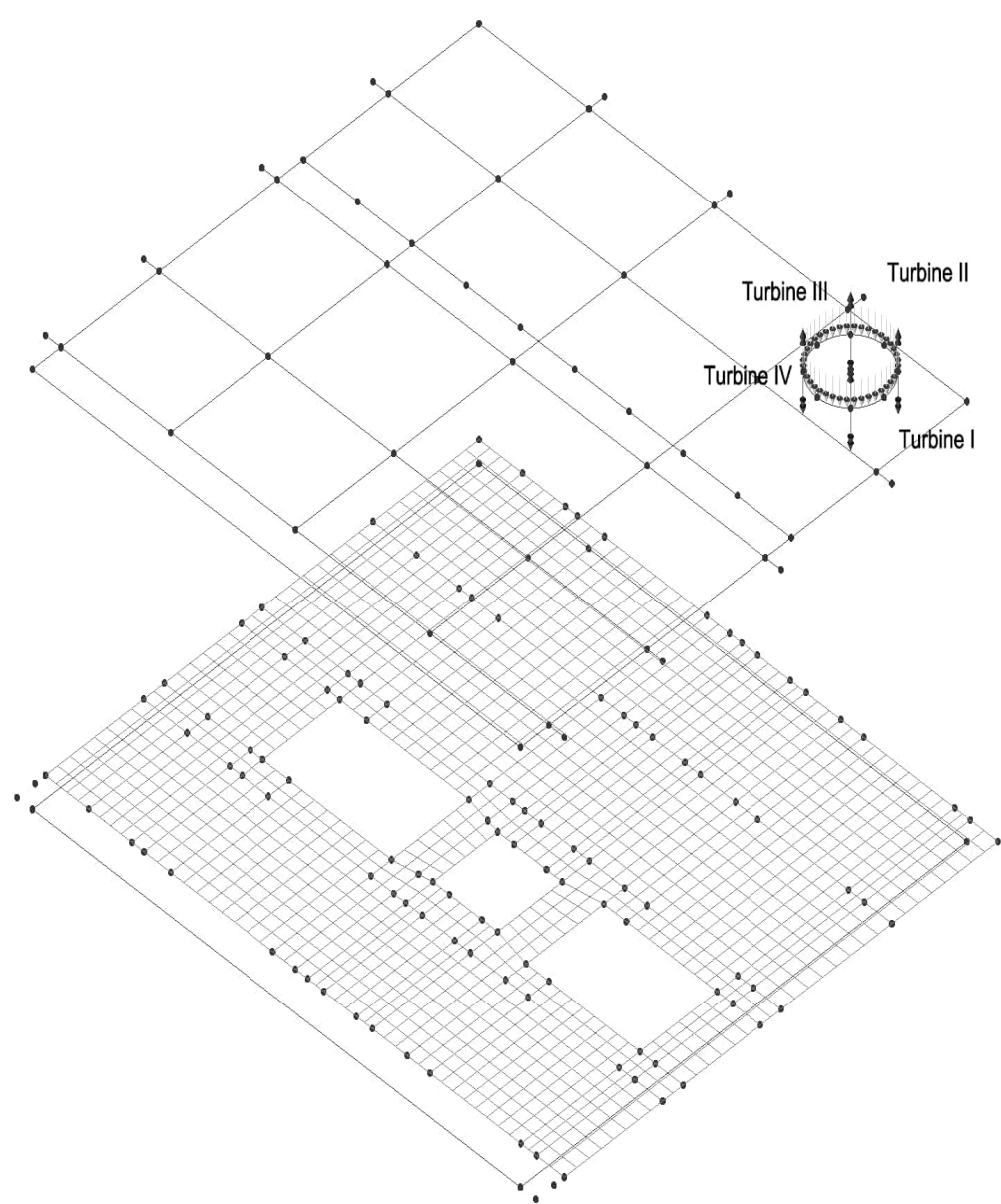
The load is considered a line load with circular form. In order to model this load it is divided into 4 separate parts I-IV.

$$R = 1.30 \text{ m}$$

$$\Sigma P = 130 \text{ kN}$$

$$p = \frac{P}{2\pi R} = \frac{130\text{kN}}{2\pi \cdot 1.30\text{m}} = 16 \frac{\text{kN}}{\text{m}}$$

..



	Hydropower plant 1 (200 MW)	Status :	Page : 148
		Date :	Created :

Loading: Turbine I

Structural loading : Discrete patch load

Search area : Slab 3

Force type : Per unit area

Component z direction : $-16\frac{kN}{m}$

Options for load outside search area : Exclude All Load

Patch type

☐ 8 node patch

☐ 4 node patch

☐ Straight line

☒ Curve

Untransformed load direction

☐ X

☒ Z

☐ Y

☐ Surface normal

Projection vector

☒ Project in load direction

X component

Y component

Z component

Attribute

Turbine I

(57)

	Hydropower plant 1 (200 MW)	Status :	Page : 149
		Date :	Created :

Loading: Turbine II

Structural loading : Discrete patch load

Search area : Slab 3

Force type : Per unit area

Component z direction : $-16\frac{kN}{m}$

Options for load outside search area : Exclude All Load

Patch type

☐ 8 node patch

☐ 4 node patch

☐ Straight line

☒ Curve

Untransformed load direction

☐ X

☒ Z

☐ Y

☐ Surface normal

Projection vector

☒ Project in load direction

X component

Y component

Z component

Attribute

Turbine II

(65)

	Hydropower plant 1 (200 MW)	Status :	Page : 150
		Date :	Created :

Loading: Turbine III

Structural loading : Discrete patch load

Search area : Slab 3

Force type : Per unit area

Component z direction : $-16 \frac{kN}{m}$

Options for load outside search area : Exclude All Load

Patch type

☐ 8 node patch
☐ 4 node patch
☐ Straight line
☒ Curve

Untransformed load direction

☐ X
☒ Z

☐ Y
☐ Surface normal

Projection vector
☒ Project in load direction

X component
Y component
Z component

	X Coordinate	Y Coordinate	Z Coordinate	Load
1	17.1	-7.8	77.85	-18.0
2	16.7192	-6.88076	77.85	-18.0
3	15.8	-6.5	77.85	-18.0

Attribute (67)

	Hydropower plant 1 (200 MW)	Status :	Page : 151
		Date :	Created :

Loading: Turbine IV

Structural loading : Discrete patch load

Search area : Slab 3

Force type : Per unit area

Component z direction : $-16 \frac{kN}{m}$

Options for load outside search area : Exclude All Load

Patch type

☐ 8 node patch
☐ 4 node patch
☐ Straight line
☒ Curve

Untransformed load direction

☐ X
☒ Z

☐ Y
☐ Surface normal

Projection vector
☒ Project in load direction

X component
Y component
Z component

	X Coordinate	Y Coordinate	Z Coordinate	Load
1	14.5	-7.8	77.85	-16.0
2	14.8808	-6.88076	77.85	-16.0
3	15.8	-6.5	77.85	-16.0

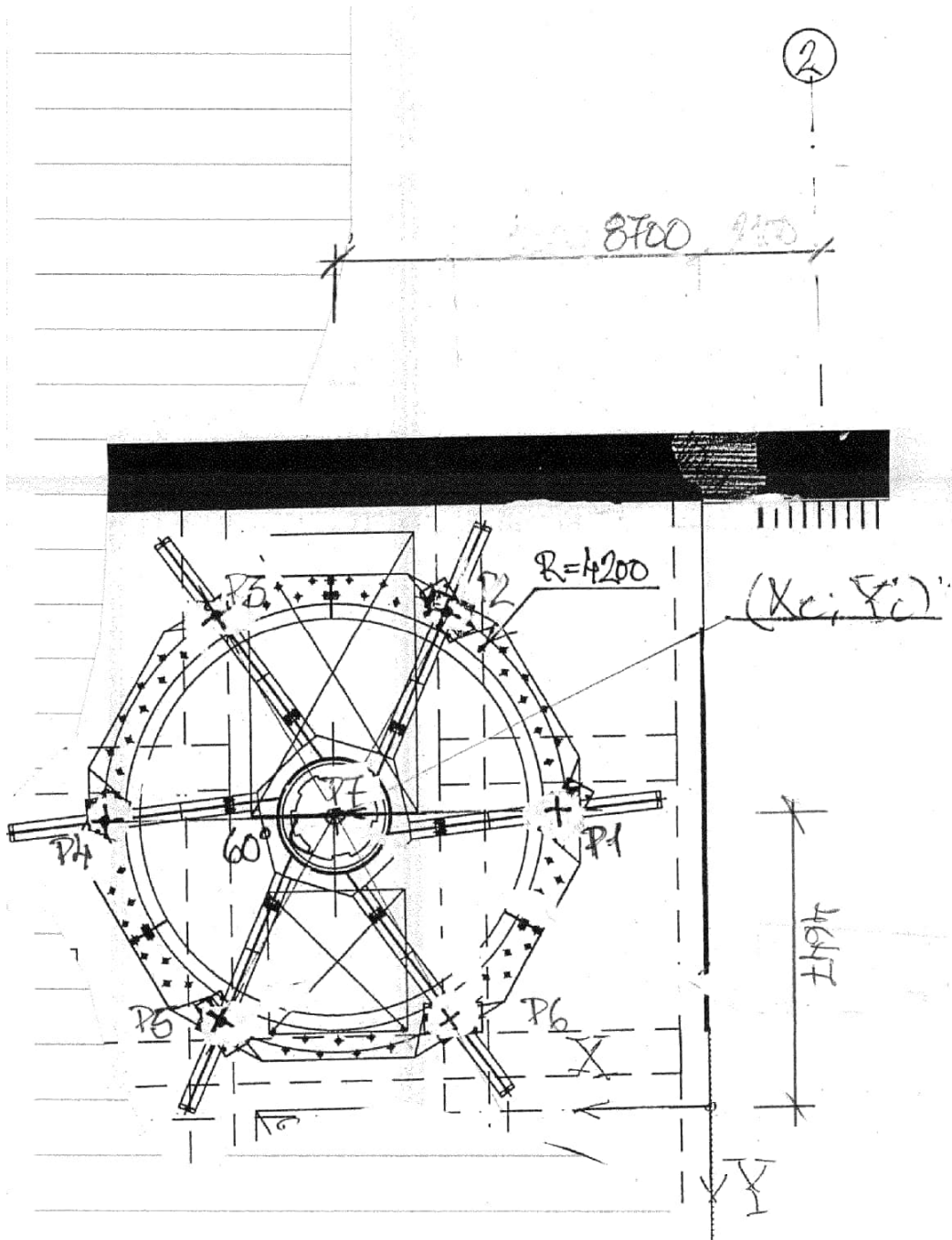
Attribute (68)

Loadcase: Turbine..

Loading : Turbine I / Turbine II / Turbine III / Turbine IV

	Hydropower plant 1 (200 MW)	Status :	Page : 152
		Date :	Created :

3.7.2 Stator frame



$$X_c = +7.20 \text{ m}$$

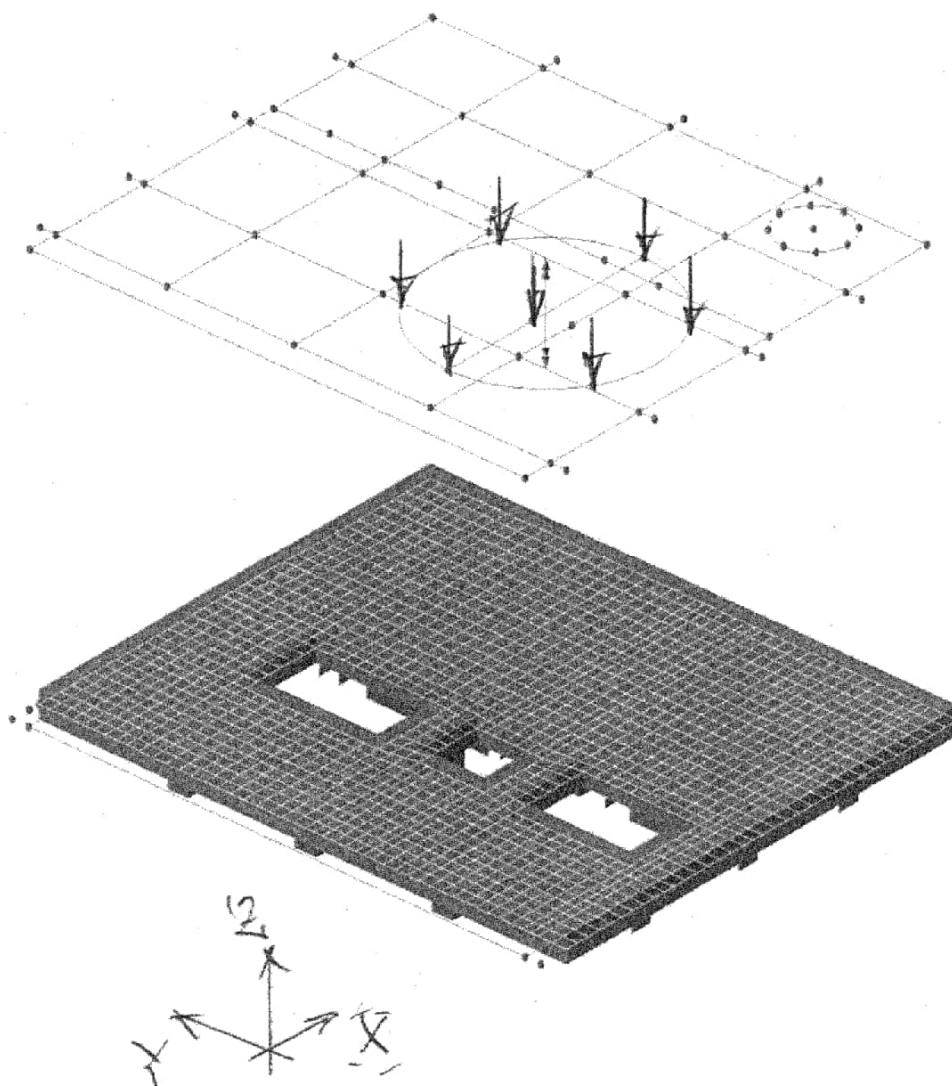
$$Y_c = -4.647 \text{ m}$$

	Hydropower plant 1 (200 MW)	Status :	Page : 153
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The load is considered as 7 point loads.

$$\Sigma P = 1200 \text{ kN}$$

$$P = \frac{\Sigma P}{7} = 171 \text{ kN}$$



	Hydropower plant 1 (200 MW)	Status :	Page : 154
		Date :	Created :

Loadcase: Stator

Structural loading : Discrete patch load

Search area : Slab 3

Discrete load : Stator

Options for load outside search area : Exclude All Load

☒ Arbitrary

☐ Grid

x

y

0

0

Untransformed load direction

☐ X

☒ Z

☐ Y

☐ Surface normal

Projection vector

☒ Project in load direction

X component

Y component

Z component

0.0

0.0

1.0

	X Coordinate	Y Coordinate	Z Coordinate	Load
1	3.0	-4.647	77.85	-171.0
2	11.4	-4.647	77.85	-171.0
3	5.1	-1.00969	77.85	-171.0
4	9.3	-1.00969	77.85	-171.0
5	5.1	-8.28431	77.85	-171.0
6	9.3	-8.28431	77.85	-171.0
7	7.2	-0.447	77.85	-171.0
8				

Attribute

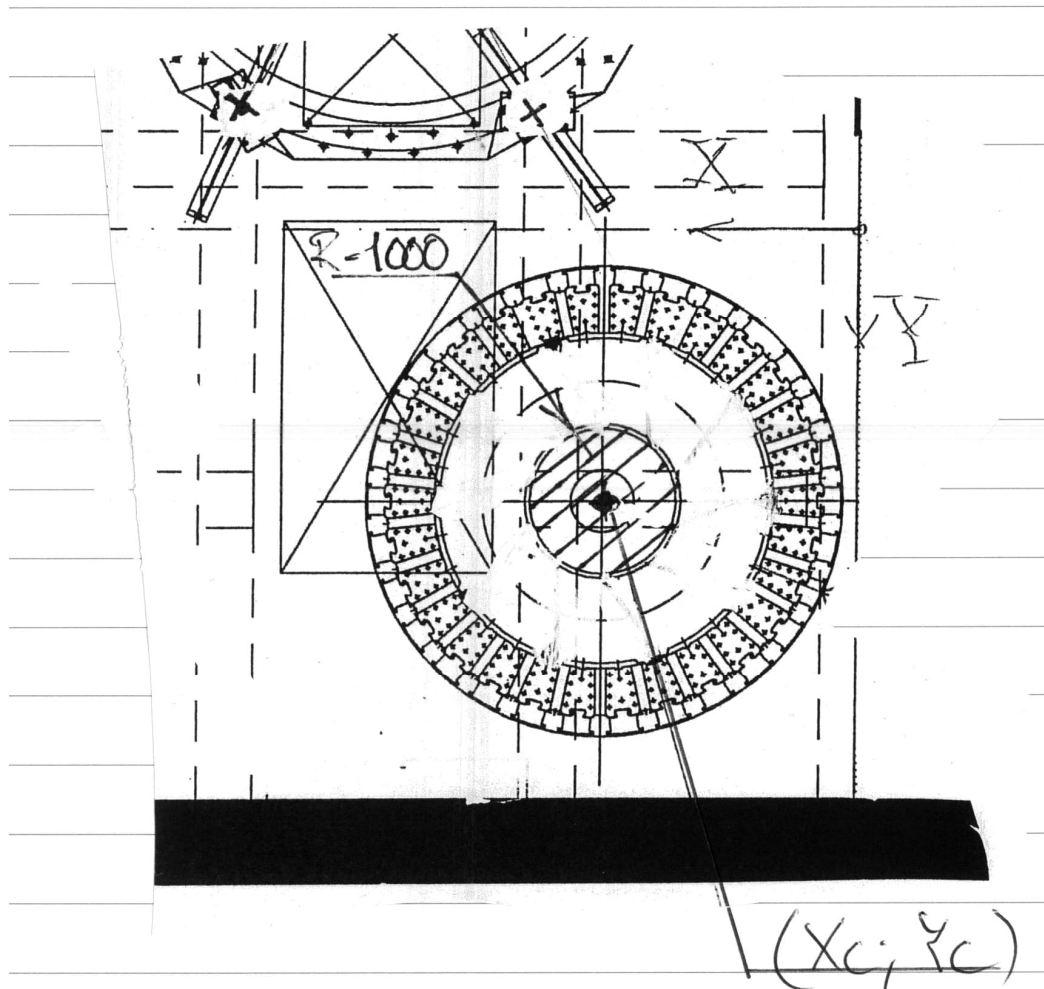
Stator

(69)

	Hydropower plant 1 (200 MW)	Status :	Page : 155
		Date :	Created :

3.7.3 Generator rotor

-



The load is considered as a line load with circular form. In order to model this load it is divided into 4 separate parts I-IV

$$\Sigma P = 2000 \text{ kN}$$

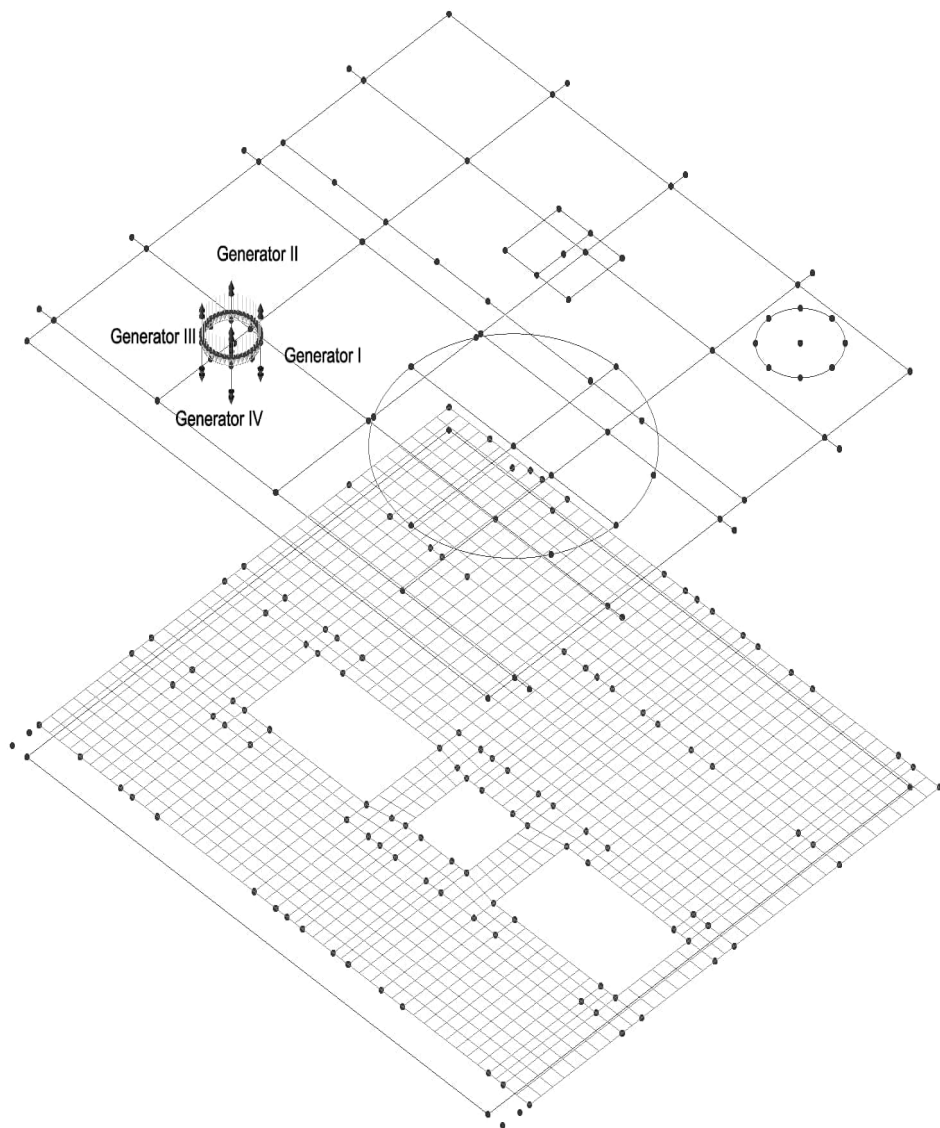
$$R = 0.85 \text{ m}$$

$$p = \frac{\Sigma P}{2\pi R} = 375 \frac{\text{kN}}{\text{m}}$$

$$X_c = +4.15 \text{ m}$$

$$Y_c = +3.875 \text{ m}$$

	Hydropower plant 1 (200 MW)	Status :	Page : 156
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	Hydropower plant 1 (200 MW)	Status :	Page : 157
		Date :	Created :

Loadcase: Generator I

Search area : Slab 3

Force type : Per unit area

Component z direction : $-375\frac{kN}{m}$

Options for load outside search area : Exclude All Load

Patch type

☐ 8 node patch
☐ 4 node patch
☐ Straight line
☒ Curve

Untransformed load direction

☐ X
☒ Z

☐ Y
☐ Surface normal

Projection vector

☒ Project in load direction

X component

Y component
Z component

	X Coordinate	Y Coordinate	Z Coordinate	Load
1	3.3	3.875	77.85	-375.0
2	3.54896	3.27396	77.85	-375.0
3	4.15	3.025	77.85	-375.0

Attribute
(66)

	Hydropower plant 1 (200 MW)	Status :	Page : 158
		Date :	Created :

Loadcase: Generator II

Search area : Slab 3

Force type : Per unit area

Component z direction : $-375\frac{kN}{m}$

Options for load outside search area : Exclude All Load

Patch type

☐ 8 node patch

☐ 4 node patch

☐ Straight line

☒ Curve

Untransformed load direction

☐ X

☒ Z

☐ Y

☐ Surface normal

Projection vector

☒ Project in load direction

X component

Y component

Z component

Attribute

Generator II

(86)

	Hydropower plant 1 (200 MW)	Status :	Page : 159
		Date :	Created :

Loadcase: Generator III

Search area : Slab 3

Force type : Per unit area

Component z direction : $-375\frac{kN}{m}$

Options for load outside search area : Exclude All Load

Patch type

☐ 8 node patch

☐ 4 node patch

☐ Straight line

☒ Curve

Untransformed load direction

☐ X

☒ Z

☐ Y

☐ Surface normal

Projection vector

☒ Project in load direction

X component

Y component

Z component

	X Coordinate	Y Coordinate	Z Coordinate	Load
1	5.0	3.875	77.85	-375.0
2	4.75104	4.47604	77.85	-375.0
3	4.15	4.725	77.85	-375.0

Attribute

Generator III

(87)

	Hydropower plant 1 (200 MW)	Status :	Page : 160
		Date :	Created :

Loadcase: Generator IV

Search area : Slab 3

Force type : Per unit area

Component z direction : $-375 \frac{kN}{m}$

Options for load outside search area : Exclude All Load

Patch type

☐ 8 node patch
☐ 4 node patch
☐ Straight line
☒ Curve

Untransformed load direction

☐ X
☒ Z

☐ Y
☐ Surface normal

Projection vector
☒ Project in load direction

X component
Y component
Z component

	X Coordinate	Y Coordinate	Z Coordinate	Load
1	3.3	3.875	77.85	-375.0
2	3.54896	4.47604	77.85	-375.0
3	4.15	4.725	77.85	-375.0

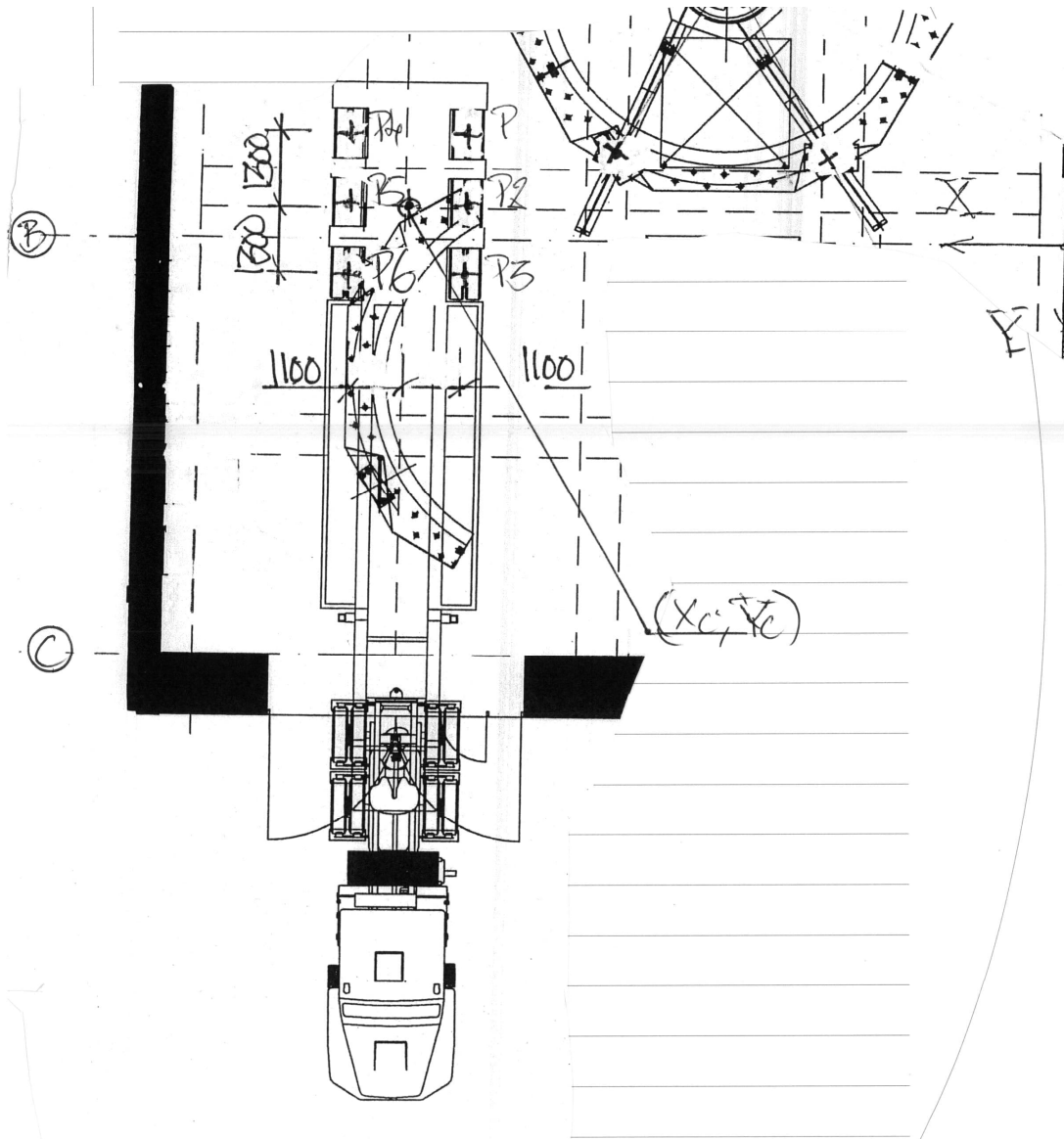
Attribute (88)

Loadcase: Generator

Loading : Generator I / Generator II / Generator III / Generator IV

	Hydropower plant 1 (200 MW)	Status :	Page : 161
		Date :	Created :

3.7.4 Trailer load



The load is considered as 6 point loads.

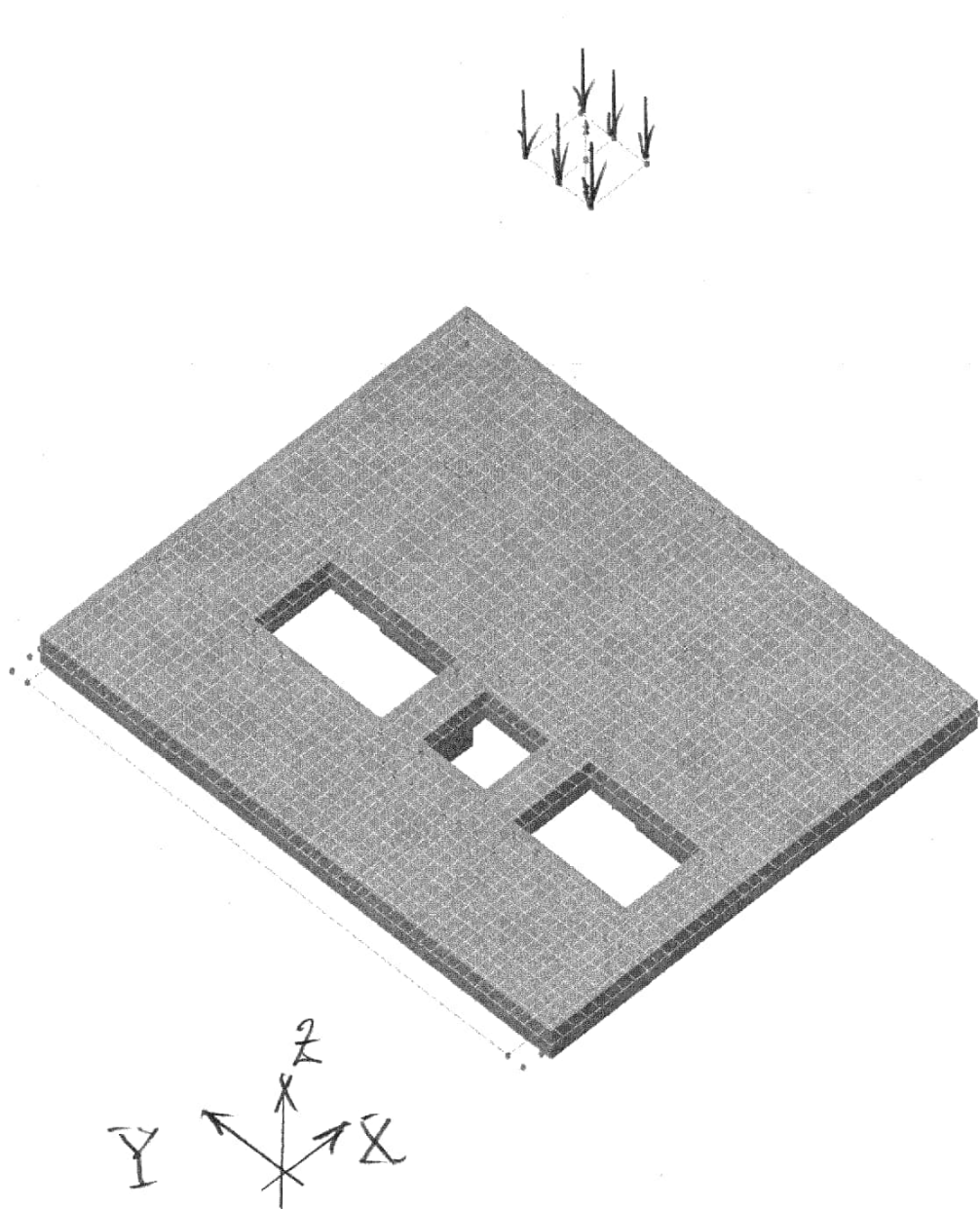
$$\Sigma P = 130 \text{ kN}$$

$$P = \frac{\Sigma P}{6} = 22 \text{ kN}$$

	Hydropower plant 1 (200 MW)	Status :	Page : 162
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$X_c = +13.30 \text{ m}$

$Y_c = +77.85 \text{ m}$



	Hydropower plant 1 (200 MW)	Status :	Page : 163
		Date :	Created :

Loadcase: Trailer

Structural loading : Discrete patch load

Search area : Slab 3

Discrete load : Trailer

Options for load outside search area : Exclude All Load

$$P = \frac{\sum P}{6} = \frac{130kN}{6} = 22kN$$

	Hydropower plant 1 (200 MW)	Status :	Page : 164
		Date :	Created :

3.7.5 Load combinations

Smart loadcombination : Machine load

Loadcase	Permanent factor	Variable factor
Turbine	0	1.00
Strator	0	1.00
Generator	0	1.00
Trailer	0	1.00

	Hydropower plant 1 (200 MW)	Status :	Page : 165
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3.8 WIND LOAD

The effect of wind is neglected at the study of concrete structure since it is considered neglectable.

	Hydropower plant 1 (200 MW)	Status :	Page : 166
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3.9 EARTHQUAKE LOADS

The effect of earthquake is considered by using at simplified method. The method increases the effect of dead weight as seen below (see also OTR 5.6.4).

3.9.1 Unusual loading

The effect is considered by increasing loadcase Dead Weight by 10 % in both vertical and horizontal directions.

Load effect of earthquake (E) : $1.9 \cdot 0.10D = 0.19D$

Loadcase surcharge/dead weight are used to create loadcase earthquake. This is a simplification but considered on the safe side since the resultant of horizontal force is higher than assumed due to the fact that exterior wall is thicker at the bottom than at the top of the structure.

Loading in vertical direction :

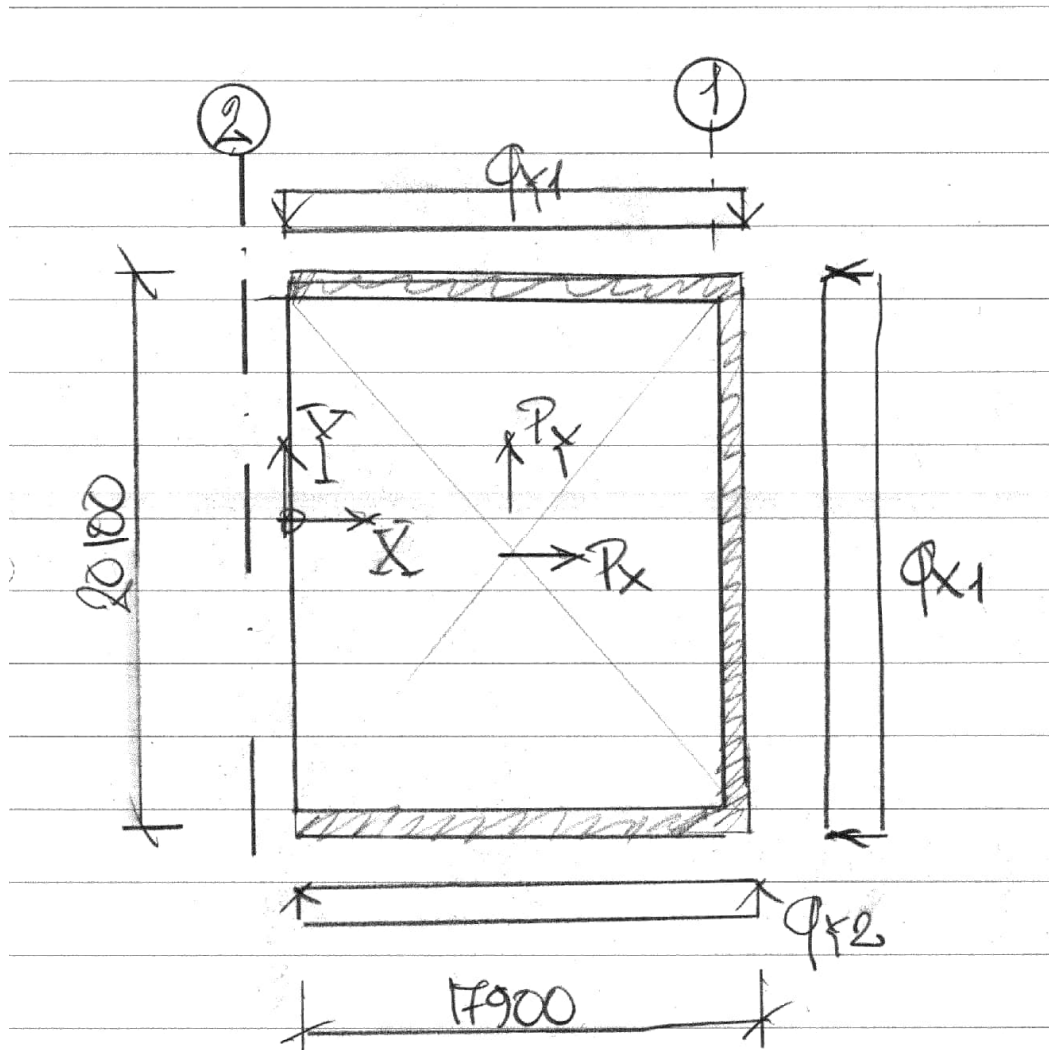
The load effect is transformed using load case *Dead Weight*.

$$f_E = 0.10$$

	Hydropower plant 1 (200 MW)	Status :	Page : 167
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Loading in horizontal direction :

The load effect is transformed using load case *Surcharge*.



Total dead weight : $\Sigma P = 53440 \text{ kN}$

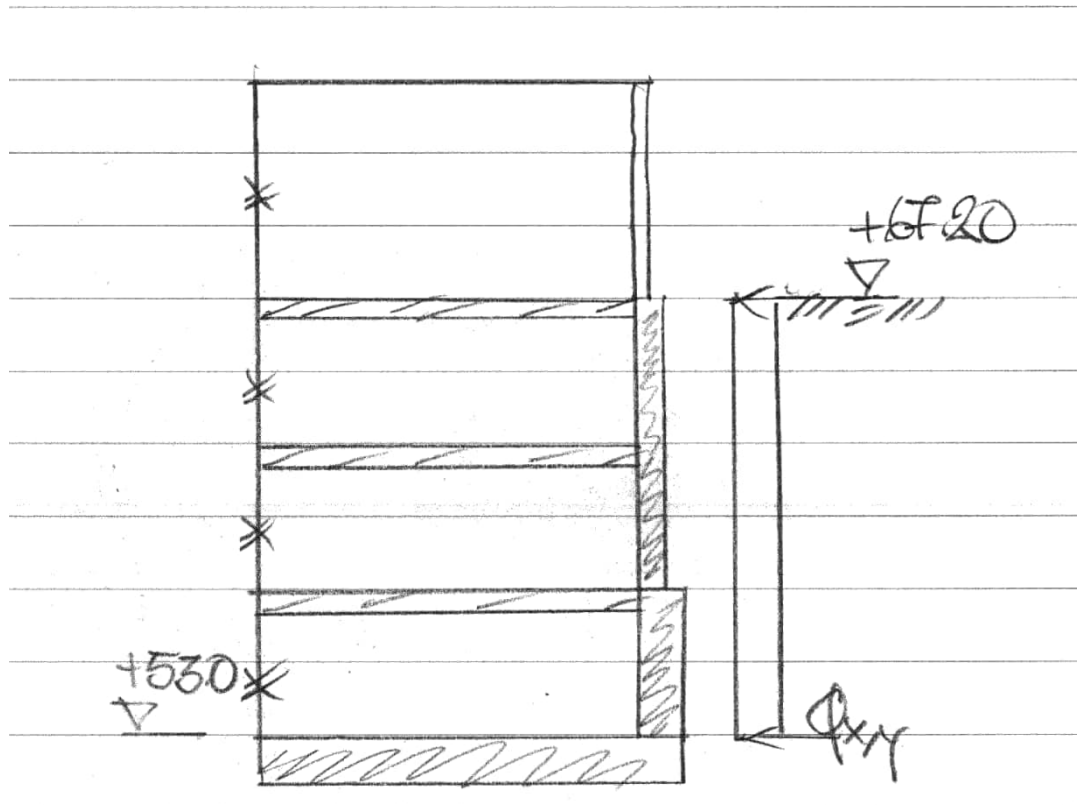
$P_x = P_y = 0.1 \cdot \Sigma P = 5344 \text{ kN}$

Surcharge $qx1 : P_x = 1054 \text{ kN} \Rightarrow f_{E,x1} = \frac{5344 \text{ kN}}{1054 \text{ kN}} = 5.1$

Surcharge $qy1 : P_y = 965 \text{ kN} \Rightarrow f_{E,y1} = \frac{5344 \text{ kN}}{965 \text{ kN}} = 5.5$

Surcharge $qy2 : P_y = 965 \text{ kN} \Rightarrow f_{E,y2} = \frac{5344 \text{ kN}}{965 \text{ kN}} = 5.5$

	Hydropower plant 1 (200 MW)	Status :	Page : 168
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Basic load combinations :

Load combinations	Load case	Load factor
Earthquake max qx	Surcharge qx1	+5.10
Earthquake min qx	Surcharge qx1	-5.10
Earthquake max qy	Surcharge qy1	+5.50
Earthquake min qy	Surcharge qy2	+5.50
Earthquake max qz	Dead weight 1	+0.10
Earthquake min qz	Dead weight 1	-0.10

Smart load combination : Earthquake

Load combinations	Permanent factor	Variable factor
Earthquake max qx	0	1
Earthquake min qx	0	1
Earthquake max qy	0	1
Earthquake min qy	0	1
Earthquake max qz	0	1
Surcharge qy2	0	1

	Hydropower plant 1 (200 MW)	Status :	Page : 169
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3.9.2 Extreme loading

The effect is considered by increasing loadcase Dead Weight by 15 % in both vertical and horizontal directions.

Load effect of earthquake (E) : $1.25 \cdot 0.15D = 0.1875D$

Since $0.19D > 0.1875D$ the effect of earthquake is neglected.

	Hydropower plant 1 (200 MW)	Status :	Page : 170
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3.10 LOAD COMBINATIONS

Document OTR part B chapter 5.5.3 requires control of 6 loading conditions as seen bellow.

- L.C.1 Construction stage loading
- L.C.2 Operating stage loading
- L.C.3 Design flood loading
- L.C.4 Earthquake during operating loading
- L.C.5 Earthquake during construction stage loading
- L.C.6 Post earthquake loading

Control is conducted for L.C.2 and L.C.4 which are considered most dangerous

Remark

In order to avoid checking service state reinforcement the load effect for ultimate state is increased by 33 % (see ACI 10.5.3) when designing.

The hydraulic factor $H_f = 1.3$ applied to load effect in order to avoid using $0.9 \cdot 1.3$ when studying unfavourable effect of permanent loads.

Since extreme earthquake load is less dangerous than unusual earthquake load when applying correct load coefficient it is not considered, see page A3:82.

	Hydropower plant 1 (200 MW)	Status :	Page : 171
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3.10.1 L.C.2

Presented load combination “Ultimate State” corresponds to normal loading corresponds during operating stage.

Normal loading – Max : $U_h = 1.7 \cdot (D+W+E+L)$

Normal loading – Min : $U_h = 0.9 \cdot (D+W+E) + 1.7 \cdot L$

Loadcase	Permanent factor	Variable factor
Dead loads (D)	0.90	0.80
Water loads (W)	0.90	0.80
Earth pressure (E)	0.90	0.80
Surcharge (L)	0	1.70
Surface load (L)	0	1.70
Crain load (L)	0	1.70
Machine load (L)	0	1.70

Loadcombination smart *Permanent Ultimate:LLW*

Loadcase	Permanent factor	Variable factor
Dead weight	0.90	0.70
Water LLW	0.90	0.70
Earth pressure LLW	0.90	0.70

Loadcombination smart *Permanent Ultimate:HHW*

Loadcase	Permanent factor	Variable factor
Dead weight	0.90	0.70
Water HHW	0.90	0.70
Earth pressure HHW	0.90	0.70

Envelope *Permanent Ultimate*

Loadcombination
<i>Permanent Ultimate:LLW</i>
<i>Permanent Ultimate:HHW</i>

	Hydropower plant 1 (200 MW)	Status :	Page : 172
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Loadcombination smart *Variable Ultimate*

Loadcases to consider : 4

Variable cases : 4

Loadcase	Permanent factor	Variable factor
Surcharge	0	1.70
Surface load	0	1.70
Crain load	0	1.70
Machine load	0	1.70

Loadcombination smart *Ultimate*

Loadcase	Permanent factor	Variable factor
Permanent Ultimate	1.00	0
Variable Ultimate	0	1.00

	Hydropower plant 1 (200 MW)	Status :	Page : 173
		Date :	Created :

3.10.2 L.C.4

Presented load combination “Accident State” corresponds to unusual loading corresponds during operating stage.

Unusual loading – Max : $U_h = 1.7 \cdot (D+W+E+L) + 1.9 \cdot E$

Unusual loading – Min : $U_h = 0.9 \cdot (D+W+E) + 1.7 \cdot L + 1.9 \cdot E$

Loadcase	Permanent factor	Variable factor
Dead loads (D)	0.90	0.80
Water loads (W)	0.90	0.80
Earth pressure (E)	0.90	0.80
Surcharge (L)	0	1.70
Surface load (L)	0	1.70
Crain load (L)	0	1.70
Machine load (L)	0	1.70

Loadcombination smart *Permanent Accident:LLW*

Loadcase	Permanent factor	Variable factor
Dead weight	0.90	0.70
Water LLW	0.90	0.70
Earth pressure LLW	0.90	0.70

Loadcombination smart *Permanent Accident:HHW*

Loadcase	Permanent factor	Variable factor
Dead weight	0.90	0.70
Water HHW	0.90	0.70
Earth pressure HHW	0.90	0.70

Envelope *Permanent Accident*

Loadcombination
<i>Permanent Accident:LLW</i>
<i>Permanent Accident:HHW</i>

	Hydropower plant 1 (200 MW)	Status :	Page : 174
		Date :	Created :

Loadcombination smart *Variable Accident*

Loadcases to consider : 5

Variable cases : 5

Loadcase	Permanent factor	Variable factor
Surcharge	0	1.70
Surface load	0	1.70
Crain load	0	1.70
Machine load	0	1.70
Earthquake	0	1.90

* = Vertical contribution of earthquake loading

** = Horizontall contribution of earthquake loading

Loadcombination smart *Accident*

Loadcase	Permanent factor	Variable factor
Permanent Accident	1.00	0
Variable Accident	0	1.00