ภาคผนวก 2-1

รายการคำนวณระบบรวบรวมน้ำเสีย

เอกสารรับรองระบบรวบรวมน้ำเสีย

บริษัท บางกอกโคเจนเนอเรชั่น จำกัด

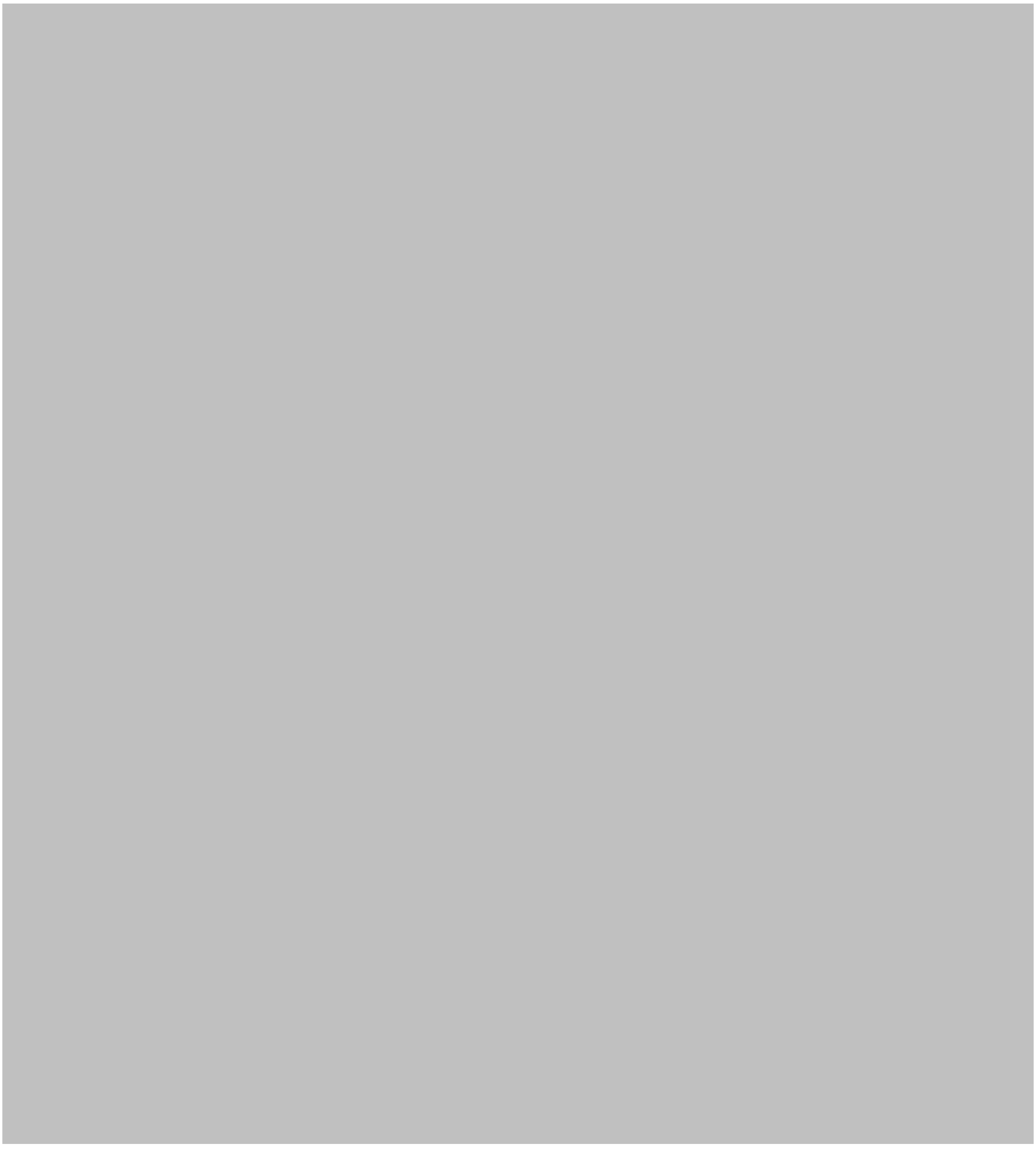
สถานที่ตั้งโครงการ

นิคมอุตสาหกรรมมาบตาพุด ต.มาบตาพุด

อ.เมืองระยอง จ.ระยอง

หนังสือรับรองวิศวกร

ผู้ประกอบวิชาชีพวิศวกรรมควบคุม



PROJECT DESIGN : SEWAGE SYSTEM LOW BOD CALCULATION

บริษัท บางกอกโคเจนเนอเรชั่น จำกัด สถานที่ตั้งโครงการ : นิคมอุตสาหกรรมมาบตาพุด ต.มาบตาพุด อ.เมืองระยอง จ.ระยอง

ตารางที่ 1 การคำนวณขนาดท่อ และรางระบายน้ำของระบบบำบัดน้ำเสียชนิดความสกปรกต่ำ

ลำดับ	ข้อมูลออกแบบ				ท่อระบายน้ำ										
	Line Drainage	Q	Q_{Peak}	SF. 1.3	Pump	T	Q	D	V	L	hL	Z	η	$P_{req.}$	P_{use}
		m^3/day	m^3/hr	m^3/hr	No.	hr	l/s	mm.	m/s	m.	m.	m.	%	HP	HP
A	Cooling Tower blowdown water[/1]	1,521.90	126.83	**164.87**	1	2.20	20.82	100	2.65	445	25.0	6.5	55	18.02	**20.00**
B	RO rejects water	2,652.90	221.08	**287.40**	1	3.00	26.61	150	1.51	150	20.0	6.5	55	19.38	**20.00**
C	Septic Tank 1 (Control and Administration Building)	3.10	0.26	**0.34**	1	0.10	0.93	50	0.48	250	25.0	6.5	55	0.81	**1.50**
D	Septic Tank 2 (Workshop and Warehouse Building)	3.10	0.26	**0.34**	1	0.10	0.93	50	0.48	165	25.0	6.5	55	0.81	**1.00**
E	Plant Sump#1	18.00	1.50	**1.95**	1	0.10	5.42	80	1.08	215	25.0	6.5	55	4.69	**5.50**
F	Plant Sump#2	18.00	1.50	**1.95**	1	0.10	5.42	80	1.08	170	25.0	6.5	55	4.69	**5.50**
G	Neutralization pit	195.00	16.25	**21.13**	1	0.50	11.74	100	1.49	185	20.0	6.5	55	8.55	**10.00**

/1 ตัวอย่างการคำนวณ

Cooling Tower blowdown water	=	1,521.90	m^3/day
จุดเกิดน้ำเสียจำนวน	=	1.00	Sources
น้ำเสียเฉลี่ยของแต่ละแหล่งกำเนิด	=	1,521.90	m^3/day
Peak flow	=	2.00	time of average of wastewater flow
	=	126.83	m^3/hr
	=	**164.87**	m^3/hr

/2 ตัวอย่างการคำนวณขนาดเครื่องสูบน้ำเสียจาก Cooling Tower blowdown water

1) คำนวณความเร็วในท่อ

อัตราการสูบน้ำเสีย (Q)	=	164.87	m^3/hr
จำนวนเครื่องสูบน้ำ	=	1.00	No.
ระยะเวลาสูบน้ำเสีย	=	2.20	hr
	=	20.82	lps
Q	=	AV	
เลือกใช้ขนาดท่อ (D)	=	100.00	mm.
ความเร็วในท่อ	=	$\frac{20.817}{\pi/4\,(0.10^2)}$	
	=	2.65	m/s

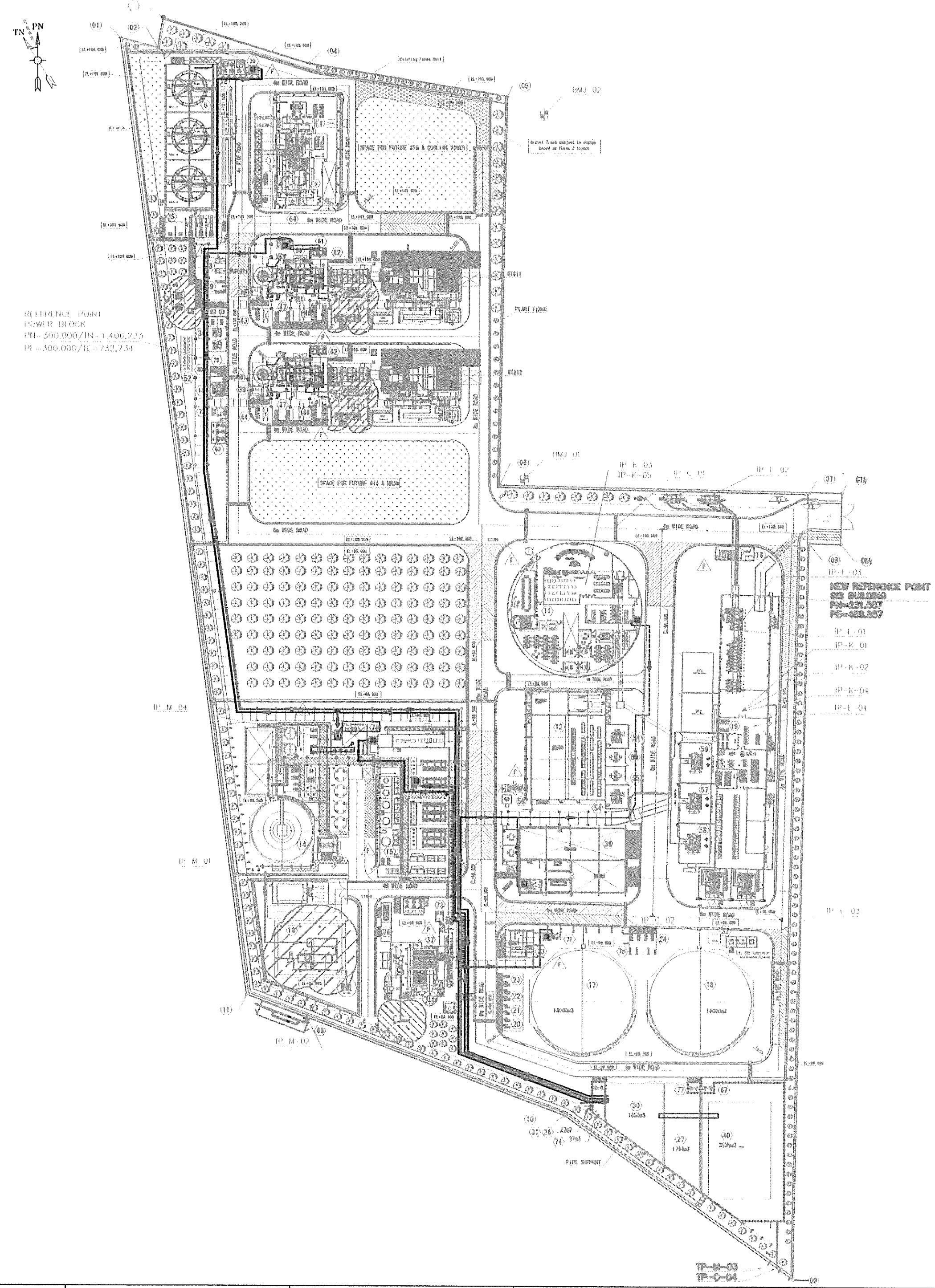
<u>จากสูตรการคำนวณความดันสูญเสียของระบบ</u>

h_L	=	$f\,(L/D)\,(V^2/2g)$	
ระยะทางที่ส่งน้ำเสียประมาณ		445.00	m.
h_L	=	0.015 x (445.00/0.10)*(2.65^2/(2 x 9.81))	
		23.9	m.
ค่าความดันสูญเสียจากความสูง	=	6.50	m. (ความลึกของถัง รวมกับความสูงของ Pipe Rack)
ความความดันสูญเสียทั้งสิ้น	=	23.90 + 6.50	
	=	**30.40**	m.
Safety Factor 15%	=	**34.96**	m.

3) คำนวณขนาดเครื่องสูบน้ำ

PWR	=	$\frac{QH}{102\eta}$	
กำหนดให้ประสิทธิภาพของเครื่องสูบน้ำ ($P_{req.}$)	=	50.00	%
	=	$\frac{20.82 \times 34.96}{102 \times 0.50}$	%
	=	14.27	
	=	19.13	HP
เลือกใช้เครื่องสูบน้ำขนาด	=	**20.00**	HP
จำนวนเครื่องสูบน้ำ	=	2.00	No.

โดยทำงาน 1 เครื่อง สำรอง 1 เครื่อง (สลับกันทำงาน)



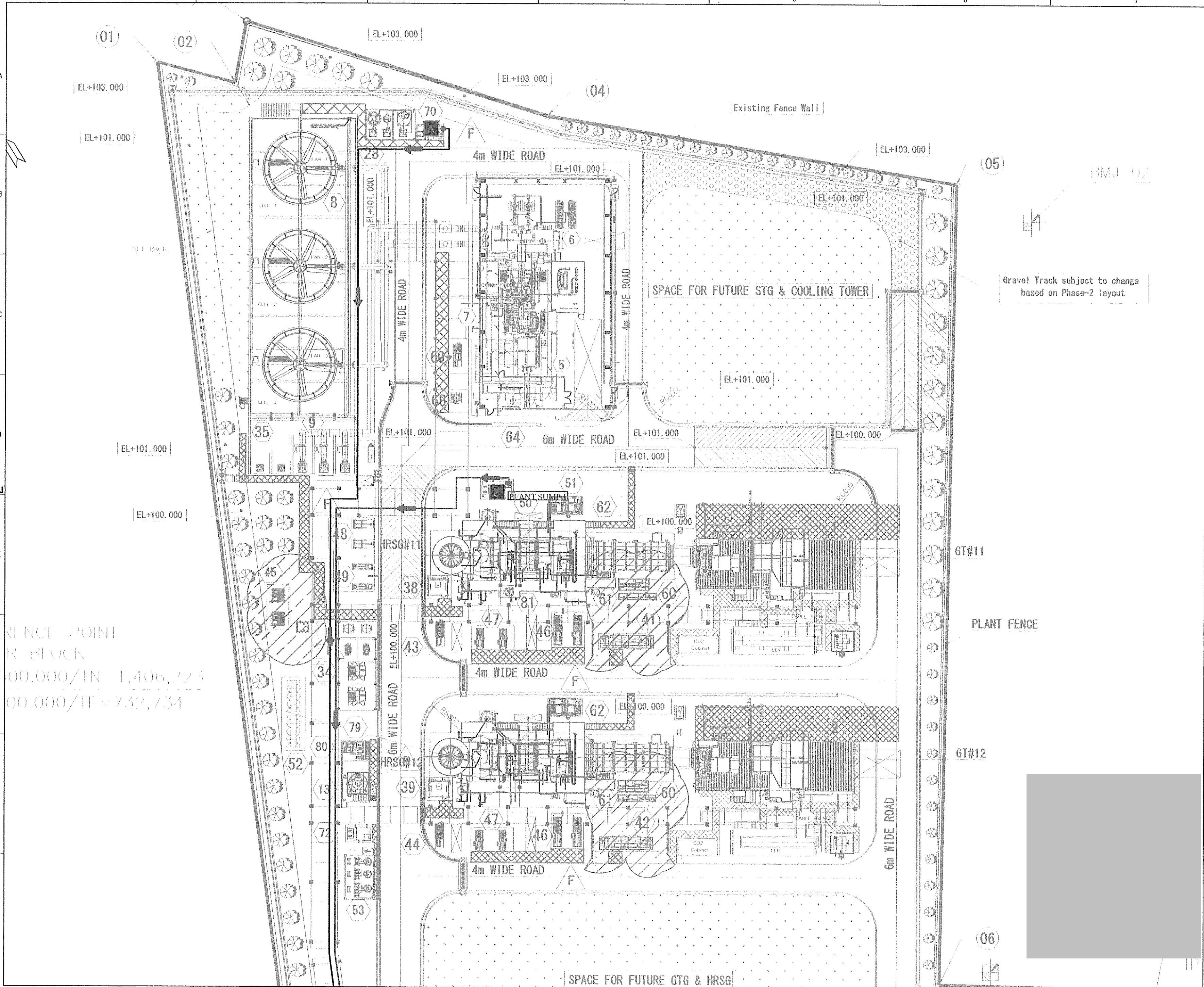
ITEM	DESCRIPTION
(A)	Cooling Tower blowdown water
(B)	RO rejects water
(C)	Septic Tank 1 (Control and Administration Building)
(D)	Septic Tank 2 (Workshop and Warehouse Building)
(E)	Plant Sump#1
(F)	Plant Sump#2
(G)	Neutralization pit

ø50 mm. (Underground)
ø100 mm. (Underground)
ø150 mm. (Underground)
ø50 mm. (Pipe Rack)
ø80 mm. (Pipe Rack)
ø100 mm. (Pipe Rack)
ø150 mm. (Pipe Rack)
Flow direction (BY PUMP)
Flow direction (Gravity)
SLOPE 1:250

OWNER: BANGKOK COGENERATION

TITLE: แบบแปลนระบบรวบรวมน้ำเสียของโรงงาน

JOB NO:	REV	SHT
	0	1/4



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ø100 mm. (Underground)
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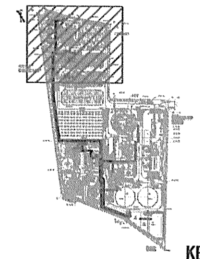
ø50 mm. (Pipe Rack)
ø80 mm. (Pipe Rack)
ø100 mm. (Pipe Rack)
ø150 mm. (Pipe Rack)
Flow direction (BY PUMP)
Flow direction (Gravity) SLOPE 1:250

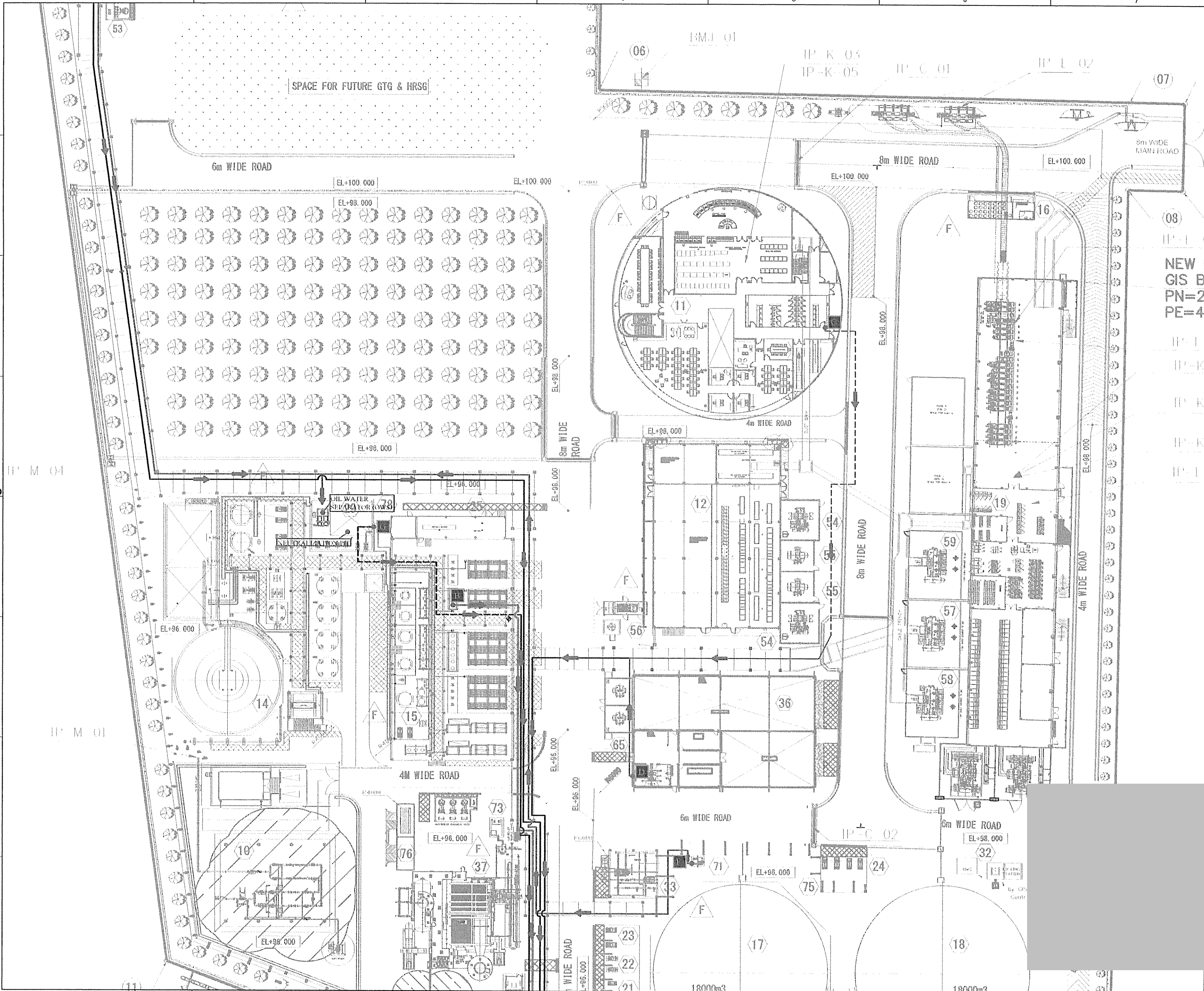


KEY PLAN

OWNER: BANGKOK COGENERATION

TITLE: แบบขยายระบบรวบรวมน้ำเสีย 1/3

JOB NO.	REV	SHT
	0	2/4



ITEM	DESCRIPTION
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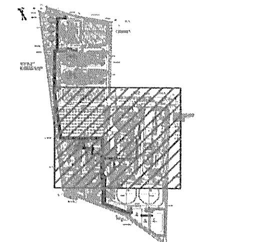
D	Septic Tank 2 (Workshop and Warehouse Building)
E	Plant Sump#1
F	Plant Sump#2
G	Neutralization pit

ø50 mm. (Underground)	
ø100 mm. (Underground)	
ø150 mm. (Underground)	
ø50 mm. (Pipe Rack)	
ø80 mm. (Pipe Rack)	
ø100 mm. (Pipe Rack)	
ø150 mm. (Pipe Rack)	
Flow direction (BY PUMP)	
Flow direction (Gravity) SLOPE 1:250	

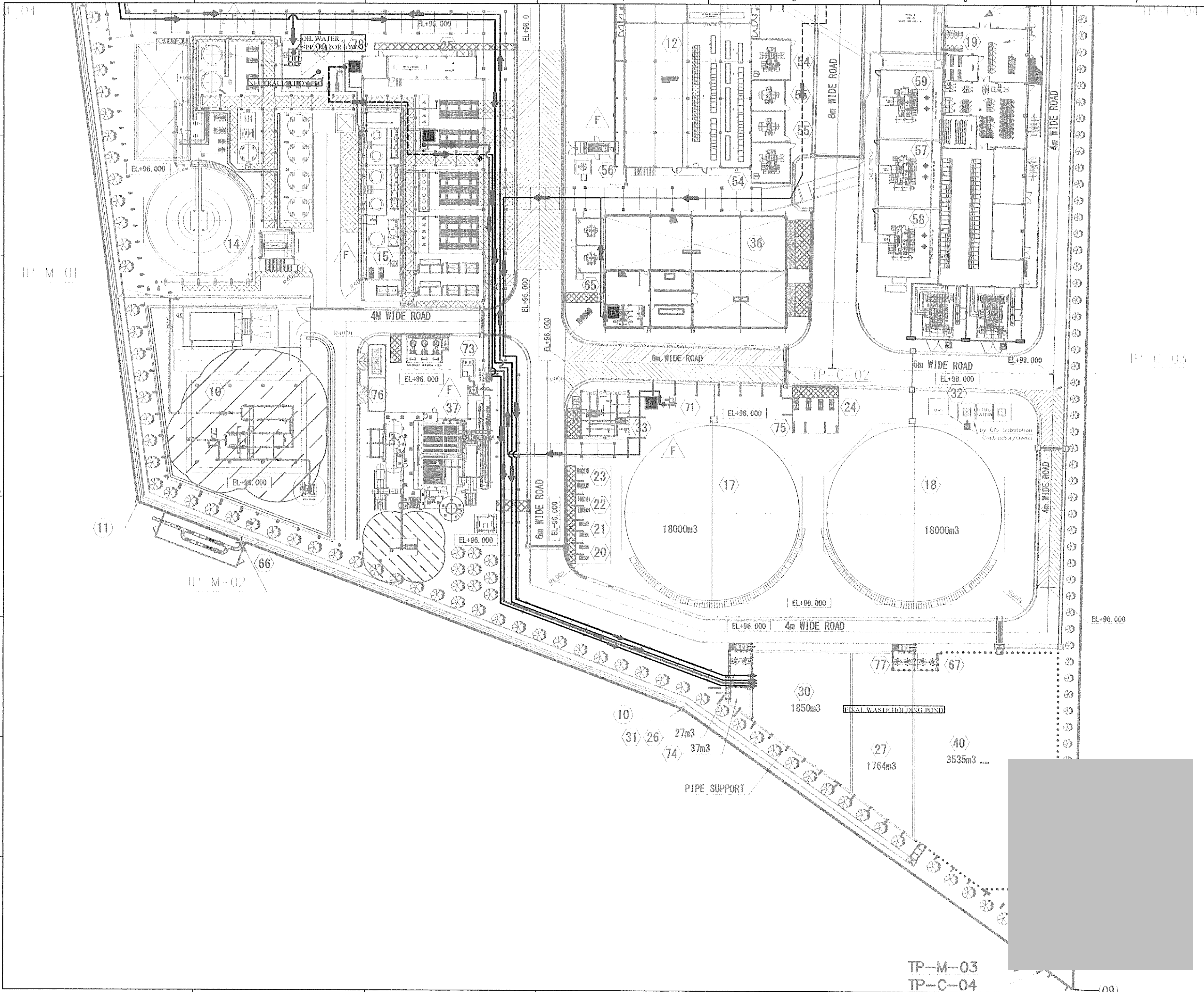


KEY PLAN

OWNER: BANGKOK COGENERATION

TITLE: แบบขยายระบบรวบรวมน้ำเสีย 2/3

JOB NO: | REV 0 | SHT 3/4



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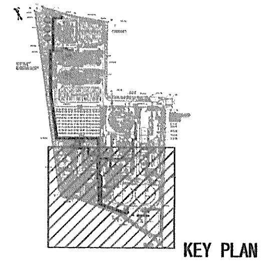
E	Plant Sump#1
F	Plant Sump#2
G	Neutralization pit

- ø50 mm. (Underground)
- ø100 mm. (Underground)
- ø150 mm. (Underground)
- ø50 mm. (Pipe Rack)
- ø80 mm. (Pipe Rack)
- ø100 mm. (Pipe Rack)
- ø150 mm. (Pipe Rack)
- Flow direction (BY PUMP)
- Flow direction (Gravity) SLOPE 1:250

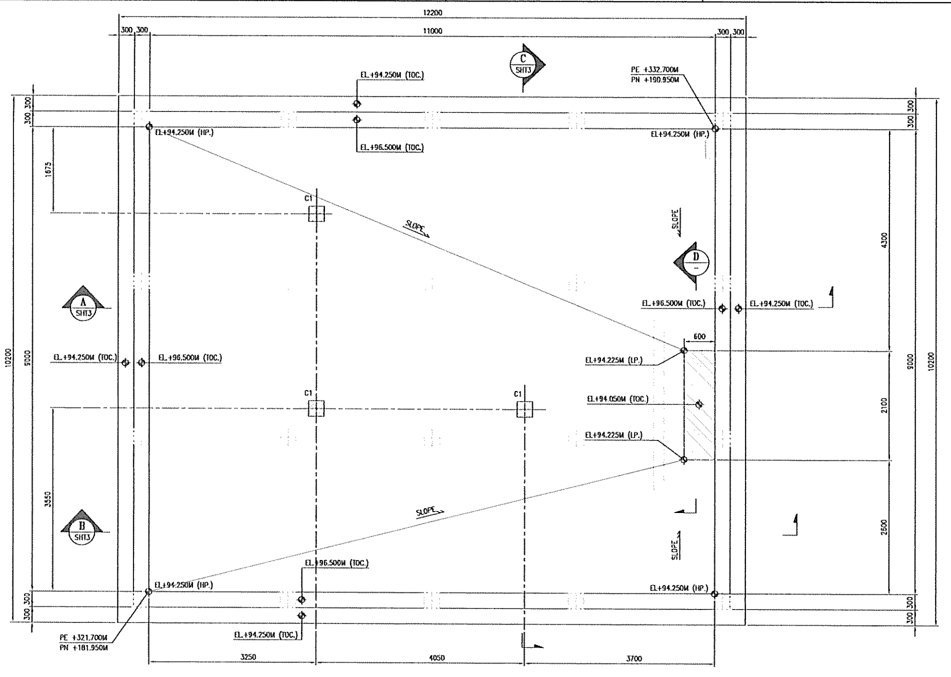


KEY PLAN

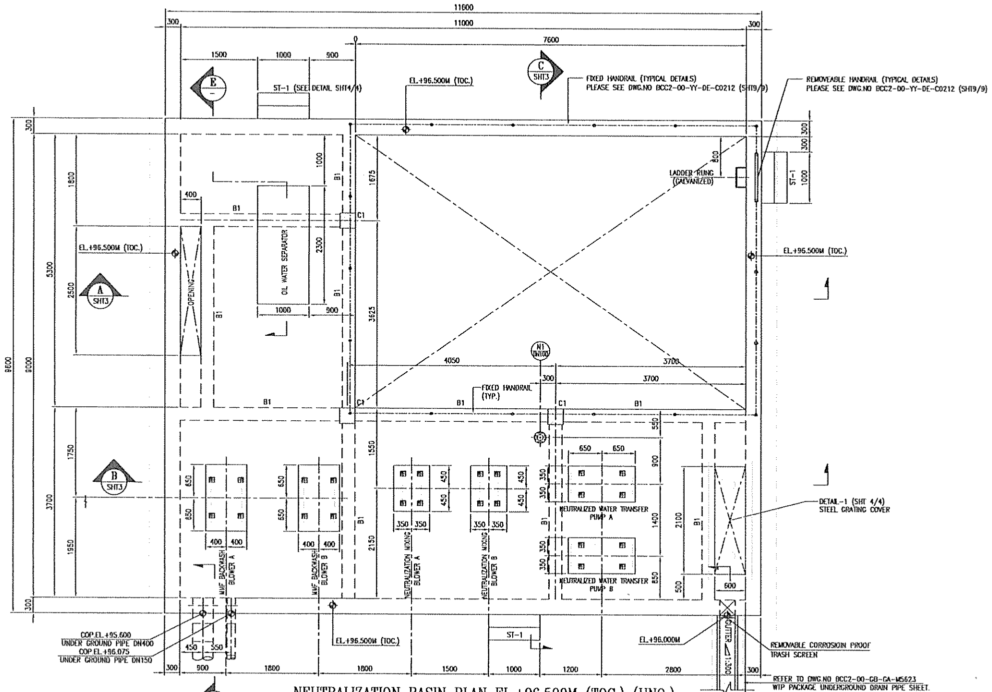
OWNER: BANGKOK COGENERATION

TITLE: แบบขยายระบบรวบรวมน้ำเสีย 3/3

JOB NO:	REV	SHT
	0	4/4

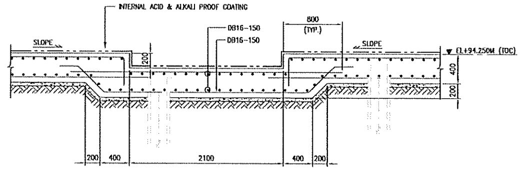


NEUTRALIZATION BASIN FOUNDATION PLAN EL.+94.250M (TOC.) (UNO.)
SCALE 1:50

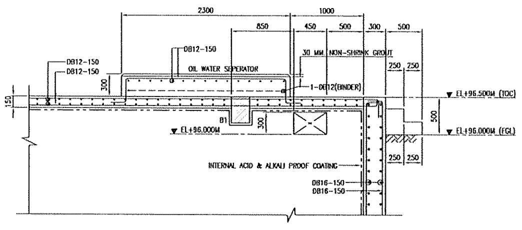


NEUTRALIZATION BASIN PLAN EL.+96.500M (TOC.) (UNO.)
SCALE 1:50

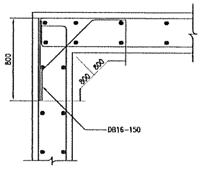
NOTE:
ADDITIONAL REINFORCEMENT AT OPENING OF SLAB OR WALL
PLEASE SEE DWG.NO BB2-00-YYY-DE-C0212 (SHT 2/9)



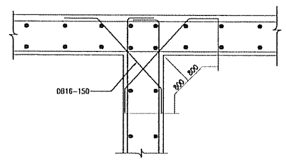
SECTION D
SCALE 1:35



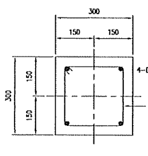
SECTION E
SCALE 1:35



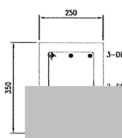
TYP.CONER DETAIL OF WALLS IN HOR. CROSS SECTION
SCALE 1:25

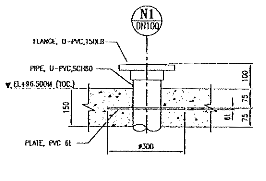


TYP.INTERSECTION DETAIL OF WALLS IN HOR. CROSS SECTION
SCALE 1:25

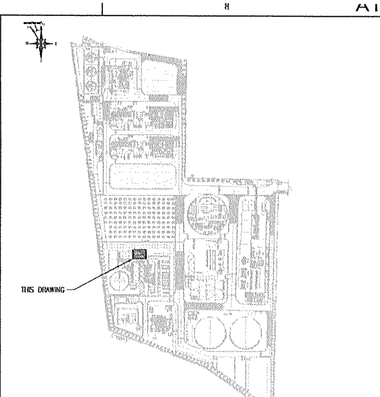


C1 DETAIL
SCALE 1:10





DETAIL NOZZEL N1
SCALE 1:10



KEY PLAN

GENERAL NOTE:

1. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE STATED.
2. ALL ELEVATIONS & COORDINATES ARE IN METERS UNO.
3. PLANT EL+100.000M (FGL) = + 25.7M ABOVE MSL.
4. CONCRETE GRADE SHALL BE AS FOLLOWS:
   (a) STRUCTURAL CONCRETE f'c=28 N/mm² (CYLINDER STRENGTH) AT 28 DAYS
   (b) LEAN CONCRETE f'c= 15 N/mm²
   (c) FOR FOUNDATION AT OR BELOW GRADE WORK (BELOW GROUND LEVEL) SHALL BE HYDRAULIC CEMENT TYPE IP AS PER ASTM C595
5. REINFORCEMENT STEEL SHALL BE AS FOLLOWS:
   (a) DB=HIGH YIELD "TYPE-2" DEFORMED BARS WITH fy=400 N/mm²
6. CRANK SLOPE OF BARS > 1:10.
7. CONCRETE COVER:

STRUCTURAL ELEMENT	CONCRETE COVERS (mm)
PILE CAP BASE	75
PILE CAP SIDE, FOOTING	75
BEAMS, COLUMNS, STUMPS, WALLS, SLABS (IN CONTACT WITH GROUND)	75
BEAMS, COLUMNS, STUMPS (NOT IN CONTACT WITH GROUND)	40
SLABS, WALLS (NOT IN CONTACT WITH GROUND)	30
CONCRETE SURFACE EXPOSED TO WEATHER (No.19 THROUGH No.57 BARS)	50
CONCRETE SURFACE EXPOSED TO WEATHER (No.16 BAR AND SMALLER)	40
CONCRETE SURFACE EXPOSED TO LIQUID	50

8. ALL EXPOSED CONCRETE EDGES TO BE CHAMFERED 25MM ON X & Y DIRECTION.
9. BCC2 -00-YYY-DE-C0212-GENERAL NOTES AND TYPICAL DETAILS FOR CIVIL AND STRUCTURES.

LEGEND:-

FFL = FINISH FLOOR LEVEL.	FGL = FINISH GROUND LEVEL.
TOG = TOP OF GROUTING.	TOC = TOP OF CONCRETE.
TOS = TOP OF STEEL.	BOS = BOTTOM OF STEEL.
UNO = UNLESS NOTED OTHERWISE.	TOGr = TOP OF GRATING
TYP = TYPICAL.	NTS = NOT TO SCALE
HDG = HOT DIPPED GALVANIZED	THK = THICKNESS
B/W = BOTH WAYS	T&B = TOP & BOTTOM
BOC = BOTTOM OF CONCRETE.	

REFERENCE DWG:

1. BCC2-00-YYY-GA-A0021_PLANT EQUIPMENT LAYOUT.
2. BCC2-00-GB-GA-M5623_WTP PACKAGE UNDERGROUND DRAIN PIPE SHEET.
3. BCC2-00-GB-GA-M5619_WTP PACKAGE-PUMPS GENERAL ARRANGEMENT.
4. BCC2-00-GB-GA-M5665 WTP PACKAGE-NEUTRALIZATION PIT GENERAL ARRANGEMENT

REV	DATE	DESCRIPTION	DRAWN	DESIGNED	CHECKED	APPROVED	STATUS
0	30-11-2021	ISSUED FOR CONSTRUCTION	SUTHEE	PHANUSIT	ANAN	PORNRUITAI	C
E	17-11-2021	REVISED AS CLOUDED AND RE-ISSUED FOR APPROVAL	SUTHEE	PHANUSIT	ANAN	PORNRUITAI	A
D	04-11-2021	REVISED AS CLOUDED AND RE-ISSUED FOR APPROVAL	SUTHEE	PHANUSIT	ANAN	PORNRUITAI	A
	15-10-2021	REVISED AS CLOUDED AND RE-ISSUED FOR APPROVAL	SUTHEE	PHANUSIT	ANAN	PORNRUITAI	A
	...08-2021	REVISED AS CLOUDED AND RE-ISSUED FOR APPROVAL	SWISS	PHANUSIT	ANAN	PORNRUITAI	A
	...07-2021	ISSUED FOR APPROVAL	SUTHEE	PHANUSIT	ANAN	PORNRUITAI	A

BANGKOK COGENERATION COMPANY LTD.

ENGINEER: AFRY (THAILAND) LTD.

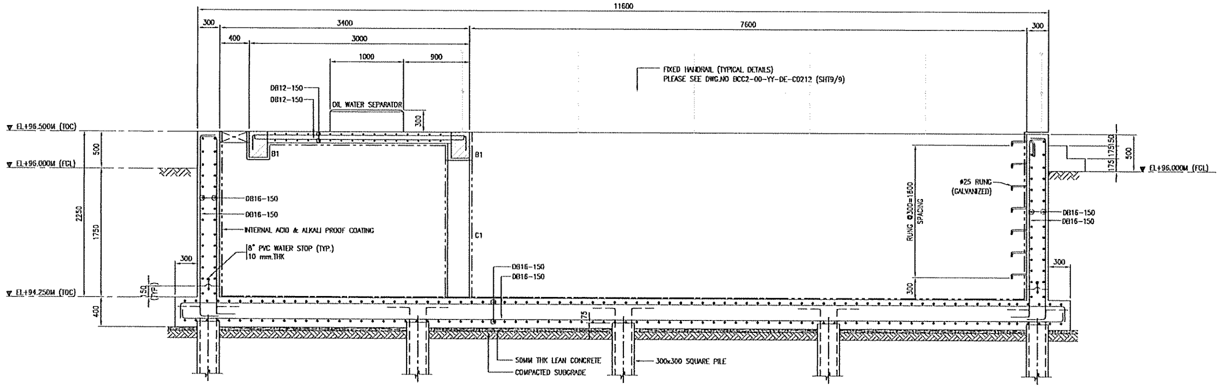
CONSORTIUM: Jurong Engineering Limited; Thai Jurong Engineering Limited

	FOR INFORMATION
	FOR REVIEW
	FOR APPROVAL
✓	FOR CONSTRUCTION
	AS BUILT

SCALE: AS SHOWN
PROJECT: BCC2 COMBINED CYCLE POWER PLANT

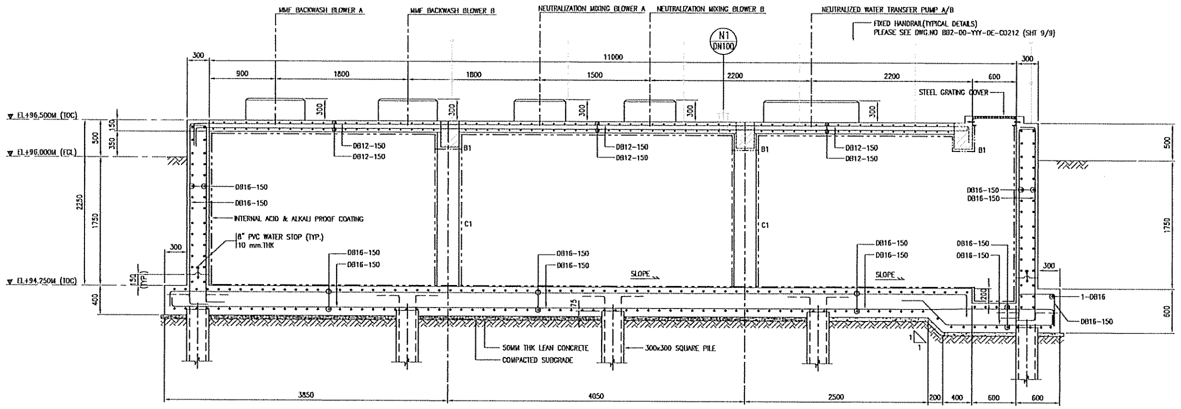
TITLE: WTP NEUTRALIZATION BASIN AND NWT PUMP STRUCTURE AND FDN LAYOUT & DETAILS

PROJECT DRAWING NO:	JOB NO:	REV	SHT
BCC2-00-UGE-FD-C5633	20054	0	2/4

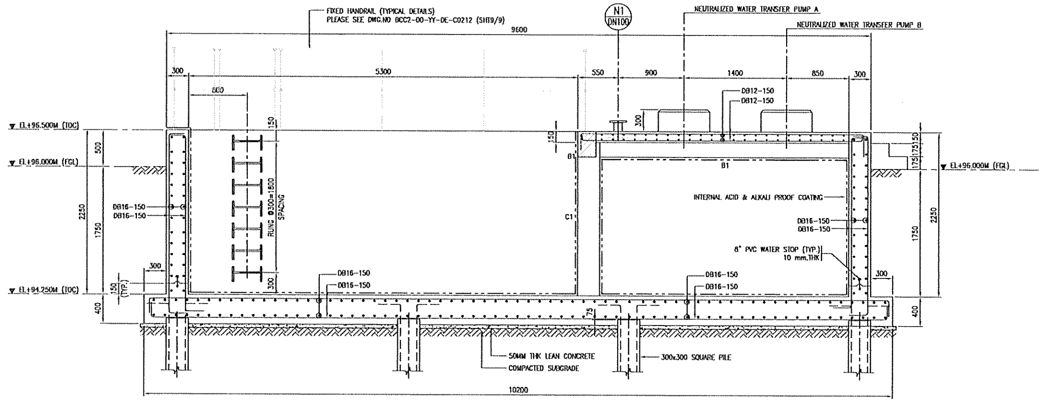


SECTION A
SCALE: 1:35
SHT1

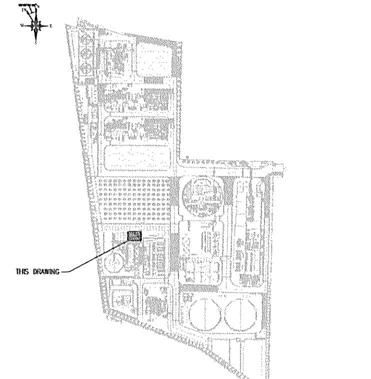
NOTE:
ADDITIONAL REINFORCEMENT AT OPENING OF SLAB OR WALL
PLEASE SEE DWG.NO BCC2-00-YYY-DE-C0212 (SHT 2/9)



SECTION B
SCALE: 1:35
SHT1



SECTION C
SCALE: 1:35
SHT1



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E	17-11-2021	REVISED AS CLOUDED AND RE-ISSUED FOR APPROVAL	SUTHEE	PHANUSIT	ANAN	PORNRUITAI	A
		REVISED AS CLOUDED AND RE-ISSUED FOR APPROVAL	SUTHEE	PHANUSIT	ANAN	PORNRUITAI	A
		REVISED AS CLOUDED AND RE-ISSUED FOR APPROVAL	SUTHEE	PHANUSIT	ANAN	PORNRUITAI	A
		REVISED AS CLOUDED AND RE-ISSUED FOR APPROVAL	SWISS	PHANUSIT	ANAN	PORNRUITAI	A
		ISSUED FOR APPROVAL	SUTHEE	PHANUSIT	ANAN	PORNRUITAI	A

BANGKOK COGENERATION COMPANY LTD.

AFRY (THAILAND) LTD.

Engineering Limited

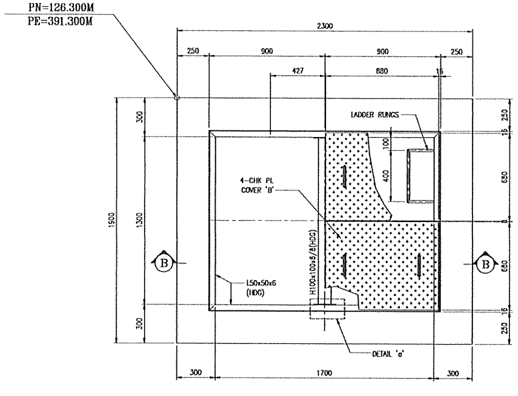
TJEL Thai Jurong Engineering Limited

	FOR REVIEW
	FOR APPROVAL
✓	FOR CONSTRUCTION
	AS BUILT

SCALE: AS SHOWN
PROJECTION
PROJECT: BCC2 COMBINED CYCLE POWER PLANT

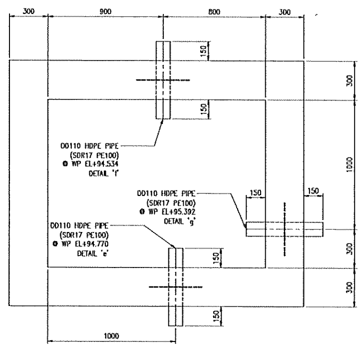
TITLE: WTP NEUTRALIZATION BASIN AND NWT PUMP STRUCTURE AND FDN LAYOUT & DETAILS

PROJECT DRAWING NO: BCC2-00-UGE-FD-C5633
JOB NO: 20054
REV: 0
SHT: 3/4



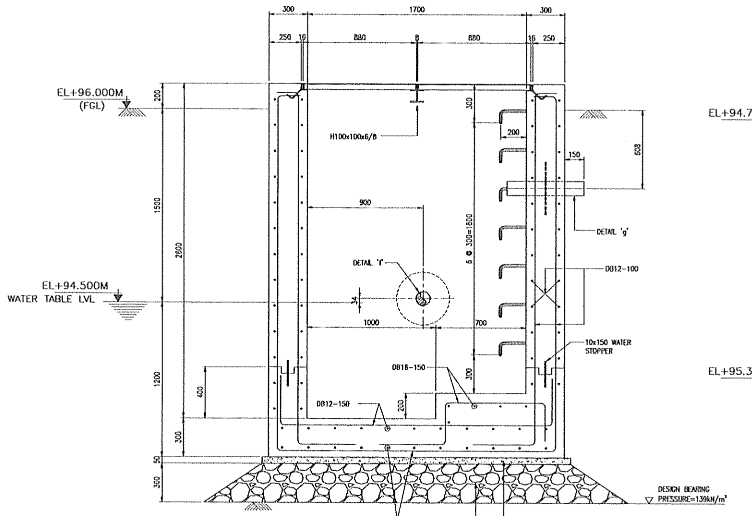
PLANT SUMP 2 LAYOUT PLAN

SCALE 1:20



PLANT SUMP 2 LAYOUT PLAN

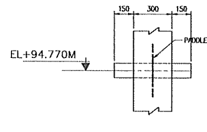
SCALE 1:20



SECTION B–B

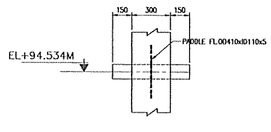
SCALE 1:20

NOTE: PLATE BEARING TESTS IN ACCORDANCE WITH ASTM D1194 SHALL BE CONDUCTED TO CONFIRM THE DESIGN BEARING CAPACITY.



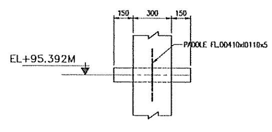
DETAIL 'e'

SCALE 1:20



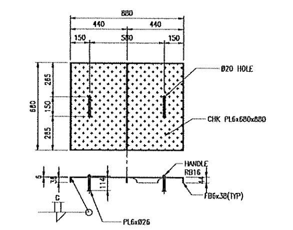
DETAIL 'f'

SCALE 1:20



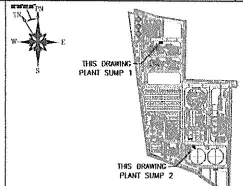
DETAIL 'g'

SCALE 1:20



CHK PL COVER 'B' (HDG)

SCALE 1:20



KEY PLAN

GENERAL NOTE:

1. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE STATED.
2. ALL ELEVATIONS & COORDINATES ARE IN METERS UNO.
3. PLANT EL+100.000M (FGL) = +25.7M ABOVE MSL.
4. PLANT AREA FINISH GROUND LEVEL (FGL)

AREA DESCRIPTION	FGL (M)	SURVEY LEVEL (M)	ABOVE MSL (M)
PLANT SUMP 1	EL+100	+10.5	+25.7
PLANT SUMP 2	EL+96	+6.50	+21.7

5. CONCRETE GRADE SHALL BE AS FOLLOWS:
   (a) STRUCTURAL CONCRETE f'c=28 N/mm² (CYLINDER STRENGTH) AT 28 DAYS
   (b) LEAN CONCRETE f'c= 15 N/mm²
   (c) CEMENT SHALL BE ORDINARY PORTLAND CEMENT TYPE 1 FOR ABOVE GRADE WORK (ABOVE GROUND LEVEL) AS PER ASTM C150 AND HYDRAULIC CEMENT TYPE IP FOR BELOW GRADE WORK (BELOW GROUND LEVEL) AS PER ASTM C595.
6. REINFORCEMENT STEEL SHALL BE AS FOLLOWS:
   (a) DB=HIGH YIELD "TYPE-2" DEFORMED BARS WITH fy=400 N/mm²
7. LAP SPLICE IN TENSION FOR DIFFERENT BAR SIZE SHALL BE THE GREATER OF LARGER BAR DEVELOPMENT LENGTH AND TENSION LAP SPLICE LENGTH OF THE SMALLER BAR.
8. CRANK SLOPE OF BARS > 1:10.
9. CONCRETE COVER:

STRUCTURAL ELEMENT	CONCRETE COVERS (mm)
PILE CAP BASE	75
COLUMNS, BEAMS, STUMPS, WALLS, SLABS (IN CONTACT WITH GROUND)	75
COLUMNS, BEAMS, STUMPS, WALLS, SLABS (CONTACT WITH LIQUID)	50

10. ALL EXPOSED CONCRETE EDGES TO BE CHAMFERED 25MM ON X & Y DIRECTION.
11. FOR GENERAL NOTES FOR CIVIL AND STRUCTURE REFER TO DWG. NO BCC2-00-YYY-DE-C0212.

LEGEND:–

FFL = FINISH FLOOR LEVEL
TOC = TOP OF CONCRETE.
UNO = UNLESS NOTED OTHERWISE
NTS = NOT TO SCALE
B/W = BOTH WAYS
FGL = FINISH GROUND LEVEL
TOS = TOP OF STEEL
TOGr = TOP OF GRATING
HDG = HOT DIPPED GALVANIZED
T&B = TOP & BOTTOM
TOG = TOP OF GROUTING
BOS = BOTTOM OF STEEL
TYP = TYPICAL
THK = THICKNESS
CJ = CONSTRUCTION JOINT

REFERENCE DWG:

BCC2-00-YYY-DE-C0212-GENERAL NOTES AND TYPICAL DETAILS FOR CIVIL AND STRUCTURES
BCC2-00-GMA-GA-P7602-UNDERGROUND PIPING GA DRAWING (PLAN)
BCC2-00-GMA-GA-P7603-UNDERGROUND PIPING GA DRAWING (SECTION)
BCC2-00-GNB-CL-M7211-OIL WATER SEPARATOR SIZING CALCULATION

DATE	DESCRIPTION	DRAWN	DESIGNED	CHECKED	APPROVED	STATUS
9/09/21	ISSUED FOR CONSTRUCTION	Dav.	SMR	RAM	RAM	C
3/09/21	REVISED AS CLOUDED AND ISSUED FOR APPROVAL	Dav.	SMR	RAM	RAM	A
5/08/21	ISSUED FOR APPROVAL	Dav.	SMR	RAM	RAM	A

	FOR INFORMATION
	FOR REVIEW
	FOR APPROVAL
✓	FOR CONSTRUCTION
	AS BUILT

BANGKOK COGENERATION COMPANY LTD.

ENGINEER :

AFRY (THAILAND) LTD.

SORTIUM :

Jurong Engineering Limited

Thai Jurong Engineering Limited

SCALE: AS SHOWN

PROJECTION

PROJECT : BCC2 COMBINED CYCLE POWER PLANT

TITLE: PLANT SUMP STRUCTURE LAYOUT & DETAILS

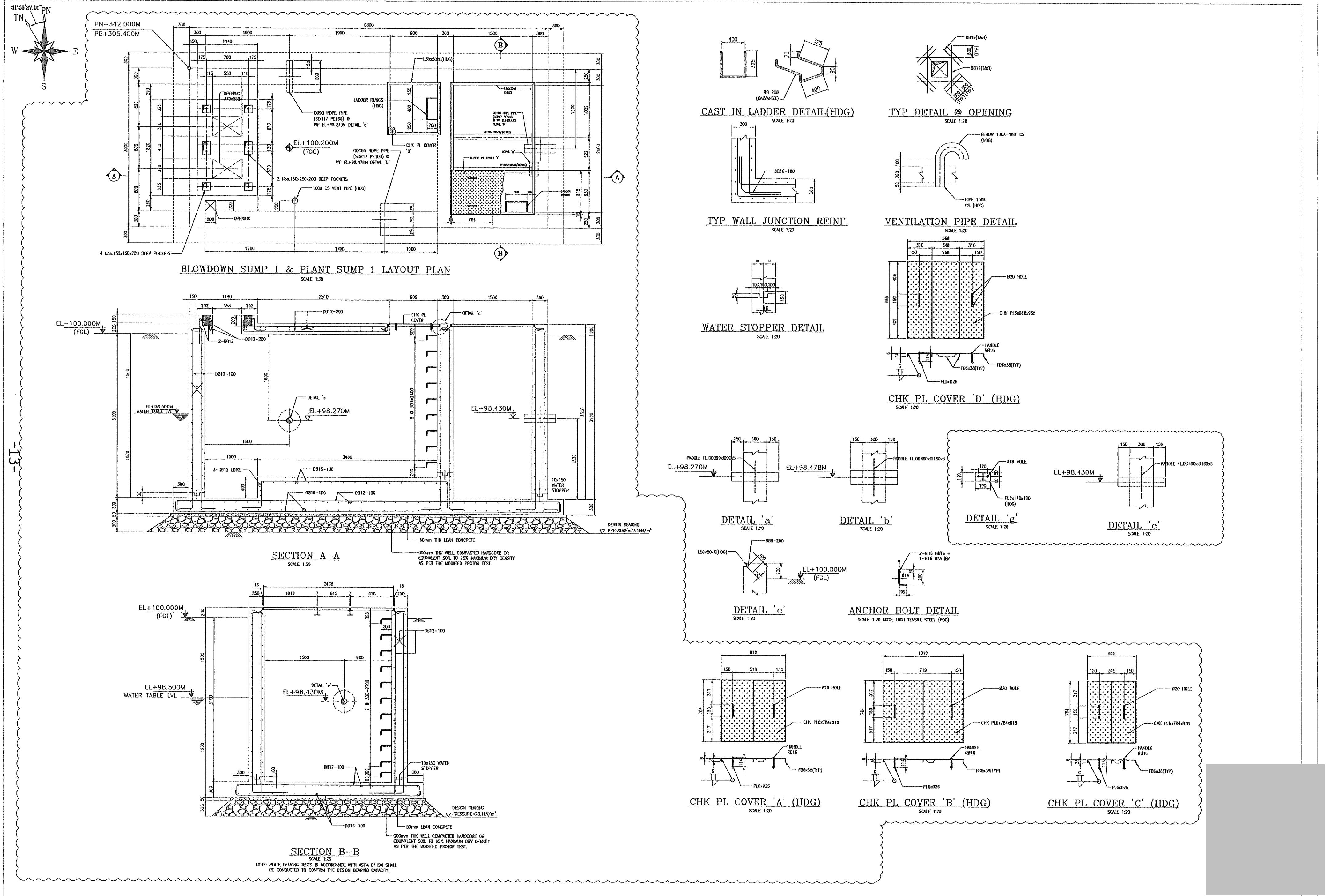
PROJECT DRAWING NO: BCC2-00-UGH-FD-C7304

JOB NO: 20054

REV: 0

SHT: 2/2

-12-



PN+342.000M
PE+305.400M
EL+100.200M
(TOC)
BLOWDOWN SUMP 1 & PLANT SUMP 1 LAYOUT PLAN
SCALE 1:30
EL+100.000M
(FGL)
EL+98.500M
WATER TABLE LVL
EL+98.270M
EL+98.430M
SECTION A–A
SCALE 1:30
SECTION B–B
SCALE 1:20
NOTE: PLATE BEARING TESTS IN ACCORDANCE WITH ASTM D1194 SHALL BE CONDUCTED TO CONFIRM THE DESIGN BEARING CAPACITY.
CAST IN LADDER DETAIL(HDG)
SCALE 1:20
TYP DETAIL @ OPENING
SCALE 1:20
TYP WALL JUNCTION REINF.
SCALE 1:20
VENTILATION PIPE DETAIL
SCALE 1:20
WATER STOPPER DETAIL
SCALE 1:20
CHK PL COVER 'D' (HDG)
SCALE 1:20
DETAIL 'a'
SCALE 1:20
DETAIL 'b'
SCALE 1:20
DETAIL 'g'
SCALE 1:20
DETAIL 'e'
SCALE 1:20
DETAIL 'c'
SCALE 1:20
ANCHOR BOLT DETAIL
SCALE 1:20 NOTE: HIGH TENSILE STEEL (HDG)
CHK PL COVER 'A' (HDG)
SCALE 1:20
CHK PL COVER 'B' (HDG)
SCALE 1:20
CHK PL COVER 'C' (HDG)
SCALE 1:20

ภาคผนวก 2-2

รายการคำนวณระบบบำบัดน้ำเสียสำเร็จรูป

เอกสารรับรองระบบบำบัดน้ำเสียสำเร็จรูป

บริษัท บางกอกโคเจนเนอเรชั่น จำกัด

สถานที่ตั้งโครงการ

นิคมอุตสาหกรรมมาบตาพุด ต.มาบตาพุด

อ.เมืองระยอง จ.ระยอง

หนังสือรับรองวิศวกร

ผู้ประกอบวิชาชีพวิศวกรรมควบคุม

ระบบบำบัดน้ำเสียแบบสำเร็จรูป

Control and Administration Building

บริษัท บางกอกโคเจนเนอเรชั่น จำกัด

นิคมอุตสาหกรรมมาบตาพุด ต.มาบตาพุด อ.เมืองระยอง จ.ระยอง

ลักษณะของน้ำเสียจากอาคารประเภทต่างๆ

ลักษณะ	หอพัก		ภัตตาคาร		โรงพยาบาล	ตลาดสด	อาหารสำนักงาน		สถานบริการอาบ อบ นวด*	ห้างสรรพสินค้า	โรงภาพยนตร์	โรงแรม	อาคารชุด (คอนโดมิเนียม)
	จากส้วม	จากส่วนอื่นๆ	จากส้วมบำบัดแล้ว+ครัวและอื่นๆ	จากครัว+อื่นๆ			จากส้วม	จากครัวอื่นๆ					
pH	8.55	7.78	6.54	6.74	6.84	6.67	8.10	7.4	6.6	7.51	7.53	7.05	7.20
COD(mg/l)	1,290	135	1,785	3,164	350	2,528	392	96	117	253	110	311	221
BOD(mg/l)	723	75	919	1,759	238	1,172	181	41	55	81	60	190	151
TKN(mg/l)	329	19.2	55.1	63.2	15.2	76.5	44.1	9.7	14.1	66.8	72.7	23	33.7
PO_4 (mg/l)	6.8	3.9	3.2	2.6	3.29	5.1	2.0	0.4	14.7	10.1	2.7	1.8	2.0
SS (mg/l)	666	29	401	913	87.06	662	158	26	17.1	61	45	84	63
FOG(mg/l)	377	411	1,136	1,570	631	897	455	527	452.86	577	219	563	473

* บำบัดมาแล้วบางส่วน

ที่มา : น้ำเสียชุมชนและปัญหามลภาวะทางน้ำในเขต กทม. และปริมณฑล, ธงชัย พรรณสวัสดิ์ และคณะ, สำนักงานคณะกรรมการสิ่งแวดล้อมแห่งชาติ, 2530

รุ่นที่ใช้ : **Premier Product รุ่น SS-5**

จุดติดตั้ง : **Control and Administration Building**

ระบบบำบัดที่ใช้ : **ระบบบำบัดน้ำเสียแบบเติมอากาศชนิดที่มีตัวกลางยึดเกาะ**

<u>ข้อมูลการออกแบบ</u>

1.จากตารางลักษณะของน้ำเสียจากอาคารประเภทต่างๆ ค่า BOD เข้าระบบ = **181 mg/l**

ในการออกแบบเลือกออกแบบค่าความสกปรกในรูปของค่า BOD ที่เข้าระบบ = 250 mg./l.

2.ปริมาณน้ำเสียรวม, Q

จำนวนพนักงานต่อห้อง = 60 คน

อัตราการเกิดน้ำเสีย = 0.8 x อัตราการใช้น้ำ

อัตราการใช้น้ำต่อคน = 75 ลิตร/ คน/ วัน

Ref : แนวทางการจัดทำรายงานการวิเคราะห์ผลกระทบสิ่งแวดล้อมโครงการหรือกิจการด้านอาคาร การจัดสรรที่ดิน และบริการชุมชน, สำนักงานนโยบายและแผนทรัพยากรธรรมชาติและสิ่งแวดล้อม. กรกฎาคม 2560.

ปริมาณน้ำเสียรวม = 0.8x60x75 = 3.60 m^3/d

Safety Factor = 20%

ปริมาณน้ำเสีย = 3.60 x 1.20 = 4.32 m^3/d

- **เลือกใช้ถังบำบัดน้ำเสียที่สามารถบำบัดน้ำเสียได้ปริมาตร 5 ลูกบาศก์เมตร/วัน**

รายการคำนวณระบบบำบัดน้ำเสียสำเร็จรูป

Control and Administration Building

บริษัท บางกอกโคเจนเนอเรชั่น จำกัด

สถานที่ตั้งโรงงาน นิคมอุตสาหกรรมมาบตาพุด ต.มาบตาพุด อ.เมืองระยอง จ.ระยอง

รายการคำนวณระบบบำบัดน้ำเสีย

ข้อมูลการออกแบบ

1. ค่าบีโอดีเข้าระบบ	=	250.00	มก./ลิตร
2. ปริมาณน้ำเสียรวม	=	5.00	ลบ.ม./วัน
3. ปริมาณน้ำเสียที่คิด	=	5,000.00	ลิตร/วัน
4. ค่าบีโอดีที่มีอยู่ในน้ำเสียที่เข้าระบบ, BOD_{inf}	=	250.00	มก./ลิตร
ค่าบีโอดีที่มีอยู่ในน้ำเสียที่ออกจากระบบ, BOD_{eff}	=	20.00	มก./ลิตร
ประสิทธิภาพการกำจัดบีโอดี	=	(BODinf - BODeff) / BODinf	
	=	0.92	
5. ภาระสารอินทรีย์ทั้งหมดในรูปบีโอดี, Lr	=	1.25	กก./วัน

6. ถังเกรอะ (Separation Chamber)

เพื่อแยกกาก, ของแข็ง และ ให้เกิดการย่อยสลายสิ่งปฏิกูลด้วยกระบวนการไม่ใช้อากาศ

ระยะเวลาในการกักเก็บน้ำเสียภายในถัง, RT	=	12.00	ชั่วโมง
ปริมาตรทั้งหมดของถังเกรอะ	=	F * RT	
	=	2.50	ลบ.ม.
ประสิทธิภาพในการลด บีโอดี	=	0.20	
บีโอดี เข้าส่วนกรองเติมอากาศ	=	200.00	มก./ลิตร
บีโอดีโหลด เข้าส่วนกรองเติมอากาศ	=	1.00	กก.บีโอดี/วัน

7. ถังเติมอากาศ (Aeration Tank)

เพื่อทำการบำบัดน้ำเสียด้วยจุลินทรีย์ที่ต้องการอากาศ โดยในระบบจะมีการเติมอากาศให้แก่จุลินทรีย์ที่ต้องการอากาศโดยใช้แอร์ปั๊ม

7.1 ส่วนเติมอากาศ (Aeration Chamber)

ระยะเวลาในการกักเก็บน้ำเสีย, RT	=	10.00	ชั่วโมง
ปริมาตรน้ำเสียทั้งหมดที่เกิดขึ้น, F	=	5.00	ลบ.ม./วัน
ปริมาตรส่วนเติมอากาศ	=	F * RT	
	=	2.08	ลบ.ม.

7.2 ปริมาตรถังเติมอากาศ (Aeration Tank)

กำหนดค่าอัตราส่วน F / M	=	0.30	กก.BOD / กก.MLVS
ภาระสารอินทรีย์ทั้งหมดในรูปบีโอดี, Lr	=	1.00	กก.BOD/

ค่า MLVSS ทั้งหมดในถังเติมอากาศ	=	3.33	กก.
ค่า MLVSS	=	0.80	ของ MLSS
ค่า MLSS ทั้งหมดในถังเติมอากาศ	=	4.17	กก.
	=	4,166,666.67	มก.
ค่าความเข้มข้น MLSS ในถังเติมอากาศ	=	2,000.00	มก./ลิตร
ปริมาตรของถังเติมอากาศที่คำนวณได้	=	2.08	ลบ.ม.

7.3 ปริมาณอากาศที่ต้องการ (Air Required)

ปริมาณออกซิเจนที่ต้องการ, O2 required	=	a * Lr + b * Sa	
เมื่อ a คือ สัมประสิทธิ์การกำจัดบีโอดี	=	0.50	กก.O2 /กก.BOD
Lr คือ ภาระสารอินทรีย์ทั้งหมดในรูปบีโอดี	=	1.00	กก.BOD/วัน
b คือ สัมประสิทธิ์อัตราการย่อยสลายจำเพาะ	=	0.10	กก.O2/kgMLSS-วัน
ปริมาตรของถังเติมอากาศ	=	2.08	ลบ.ม.
Sa คือ ค่า MLSS ทั้งหมดในถังเติมอากาศ	=	4,166,666.67	มก.MLSS
	=	4.17	กก.MLSS
ปริมาณออกซิเจนที่ต้องการ, O2 required	=	0.92	กก.O2/วัน
ค่าการละลายของออกซิเจนในน้ำ	=	0.03	
ปริมาณออกซิเจนในอากาศที่อุณหภูมิ 28 C	=	0.28	กก.O2/ลบ.ม.อากาศ
ปริมาณอากาศที่ต้องการ, Air required	=	110.31	ลบ.ม.อากาศ/วัน
	=	76.60	ลิตร-อากาศ/นาที
Safety Factor	=	1.50	
ใช้ลม	=	114.91	ลิตร-อากาศ/นาที
เลือกใช้ Air Pump รุ่น AP-120L at 0.2bar 110w.	=	120.00	ลิตร-อากาศ/นาที
	=	7.20	ลบ.ม/ชม.
จำนวน	=	1.00	ตัว
	=	120.00	ลิตร-อากาศ/นาที

7.4 ตัวกลาง

BOD Loading เข้าส่วนเติมอากาศ	=	1.00	กก./วัน
ชนิดของตัวกลาง Big Bio			
พื้นที่ผิวสัมผัส	=	105.00	ตร.ม./ลบ.ม.-ตัวกรอง
ปริมาณตัวกลาง	=	0.50	ลบ.ม
ปริมาณพื้นที่ผิวตัวกลาง	=	52.50	ตร.ม.
ความหนาของชั้นฟิมส์	=	70.00	ไมครอน
	=	70.00	กรัม/ตร.ม.
ปริมาณจุลินทรีย์	=	3.68	กก
F/M ratio	=	0.27	กก.BOD/กก.MLVSS-วัน
F/M ratio ที่ออกแบบ	=	0.30	กก.BOD/กก.MLVSS-วัน
			OK

8. ส่วนตกตะกอน (Sedimentation Chamber)

ระยะเวลาในการตกตะกอน (RT)	=	1.98	ชั่วโมง

ปริมาณน้ำเสียทั้งหมด, F	=	5.00	ลบ.ม./วัน
ปริมาตรส่วนตกตะกอน	=	F * RT/24	
	=	0.41	ลบ.ม.
อัตราการไหลล้นต่อพื้นที่ (overflow rate/sq.m)	=	24.00	ลบ.ม./ตร.ม.-วัน
พื้นที่ผิวของถังตกตะกอน	=	0.22	ตร.ม.
ต้องการพื้นที่ผิวที่ต้องการ (surface area required)	=	0.21	ตร.ม.

9. เปรียบเทียบสมรรถนะของถังบำบัดที่มาจากการออกแบบกับที่ใช้งานจริง

	สมรรถนะของถังบำบัด ที่มาจากการออกแบบ		สมรรถนะของถังบำบัด ที่ใช้งานจริง
1. ปริมาตรถังเกรอะ, ลบ.ม.	2.50	>=	2.50
3. ปริมาตรส่วนเติมอากาศ, ลบ.ม.	2.09	>	2.08
4. ปริมาณอากาศที่ต้องการ, ลิตร-อากาศ/นาที	120.00	>	114.91
5. ปริมาตรส่วนตกตะกอน, ลบ.ม.	0.41	>=	0.41

รับน้ำเสียจาก : Control and Administration Building

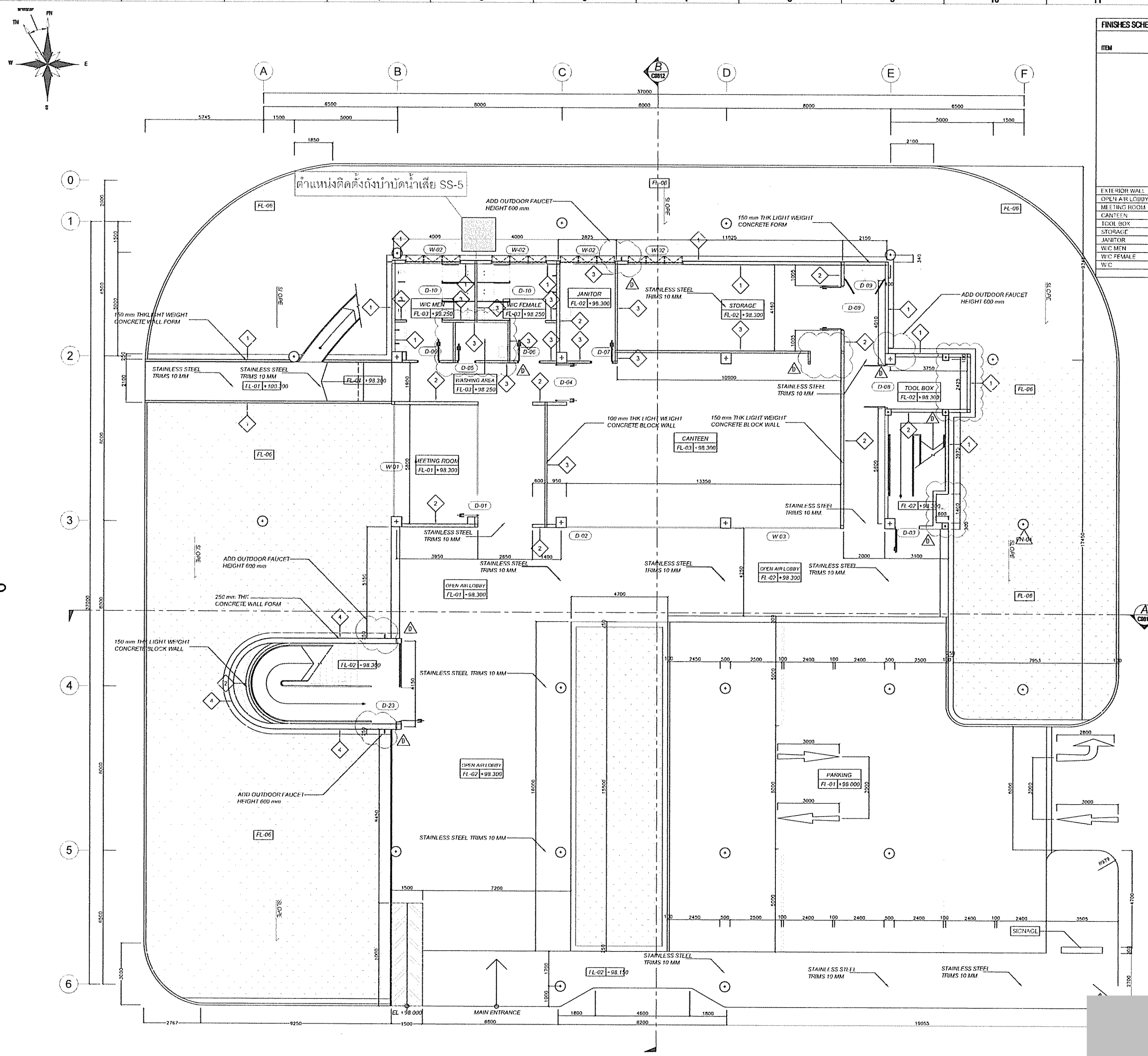
ถังบำบัดน้ำเสีย รุ่น SS-5 จำนวน ......1... ชุด

ข้อมูลรายละเอียด (Specification) /ชุด

1. ชนิดน้ำเสีย	ระบบบำบัดน้ำเสียรวม
2. ชนิดของระบบที่ใช้บำบัด	ระบบบำบัดน้ำเสียแบบเติมอากาศชนิดที่มีตัวกลางยึดเกาะ
3. ปริมาณน้ำเสีย	5ลบ.ม./วัน บีโอดีเข้า 250 มก./ล. บีโอดี ออก 20 มก/ลิตร
4. ปริมาตรของถังบำบัดแต่ละส่วน	ความจุส่วนเกรอะ 2.5 ลบ.ม. ส่วนเติมอากาศ 2.09 ลบ.ม.
	ส่วนตกตะกอน 0.41 ลบ.ม
5. ปริมาตรรวมของถังบำบัดน้ำเสีย	5.00 ลบ.ม.
6. ขนาดถัง	ถังบำบัด เส้นผ่าศูนย์กลาง 2.04 ม. สูง 2.42 ม.
7. ชนิดของสื่อชีวภาพ	
7.1ในส่วนเติมอากาศ	POLYETHYLENE ทรงกระบอกสูง dia 90 มม. สูง 90 มม.
	พื้นที่ผิว 105 ตร.ม/ลบ.ม Void 95 % จำนวน 0.5 ลบ.ม
8. เครื่องเติมอากาศ	ใช้ Diaphargm air pump ให้อากาศได้ 120 ลิตร/นาที กำลังไฟ 110 วัตต์
	ความดัน 0.20 กิโลกรัม/ตารางเซนติเมตร ไฟฟ้า 220/1/50
	จำนวนเครื่อง 1 เครื่อง และได้รับรองความปลอดภัย จากสถาบันที่เชื่อถือได้ เช่น UL เป็นต้น
9. ขนาดท่อน้ำเสีย / ระบายอากาศ	4 นิ้ว / 2 นิ้ว พีวีซี
10. วัสดุตัวถัง	ไฟเบอร์กลาสเสริมแรง (FRP)
11. ผู้ผลิต	เป็นบริษัทที่ได้รับการรับรองมาตรฐาน ISO 9001 : 2008
12. วิธีการพันถัง/สีตัวถัง	ใช้ระบบ Auto- Spay up
13. น้ำหนักถังเปล่า+น้ำหนักของเสีย	ถังเกรอะ 5,200 กิโลกรัม
14. จำนวนถังบำบัดน้ำเสีย	1 ใบ/ ชุด

ขบวนการบำบัดน้ำเสีย

ถังบำบัดน้ำเสียที่นำมาใช้นี้จะใช้กับน้ำเสียรวมจากกิจกรรมต่างๆ ตัวถังทำด้วยไฟเบอร์กลาสเสริมแรง ประกอบด้วย ถังเกรอะ เป็นส่วนแยกกากตะกอนหนักและเบา และส่วนบำบัดแบบเติมอากาศ ซึ่งเป็นระบบแบบ Fix Film Aeration ทำหน้าที่ลดค่าความสกปรกของน้ำเสีย จนได้น้ำทิ้งตามมาตรฐานน้ำทิ้ง และส่งไปยังบ่อพักน้ำทิ้ง



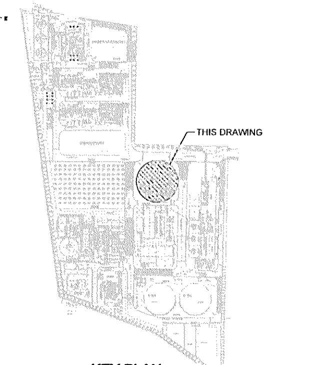
FLOOR PLAN & WALL STRUCTURE PLAN @EL +98.300M (FFL)

SCALE 1:100

FINISHES SCHEDULE

ITEM	ROOF	FLOOR: NON SLIP TERRAZZO TILE WITH STAINLESS STRIP 8mm. THK.	FLOOR: NON SLIP CONCRETE FLOOR WITH STAINLESS STRIP 8mm. THK.	FLOOR: NON SLIP CERAMIC FLOOR TILE 600x600	WALL: CONCRETE WALL CONCRETE FORM TIE	WALL: PLASTERED WALL WITH A POLISHED CONCRETE SURFACE	WALL: PLASTERED WALL + WALL PAINT	WALL: PLASTERED WALL + MIRROR 6mm. THK.	WALL: PLASTERED WALL + CERAMIC WALL TILE 600x600	CEILING: 600 x 1200 SUSPENDED ACOUSTIC PLANEL (MOISTURE RESISTANT)	CEILING: EXPOSED CEILING	HEIGHT TO SOFFIT OF CEILING FROM FINISHED FLOOR (m)
EXTERIOR WALL					X						X	
OPEN AIR LOBBY			X			X					X	
MEETING ROOM			X					X			X	
CANTEEN		X				X					X	
TOOL BOX			X				X				X	
STORAGE			X				X				X	
JANITOR			X				X				X	
W/C MEN				X					X	X		3.2
W/C FEMALE				X					X	X		3.2
W/C				X					X	X		3.2

LEGEN	DETAIL
FLOOR	
FLR-01	CONCRETE ROAD
FLR-02	POLISHED CONCRETE
FLR-03	TERRAZZO
FLR-04	WOOD LOOK TILE
FLR-05	RAISED FLOOR
FLR-06	GRASS & VOLCANIC STONE WALL
FLR-07	CONCRETE ROOF WITH WATERPROOFER and COVER WITH WATERPROOF MEMBRANE
WALL	
1	CONCRETE WALL FORM 150 mm
2	LIGHT WEIGHT CONCRETE BLOCK WALL 150 mm. (TOTAL THK.)
3	LIGHT WEIGHT CONCRETE BLOCK WALL 100 mm (TOTAL THK.)
4	CONCRETE WALL FORM 250 mm.
5	LIGHT-WALL 100 mm



KEY PLAN

GENERAL NOTE:

1. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE STATED.
2. ALL ELEVATIONS & COORDINATES ARE IN METERS UNO.
3. PLANT EL+100.000 M.(FGL) = +25.7 M. ABOVE MSL.
4. ALL EXTERIOR WALL SHALL BE 150 mm THK. LIGHT WEIGHT CONCRETE BLOCK
5. ALL INTERIOR WALL SHALL BE 100 mm THK. LIGHT WEIGHT CONCRETE BLOCK
6. ALL ROOF SHALL BE 0.55 MM THK METAL ROOF SHEETING WITH 50MM THK MINERAL WOOL OR FIBRE GLASS INSULATION LINED WITH REFLECTIVE ALUMINIUM FOIL.
7. ALL HANDRAILS ARE HOT DIPPED GALVANIZED WITH PAINTING.
8. PLANT AREA FINISH GROUND LEVEL (FGL)

AREA DESCRIPTION	FGL (M)	SURVEY LEVEL (M)	ABOVE MSL (M)
PLAN - 1 (ST & CT AREA)	EL+101.000	+11.50	+26.7
PLAN - 2 (GT & HRSG AREA)	EL+100.000	+10.50	+25.7
PLAN - 3 (ADMIN,ELE,WTP & WORKSHOP AREA)	EL+98.000	+8.50	+23.7
PLAN - 4 (TANK & AUX, BOILER AREA)	EL+97.000	+7.50	+22.7
PLAN - 5 (POND AREA)	EL+95.000	+6.00	+21.2

LEGEND

- COLUMN
- GYPSUM BOARD PARTITION WALL (TEMPORARY)
- 150mm THK LIGHT WEIGHT CONCRETE BLOCK WALL
- MOISTURE RESISTANT CEILING
- 100mm THK LIGHT WEIGHT CONCRETE BLOCK WALL
- CONCRETE
- FLOOR ELEVATION
- LAWN

C1 - 600x1200 SUSPENDED EXPOSED GRID ACOUSTIC BOARD

C2 - 600x1200 SUSPENDED EXPOSED GRID MOISTURE RESISTANT GYPSUM BOARD

FFL = FINISH FLOOR LEVEL. FGL = FINISH GROUND LEVEL. UNO = UNLESS NOTED OTHERWISE.
TOG = TOP OF GROUTING. TOC = TOP OF CONCRETE. TYP = TYPICAL.
TOS = TOP OF STEEL. BOS = BOTTOM OF STEEL. RWDP = RAINWATER DOWN PIPE.
TOGr = TOP OF GRATING. NTS = NOT TO SCALE. HDG = HOT DIPPED GALVANIZED.
THK = THICKNESS. R = STAIR RISER. T = STAIR TREAD.
DP = DRAIN PIT

HOLD LIST:

1 : WAITING CONFIRM

REFERENCE DWG:

- BCC2-00-UYC-GA-C9812 Control and Administration Bldg Architectural Elevations & Sections
- BCC2-00-UYC-GA-C9813 Control and Administration Bldg Schedule of Doors and Windows

REV.	DATE	DESCRIPTION	DRAWN	DESIGNED	CHECKED	APPROVED	STATUS
D	23-08-2021	REVISED AS CLOUDED & REISSUE FOR APPROVAL	HYPOTHESIS	HYPOTHESIS	UKRIT	PORNRUITAI	A
C	13-07-2021	REVISED AS CLOUDED & REISSUE FOR APPROVAL	HYPOTHESIS	HYPOTHESIS	ANAN	PORNRUITAI	A
B	14-05-2021	REVISED AS CLOUDED & REISSUE FOR APPROVAL	HYPOTHESIS	HYPOTHESIS	ANAN	PORNRUITAI	A
A	02-04-2021	ISSUE FOR APPROVAL	HYPOTHESIS	HYPOTHESIS	ANAN	PORNRUITAI	A

DESIGNER: Hypothesis

STATUS	
	FOR INFORMATION
	FOR REVIEW
✓	FOR APPROVAL
	FOR CONSTRUCTION
	AS BUILT

OWNER: BANGKOK COGENERATION COMPANY LTD.

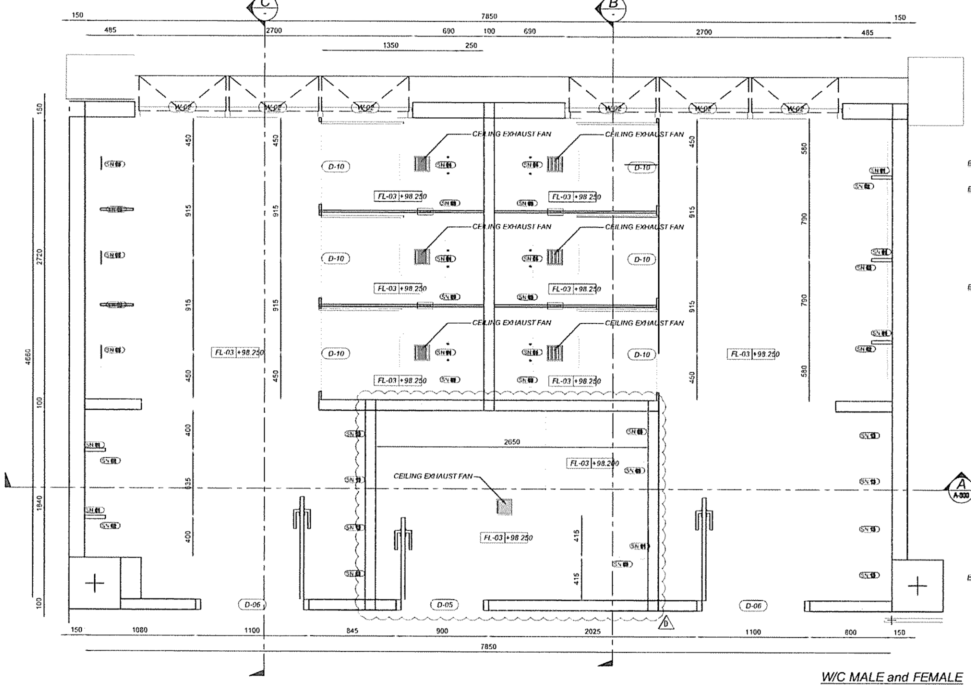
OWNER'S ENGINEER: AFRY (THAILAND) LTD.

EPC CONSORTIUM: Jurong Engineering Limited; Thai Jurong Engineering Limited

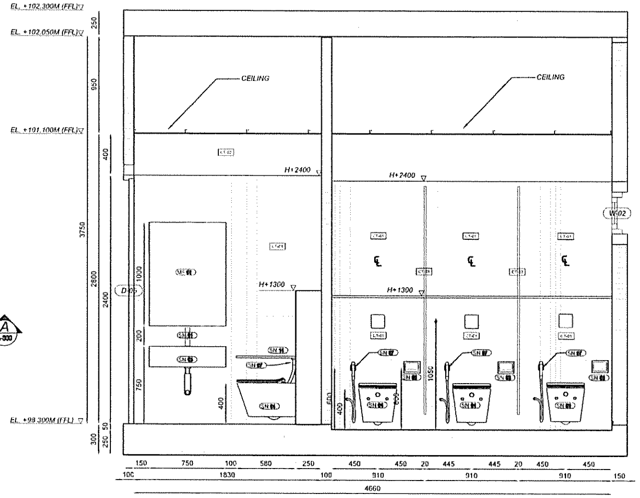
SCALE: AS SHOWN | PROJECTION | PROJECT: BCC2 COMBINED CYCLE POWER PLANT

TITLE: CONTROL AND ADMINISTRATION BLDG ARCHITECTURAL PLANS WITH FINISHES SCHEDULE

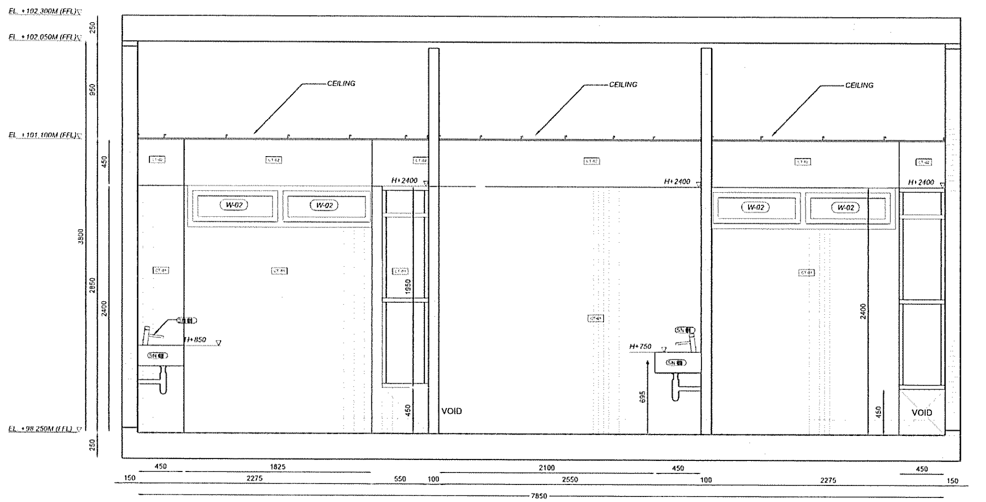
PROJECT DRAWING NO: BCC2-00-UYC-GA-C9811 | JOB NO: 20054 | REV: D | SHT: 1/7



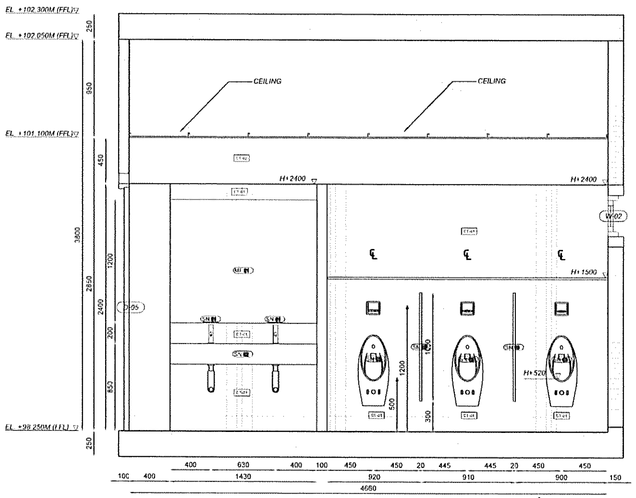
W/C MALE and FEMALE
SCALE 1:25



SECTION B
SCALE 1:25

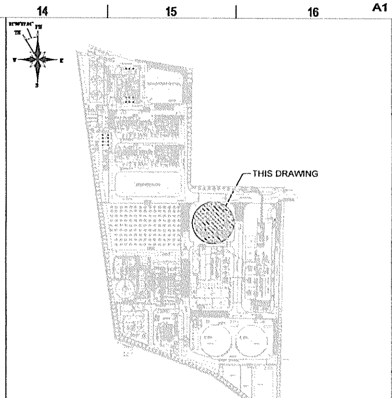


SECTION A
SCALE 1:25



SECTION C
SCALE 1:25

SANITARY WARE LEGEND									
CODE	DESCRIPTION	CODE	DESCRIPTION	CODE	DESCRIPTION	CODE	DESCRIPTION	CODE	DESCRIPTION
SN 01	FAUCET SENSOR	SN 05	CHLOP URINAL	SN [illegible]	PATITION URINAL	SN [illegible]	LOCKERS	MF 01	MIRROR
SN 02	BASIN	SN 06	TOILET PAPER HOLDER	SN [illegible]	HANDICAPPED HANDRAILS	SN [illegible]	HANDICAPPED HANDRAILS 1		
SN 03	HANDICAPPED BASIN	SN 07	BIDET SPRAY	SN [illegible]	SHELF				
SN 04	WALL HUNG WC	SN 08	FLOOR DRAIN	SN [illegible]	SHOWER				



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REFERENCE DWG:

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- BCC2-00-UYC-GA-C0813 Control and Administration Bldg Schedule of Doors and Windows

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B	14-06-2021	REVISED AS CLOUDED & REISSUE FOR APPROVAL	HYPOTHESIS	HYPOTHESIS	ANAN	PORNRUITAI	A
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OWNER:
BANGKOK COGENERATION COMPANY LTD.

OWNER'S ENGINEER:
AFRY (THAILAND) LTD.

EPC CONSORTIUM:
Jurong Engineering Limited
Thai Jurong Engineering Limited

DESIGNER: Hypothesis

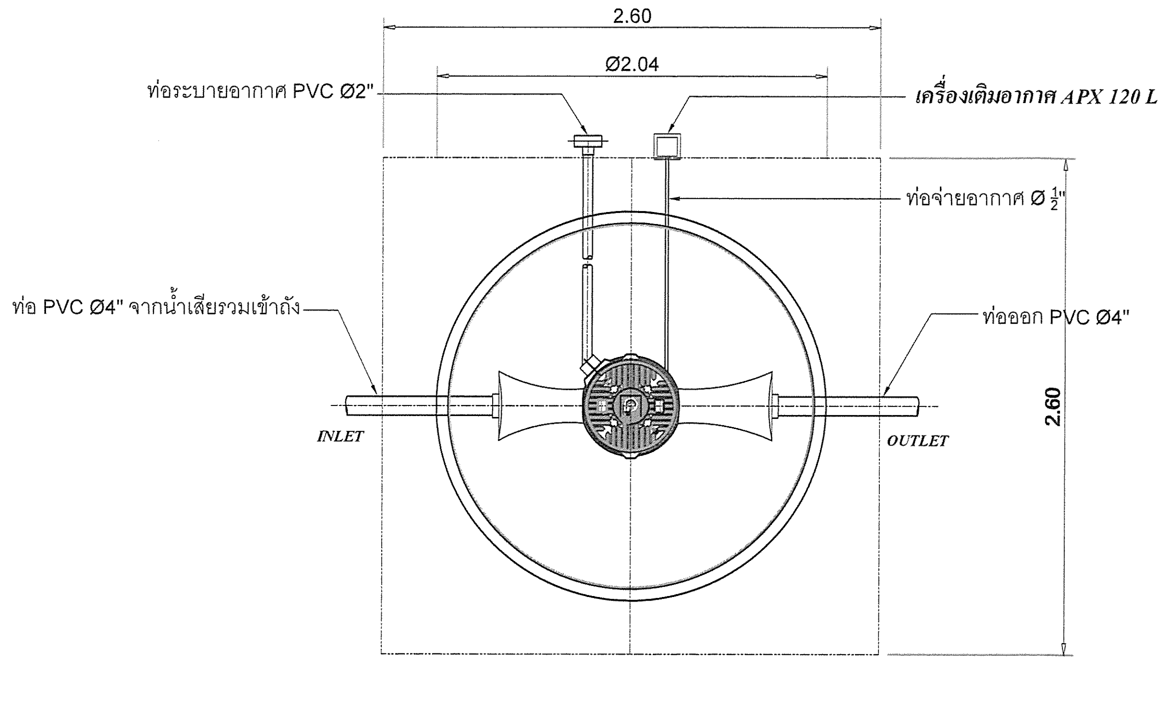
STATUS
- FOR INFORMATION
- FOR REVIEW
- ✓ FOR APPROVAL
- FOR CONSTRUCTION
- AS BUILT

SCALE: AS SHOWN
PROJECTION
PROJECT: BCC2 COMBINED CYCLE POWER PLANT

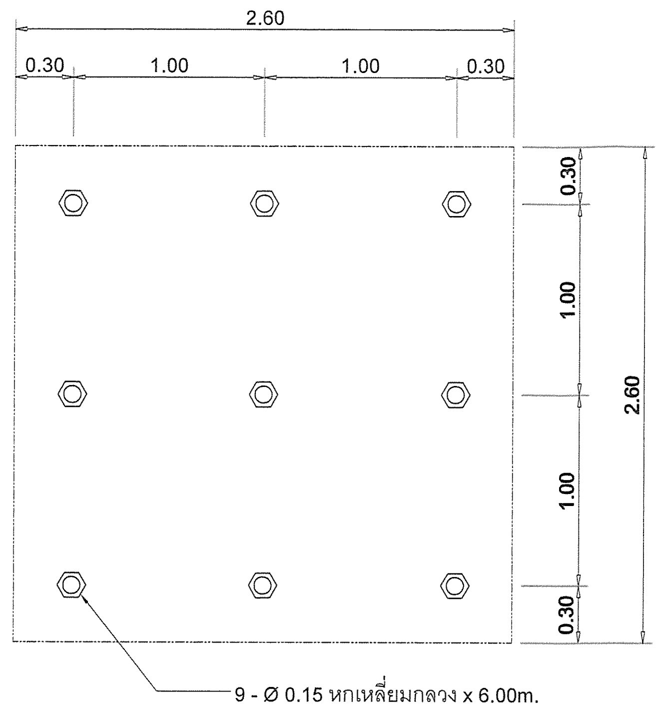
TITLE: CONTROL AND ADMINISTRATION BLDG ARCHITECTURAL ELEVATIONS & SECTIONS

PROJECT DRAWING NO: BCC2-00-UYC-GA-C0812
JOB NO: 20054
REV: D
SHT: 4/9

A1



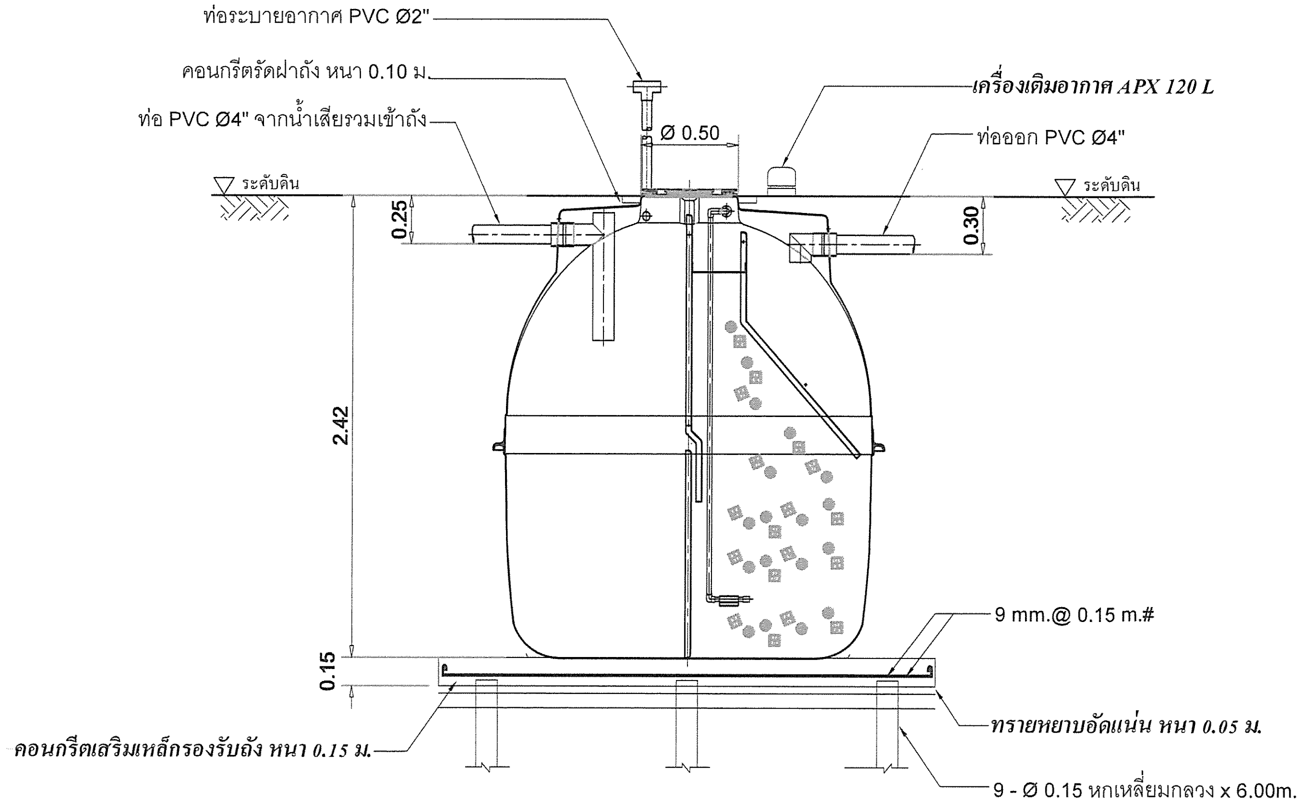
PLAN



PLAN

SHOW LAY-OUT OF PILING

SPECIFICATION (SS-5)			
NO.		ITEM	CAPACITY (CU.M.)
1.		TANK	--
	1.1	SEPTIC TANK	2.5
	1.2	AEROBIC TANK	2.08
	1.3	SEDIMENTATION TANK	0.42
		TOTAL	5
2.		MEDIA	CAPACITY (CU.M.)
	2.1	BIGBIO	0.5
3.		MATERIAL	--
	31	BODY OF TANK	FRP
	3.2	MEDIA	POLYETHYLENE SURFACE 105 Sq.m./cu.m.
	3.3	AIR PUMP	120 L/MIN , 110 WATT 0.2 Kgf / Cm 2 (1 UNIT)



SECTION

REMARK

PILING AND FOUNDATION DESIGN,SHALL BE DETERMINED OR OMITTED BASED ON ACTUAL SOIL BEARING CAPACITY BY CONSULTING WITH CIVIL ENGINEER.

Rev	Date	Description	Prepd.	Chkd.	Appd.	Authd.

Owner: BANGKOK COGENERATION
BANGKOK COGENERATION COMPANY LIMITED

Engineering Consultant:

Project Title :

Document Title : แบบขยายระบบบำบัดน้ำเสียสำเร็จรูป
MODEL SS-5
Control and Administration Building

Prepd. / Chkd. / Appd. / Authd. / DATE

Page No.: 04
A01 A02 A03 A04 A05
Scale: NTS.
A3

ภาคผนวก 2-3

รายการคำนวณระบบรวบรวมและระบายน้ำฝน
ภายหลังการเปลี่ยนแปลงรายละเอียดโครงการ

DISTRIBUTION

Table of contents Page no

DESIGN INFORMATION

2.1 INTRODUCTION

The storm water drain is designed to discharge the entire rain water from the plant to the Holding pond The rain water collected in the 300 & 400 mm wide open drains on the road side and it is connected with manholes at every intersections and road crossings . The heavy duty grating is used to cover the drain at the road crossing. The Drain , Manhole & Retaining wall modelled and analysis by Staad Pro.

2.2 DESIGN CODES

(a) ACI 318-14: Building Code Requirements for Structural Concrete and Commentary

(b) ASCE-7 -10 : Minimum Design Loads for Buildings and Other Structures

(c) DPT 1301/1302-61: Seismic Resistant Building Design Standards (New Edition)

2.3 MATERIAL SPECIFICATION

REINFORCEMENT

Main bars :	(Deformed bar)	=	400 N/mm^2
Links,fyv	(Round bar)	=	240 N/mm^2

Concrete

Characteristic Strength (cylinder strength)	f'c=	28 N/mm^2
Lean Concrete (cylinder strength)	=	15 N/mm^2
Concrete density	=	24 kN/m^2

Soil

Unit Weight of Soil	gs =	18 kN/m^3

2.4 CONCRETE COVERS

Wall & base Slab (In contact with ground)	=	75 mm
Base slab sides /Footings	=	75 mm
Slab & Wall (In contact with liquid)	=	50 mm
Wall above ground	=	30 mm
Pedestal (In contact with liquid)	=	50 mm

2.5 FOUNDATION TYPE

SBC for Shallow foundation within 2.0m depth	=	75 kN/m^2
SBC for foundation with depth 2.5m and more	=	100 kN/m^2

2.6 Modulus of Subgrade

i) Modulus of Subgrade (From Joseph E.Bowles "Foundation Analysis & Design") = 40* SF * qa

SF = Safety factor (assumed) = 3

Therefore, Modulus of subgrade = 120 * qa

= 9000 $kN/m^2/M$

ii) Modulus of Subgrade (From Joseph E.Bowles "Foundation Analysis & Design") = 40* SF * qa

SF = Safety factor (assumed) = 3

Therefore, Modulus of subgrade = 120 * qa

= 12000 $kN/m^2/M$

2.7 DESIGN CONDITIONS

Rainfall intensity I= 170 mm/hr

Run-off coefficient
i) for roof and paved area C= 0.9
ii) for landscape and gravel area C = 0.45

Free board 10 % of depth
Formulae used RATIONAL & MANNING'S EQUATION

Rational formula: $q = C\ I\ A \times 10^{-4} / 360$ m^3 / sec

where

q = Peak runoff at the point of design. (m^3/s)
C = Run-off coefficient
I = Rainfall intensity (mm/hr)
A = Catchment area (m^2)

MANNING'S formula $V = 1/n\ (R^{2/3} S^{1/2})$ m / sec

where

n = Roughness coefficient = 0.015
R = Hydraulic radius (m) A/P
A = Flow area (m^2)
P = Wetted perimeter (m)
S = Flow slope

Drain section used
Along road
i) 0.30 m 'U' concrete drain
ii) 0.400 m 'U' concrete drain
iii) 0.600 m 'U' concrete drain

Design considerations
Uniform flow is assumed
Min. Flow velocity 0.6 m/sec

For closed pipes

Flow velocity $V = 1/n (R^{2/3} S^{1/2})$ m / sec

where
n = Roughness coefficient = 0.015
R= Wetted perimeter = D/4
D = Pipe Inside diameter (m)
S = Flow slope

Discharge $Q = 0.312/n (D^{8/3} S^{1/2})$ m^3 / sec

i) concrete pipe used

roughness coeff, n = 0.015 (Concrete pipe)

Design considerations
Uniform flow is assumed
Min. Flow velocity = 0.6 m/sec

Closed pipes							
Header	pipe size	Dia of Pipe D (m)	Wetted Perimeter R (m)	Slope S		Velocity (m/sec)	Capacity Discharge (m3/sec)
Header1	ϕ600	0.600	0.15	1/300	0.0033	**1.20**	0.308
Header2	ϕ1000	1.000	0.25	1/300	0.0033	**1.60**	1.201
Header3	ϕ1200	1.200	0.30	1/300	0.0033	**1.80**	1.953

DISCHARGE CALCULATIONS

3.1 DRAIN SIZES DETERMINATION:

3.1.1 PEAK DISCHARGE CALCULATION:

Based on Rational Method,

Rainfall Intensity,	I =	170	mm/hr
Runoff Coefficient ,	C =	0.9	
Runoff Coefficient for landscape and gravel area	C =	0.45	
Total Peak Discharge	Q_T =	C.I.A/360	m^3/s

Drain Point	Catchment Area		Cumulative Catchment Area		Total Peak Discharge m^3/s
	Area, A (m^2)	Area Mark	Area, A (m^2)	Area Mark	
PLANT DRAIN - 300mm wide					
AB-AD	235	A1	235	A1	0.0100
AD-AF	150	A2	385	A2	0.0164
AB-BC	899	A3	1134	A1+A3	0.0482
BC-CD	1072	A15	2206	A1+A3+A15	0.0938
BD-BM	640	A4	640	A4	0.0272
BD-BM	296	A5	936	A4+A5	0.0398
BD-BM	526	A6	526	A6	0.0224
EC-ED	496	A7	1022	A6+A7	0.0434
BO-BM	239	A13	239	A13	0.0102
BD-BM	526	A6	1022	A4+A5+A6	0.0434
BD-BM	496	A7	1518	A4+A5+A6+A7	0.0645
BO-BM	239	A13	1757	A4+A5+A6+A7+A13	0.0747
BM-BG	91	A14	1848	A4+A5+A6+A7+A13+A14	0.0785
BG-BH	250	A12	2098	A4+A5+A6+A7+A13+A14+A12	0.0892
BH-BK	817	A16	2915	A4+A5+A6+A7+A13+A14+A12+A16	0.1239
DC-DE	1054	A17	1054	A4+A5+A6+A7+A12+A13+A14+A16+A17	0.0448
DF-TP-3	917	A20	1971	A4+A5+A6+A7++A12+A13+A14+A16+A17+A20	0.0838
TP-3	286	A19	2257	A4+A5+A6+A12+A13+A14+A16+A17+A19+A20	0.0959

Drain Point	Catchment Area		Cumulative Catchment Area		Total Peak Discharge m^3/s
	Area, A (m^2)	Area Mark	Area, A (m^2)	Area Mark	
TP-3 to DG	112	A21	2369	A4+A5+A6+A12+A13+A14+A16+A17+A19+A20+A21	0.1007
DG-DH	697	A23	3066	A4+A5+A6+A12+A13+A14+A16+A17+A19+A20+A21+A23	0.1303
DH-TP4	920	A25	3986	A4+A5+A6+A12+A13+A14+A16+A17+A19+A20+A21+A23+A25	0.1694
DG-TP-4	281	A24	4267	A4+A5+A6+A12+A13+A14+A16+A17+A19+A20+A23+A24+A25	0.1813
DK-TP-4	732	A27	732	A27	0.0311
TP-4 to DJ	127	A26	4394	A4+A5+A6+A12++A13+A14+A16+A17+A19+A20+A23+A24+A25+A26	0.1867
DJ-DK	732	A27	5126	A4+A5+A6+A12+A13+A14+A16+A17+A19+A20+A23+A24+A25+A26+A27	0.2179
TP-5	203	A29	5329	A4+A5+A6+A12+A13+A14+A16+A17+A19+A20+A23+A24+A25+A26+A27+A29+A30	0.2265
PLANT DRAIN - 400mm wide					
DJ-TP-5	1247	A30	6576	A4+A5+A6+A12+A16+A17+A19+A20+A23+A24+A25+A26+A27+A29+A30	0.2795
BL-BN	103	A32	6679	A4+A5+A6+A12+A16+A17+A19+A20+A23+A24+A25+A26+A27+A29+A30+A32	0.2839
TP-1	8885		8885	A4+A5+A6+A12+A16+A17+A19+A20+A23+A24+A25+A26+A27+A29+A30+A32	0.3776
PLANT DRAIN - 300mm wide					
CD-CF	2753	A33	2753	A33	0.0585
FC-FG	1638	A35	4391	A33+A35	0.0933
CD-CL	4391	TP1	13276	A33+A35+TP-1	0.2821
PLANT DRAIN - 300mm wide					
INLET POINT -1					
FG-CL	1447	A35a	1447	A35a	0.0307
FG-FH	1464	A38	2911	A35a+A38	0.1237175
EY-EB	2310	A43	2310	A43	0.098175
EZ-EB	2310	A43	5221	A35a+A38+A43	0.2218925
From Demco area **G1A,G6A,G2C,G3E,G6A G3B,G3C,G3A,G4A,G7A**	8537		8537	A38+A43+A41+A40+G1A+G6A+G2C+G3E+G6A+G3B+G3C+G3A+G4A+G7A	0.2879
ET-EU	958	A44	958	A44	0.040715
PLANT DRAIN - 600mm wide					
EU-EW	1077	A45	2035	A44+A45	0.0864875
EW-EY	2322	A46	4357	A44+A45+A46	0.1851725
EZ-FB	219	A47	9797	A44+A45+A46+A47+A35a+A38+A43	0.4163725
TP-6	8537		18334	A38+A43+A41+A40+G1A+G6A+G2C+G3E+G6A+G3B+G3C+G3A+G4A+G7A+A44+A45+A46+A47	0.779195

Drain Point	Catchment Area: Area, A (m^2)	Catchment Area: Area Mark	Cumulative Catchment Area: Area, A (m^2)	Cumulative Catchment Area: Area Mark	Total Peak Discharge m^3/s
PLANT DRAIN - 300mm wide					
AREA-2					
AC-AF	150	A2	150	A2	0.0064
EC-ED	496	A7	646	A7	0.0275
ED-EF	700	A8	1346	A7+A8	0.0572
EH- EG	641	A10	1987	A7+A8+A10	0.0844
EF- EA	145	A14	2132	A7+A8+A10+A14	0.0906
EA-EB	514	A9	2646	A7+A8+A10+A9+A14	0.1125
EB-EJ	1035	A18	3681	A7+A8+A9+A10+A14+A18	0.1564
EJ-EK	372	A28	4053	A7+A8+A9+A10+A14+A18+A28	0.1723
EJ-EK	503	A31	4556	A7+A8+A9+A10+A14+A18+A28+A31	0.1936
EN-EO	1016	A34	5572	A7+A8+A9+A10+A14+A18+A28+A31+A34	0.23681
ER-FQ	1016	A34a	1016	A34a	0.04318
EO-EQ	1490	A36	1490	A36	0.063325
ES-ET	973	A39	2463	A36+A39	0.1046775
ER-EE	1146	A41	3609	A36+A39+A41	0.1533825
EE-EP	660	A40	4269	A36+A39+A41+A40	0.1814325
CD-TP-2			24133	A4+A5+A6+A12+A16+A17+A19+A20+A23+A24+A25+A26+A27+A29+A30+A32+A7+A8+ A11+A18+A28+A31+A34+A34a+A36+A39+A40+A41	1.0256525
PLANT DRAIN - 900mm wide					
INLET POINT -2					
TP-5	**15739**		**15739**		0.6689
CL-CM	724	A35a	24857	A4+A5+A6+A12+A16+A17+A19+A20+A23+A24+A25+A26+A27+A29+A30+A35a	1.0564
CM-CN	1297	A37	26154	A4+A5+A6+A12+A16+A17+A19+A20+A23+A24+A25+A26+A27+A29+A30+A35a+A37	1.1115
CN-CO	1489	A42	27643	A4+A5+A6+A12+A16+A17+A19+A20+A23+A24+A25+A26+A27+A29+A30+A35a+A37+A42	1.1748
CO-CP	859	A48	28502	A4+A5+A6+A12+A16+A17+A19+A20+A23+A24+A25+A26+A27+A29+A30+A35a+A37+A42+A48	1.2113

Drain Point	Catchment Area		Cumulative Catchment Area		Total Peak Discharge m^3/s
	Area, A (m^2)	Area Mark	Area, A (m^2)	Area Mark	

For Closed Pipes

Area A31

Total area	=	503.0	m^2
q_1 per m	=	0.021	m^3/sec

Area A1

Total area	=	235.0	m^2
q_1 per m	=	0.010	m^3/sec

Area A3

Total area	=	899.0	m^2
q_1 per m	=	0.038	m^3/sec

Area A15

Total area	=	1072.0	m^2
q_1 per m	=	0.046	m^3/sec

Area A35

Total area	=	1638.0	m^2
q_1 per m	=	0.070	m^3/sec

Area A4

Total area	=	640.0	m^2
q_1 per m	=	0.027	m^3/sec

Area A5

Total area	=	296.0	m^2
q_1 per m	=	0.013	m^3/sec

Area A6

Drain Point	Catchment Area		Cumulative Catchment Area		Total Peak Discharge m^3/s
	Area, A (m^2)	Area Mark	Area, A (m^2)	Area Mark	

Total area = 526.0 m^2

q_1 per m = 0.022 m^3/sec

Area A7

Total area = 496.0 m^2

q_1 per m = 0.021 m^3/sec

Area A13

Total area = 239.0 m^2

q_1 per m = 0.010 m^3/sec

Area A12

Total area = 250.0 m^2

q_1 per m = 0.011 m^3/sec

CHECK FOR DRAIN CAPACITY

3.1.2 DRAIN CAPACITY CALCULATION:

Based on Manning's Equation,

$$Qc = (A R^{2/3} S^{1/2})/n$$

roughness coeff, n = 0.015 (concrete)

Gradient, S = 0 : 300

free-board = 10 %

Acceleration due to gravity, g = 9.81 m/s^2

Drain Point	Total Peak Discharge Q_T m^3/s	Width w m	Depth h m	Effective Depth D m	Flow Area A m^2	Hydraulic Radius R =A/P m	Bed Gradient S	Capacity Discharge Qc m^3/s	Remarks ($Qc \geq Q_T$)	Full Flowing Velocity V = Qc/A m/s	Critical Velocity $Vc = \sqrt{gD}$ m/s	Remarks (3 >V < Vc)	Froude Number $FN = V^2 / gh$	Remarks (FN <0.8)
PLANT DRAIN - 300mm wide														
AB-AD	0.0100	0.300	0.300	0.270	0.081	0.0964	300	0.0656	**OK**	0.8094	1.6275	**OK**	0.2226	**OK**
AD-AF	0.0164	0.300	0.300	0.270	0.081	0.0964	300	0.0656	**OK**	0.8094	1.6275	**OK**	0.2226	**OK**
AB-BC	0.0482	0.300	0.690	0.621	0.186	0.1208	300	0.1752	**OK**	0.9407	2.4682	**OK**	0.1307	**OK**
BC-CD	0.0938	0.300	0.720	0.648	0.194	0.1218	300	0.1839	**OK**	0.9458	2.5213	**OK**	0.1266	**OK**
BD-BM	0.0272	0.300	0.300	0.270	0.081	0.0964	300	0.0656	**OK**	0.8094	1.6275	**OK**	0.2226	**OK**
BD-BM	0.0398	0.300	0.300	0.270	0.081	0.0964	300	0.0656	**OK**	0.8094	1.6275	**OK**	0.2226	**OK**
BD-BM	0.0224	0.300	0.300	0.270	0.081	0.0964	300	0.0656	**OK**	0.8094	1.6275	**OK**	0.2226	**OK**
EC-ED	0.0434	0.300	0.300	0.270	0.081	0.0964	300	0.0656	**OK**	0.8094	1.6275	**OK**	0.2226	**OK**
BO-BM	0.0102	0.300	0.300	0.270	0.081	0.0964	300	0.0656	**OK**	0.8094	1.6275	**OK**	0.2226	**OK**
BD-BM	0.0434	0.300	0.350	0.315	0.095	0.1016	300	0.0792	**OK**	0.8381	1.7579	**OK**	0.2046	**OK**
BD-BM	0.0645	0.300	0.300	0.270	0.081	0.0964	300	0.0656	**OK**	0.8094	1.6275	**OK**	0.2226	**OK**
BO-BM	0.0747	0.300	0.350	0.315	0.095	0.1016	300	0.0792	**OK**	0.8381	1.7579	**OK**	0.2046	**OK**
BM-BG	0.0785	0.300	0.520	0.468	0.140	0.1136	300	0.1267	**OK**	0.9028	2.1427	**OK**	0.1598	**OK**
BH-BK	0.1239	0.300	0.565	0.509	0.153	0.1158	300	0.1395	**OK**	0.9146	2.2335	**OK**	0.1509	**OK**
DC-DE	0.0448	0.300	0.350	0.315	0.095	0.1016	300	0.0792	**OK**	0.8381	1.7579	**OK**	0.2046	**OK**
DF-TP-3	0.0838	0.300	0.450	0.405	0.122	0.1095	300	0.1070	**OK**	0.8807	1.9933	**OK**	0.1757	**OK**
TP-3	0.0959	0.300	0.490	0.441	0.132	0.1119	300	0.1183	**OK**	0.8939	2.0800	**OK**	0.1662	**OK**
TP-3 to DG	0.1007	0.300	0.500	0.450	0.135	0.1125	300	0.1211	**OK**	0.8970	2.1011	**OK**	0.1640	**OK**
DG-DH	0.1303	0.300	0.725	0.653	0.196	0.1220	300	0.1853	**OK**	0.9466	2.5300	**OK**	0.1260	**OK**
DH-TP4	0.1694	0.300	0.775	0.698	0.209	0.1235	300	0.1997	**OK**	0.9543	2.6158	**OK**	0.1198	**OK**
DG-TP-4	0.1813	0.300	0.725	0.653	0.196	0.1220	300	0.1853	**OK**	0.9466	2.5300	**OK**	0.1260	**OK**

DK-TP-4	0.0311	0.300	0.300	0.270	0.081	0.0964	300	0.0656	OK	0.8094	1.6275	OK	0.2226	OK
TP-4 to DJ	0.1867	0.300	0.820	0.738	0.221	0.1247	300	0.2127	OK	0.9605	2.6907	OK	0.1147	OK
DJ-DK	0.2179	0.400	0.820	0.738	0.295	0.1574	300	0.3312	OK	1.1219	2.6907	OK	0.1565	OK
TP-5	0.2265	0.400	0.820	0.738	0.295	0.1574	300	0.3312	OK	1.1219	2.6907	OK	0.1565	OK
PLANT DRAIN - 400mm wide														
DJ-TP-5	0.2795	0.400	0.840	0.756	0.302	0.1582	300	0.3404	OK	1.1257	2.7233	OK	0.1538	OK
BL-BN	0.2839	0.400	0.920	0.828	0.331	0.1611	300	0.3774	OK	1.1395	2.8500	OK	0.1439	OK
TP-1	0.3776	0.600	1.000	0.900	0.540	0.2250	300	0.7689	OK	1.4239	2.9714	OK	0.2067	OK
PLANT DRAIN - 300mm wide														
CD-CF	0.0585	0.300	0.300	0.270	0.081	0.0964	300	0.0656	OK	0.8094	1.6275	OK	0.2226	OK
FC-FG	0.0933	0.300	0.420	0.378	0.113	0.1074	300	0.0986	OK	0.8696	1.9257	OK	0.1835	OK
PLANT DRAIN - 400mm wide														
CD-CL	0.2821	0.400	0.750	0.675	0.270	0.1543	300	0.2989	OK	1.1072	2.5733	OK	0.1666	OK
INLET POINT -1														
FG-CL	0.0307	0.300	0.400	0.360	0.108	0.1059	300	0.0930	OK	0.8615	1.8793	OK	0.1891	OK
FG-FH	0.1237	0.300	0.600	0.540	0.162	0.1174	300	0.1495	OK	0.9228	2.3016	OK	0.1447	OK
EY-EB	0.0982	0.300	0.475	0.428	0.128	0.1110	300	0.1140	OK	0.8892	2.0479	OK	0.1697	OK
EZ-EB	0.2219	0.300	0.900	0.810	0.243	0.1266	300	0.2358	OK	0.9703	2.8189	OK	0.1066	OK
From Demco are	0.2879	0.400	1.000	0.900	0.360	0.1636	300	0.4145	OK	1.1515	2.9714	OK	0.1352	OK
G1A,G6A,G2C,G3E,G6A														
G3B,G3C,G3A,G4A,G7A														
ET-EU	0.0407	0.300	0.400	0.360	0.108	0.1059	300	0.0930	OK	0.8615	1.8793	OK	0.1891	OK
EU-EW	0.0865	0.300	0.400	0.360	0.108	0.1059	300	0.0930	OK	0.8615	1.8793	OK	0.1891	OK
PLANT DRAIN - 600mm wide														
EW-EY	0.1852	0.400	1.000	0.900	0.360	0.1636	300	0.4145	OK	1.1515	2.9714	OK	0.1352	OK
EZ-FB	0.4164	0.600	1.000	0.900	0.540	0.2250	300	0.7689	OK	1.4239	2.9714	OK	0.2067	OK
PLANT DRAIN - 300mm wide														
AREA-2														
AC-AF	0.0064	0.300	0.300	0.270	0.081	0.0964	300	0.0656	OK	0.8094	1.6275	OK	0.2226	OK
EC-ED	0.0275	0.300	0.400	0.360	0.108	0.1059	300	0.0930	OK	0.8615	1.8793	OK	0.1891	OK
ED-EF	0.0572	0.300	0.410	0.369	0.111	0.1066	300	0.0958	OK	0.8656	1.9026	OK	0.1863	OK
EH- EG	0.0844	0.300	0.550	0.495	0.149	0.1151	300	0.1353	OK	0.9108	2.2036	OK	0.1538	OK
EF- EA	0.0906	0.300	0.500	0.450	0.135	0.1125	300	0.1211	OK	0.8970	2.1011	OK	0.1640	OK
EA-EB	0.1125	0.300	0.640	0.576	0.173	0.1190	300	0.1609	OK	0.9312	2.3771	OK	0.1381	OK

EB-EJ	0.1564	0.300	0.650	0.585	0.176	0.1194	300	0.1638	**OK**	0.9332	2.3956	**OK**	0.1366	**OK**
EJ-EK	0.1723	0.300	0.700	0.630	0.189	0.1212	300	0.1781	**OK**	0.9424	2.4860	**OK**	0.1293	**OK**
EJ-EK	0.1936	0.400	0.700	0.630	0.252	0.1518	300	0.2760	**OK**	1.0953	2.4860	**OK**	0.1747	**OK**
PLANT DRAIN - 400mm wide														
EN-EO	0.2368	0.400	0.650	0.585	0.234	0.1490	300	0.2532	**OK**	1.0820	2.3956	**OK**	0.1836	**OK**
ER-FQ	0.0432	0.400	0.250	0.225	0.090	0.1059	300	0.0775	**OK**	0.8615	1.4857	**OK**	0.3026	**OK**
EO-EQ	0.0633	0.400	0.300	0.270	0.108	0.1149	300	0.0982	**OK**	0.9097	1.6275	**OK**	0.2812	**OK**
ES-ET	0.1047	0.400	0.380	0.342	0.137	0.1262	300	0.1325	**OK**	0.9684	1.8317	**OK**	0.2516	**OK**
ER-EE	0.1534	0.400	0.430	0.387	0.155	0.1319	300	0.1544	**OK**	0.9971	1.9485	**OK**	0.2357	**OK**
EE-EP	0.1814	0.400	0.600	0.540	0.216	0.1459	300	0.2305	**OK**	1.0669	2.3016	**OK**	0.1934	**OK**
PLANT DRAIN - 900mm wide														
INLET POINT -2														
TP-5	0.6689	0.800	0.800	0.720	0.576	0.2571	300	0.8965	**OK**	1.5564	2.6577	**OK**	0.3087	**OK**
CL-CM	1.0564	0.900	0.800	0.720	0.648	0.2769	300	1.0597	**OK**	1.6353	2.6577	**OK**	0.3407	**OK**
CM-CN	1.1115	0.900	0.920	0.828	0.745	0.2915	300	1.2611	**OK**	1.6923	2.8500	**OK**	0.3173	**OK**
CN-CO	1.1748	0.900	1.275	1.148	1.033	0.3232	300	1.8722	**OK**	1.8129	3.3551	**OK**	0.2628	**OK**
CO-CP	1.2113	0.900	1.450	1.305	1.175	0.3346	300	2.1789	**OK**	1.8551	3.5780	**OK**	0.2419	**OK**

Drain Mark	Disch.	Disch.	Disch.	Capacity	Slope	Type of	Remarks
	q	q'	Q=q + q'	Qcap	s	Drain	
	m^3/sec	m^3/sec	m^3/sec	m^3/sec			
PIPE HEADER-1	0.021	0.172	0.194	0.308	1/300	φ600	Q<Qcap, OK
PIPE HEADER-2	0.779	0.000	0.779	1.201	1/300	φ1000	Q<Qcap, OK
PIPE HEADER-3	1.211	0.000	1.211	1.953	1/300	φ1200	Q<Qcap, OK

DRAIN LEVELS DETERMINATION

3.1.3 DRAIN LEVEL DETERMINATION

Gradient		1:300	0.003333333	
Ground EL		EL +	103.000	m
		EL +	101.000	m
		EL +	100.000	m
		EL +	98.000	m
		EL +	96.000	m

TO DRAIN POINT 1

From	To	Distance (m)	Drop (m)	Invert Level Point		EL (m)
				Point	AC	100.700
AC	AB	60.40	0.201		AB	100.499
AC	AF	56.00	0.187		AF	100.513
AB	BC	56.70	0.189		BC	100.511
EC	BM	53.87	0.180		BM	100.520
BM	BG	5.00	0.017		BG	100.483
BG	BH	12.99	0.043		BH	100.440

From	To	Distance (m)	Drop (m)	Invert Level Point		EL (m)
				Point	BC	99.600
BC	CD	93.70	0.312		CD	99.288
BH	BL	81.32	0.271		BL	99.329
BN	CD	21.91	0.073		CD	99.087

From	To	Distance (m)	Drop (m)	Invert Level Point		EL (m)
				Point	DC	99.700
DC	DE	56.70	0.189		DE	99.511
DE	DF	31.10	0.104		DF	99.407
DF	TP-3	6.00	0.020		TP-3	99.387
TP-3	DH	29.10	0.097		DH	99.290
DH	TP-4	6.00	0.020		TP-4	99.270
TP-4	TP-5	20.50	0.068		TP-5	99.202
TP-5	BL	7.00	0.023		BL	99.179

From	To	Distance (m)	Drop (m)	Invert Level Point		EL (m)
				Point	DJ	99.700
DJ	TP-5	65.70	0.219		TP-5	99.481

AREA -2

From	To	Distance (m)	Drop (m)	Invert Level Point		EL (m)
				Point	AC	100.700
AC	AF	56.00	0.187		AF	100.513
EC	ED	27.00	0.090		ED	100.610
ED	EF	5.00	0.017		EF	100.593
EF	EH	39.50	0.132		EH	100.462
EH	EG	19.40	0.065		EG	100.397
EG	EA	4.90	0.016		EA	100.381
EA	EB	20.60	0.069		EB	100.312

From	To	Distance (m)	Drop (m)	Invert Level Point		EL (m)
				Point	AC	99.700
EB	EJ	68.15	0.227		EJ	99.473
EJ	EK	10.79	0.036		EK	99.437

From	To	Distance (m)	Drop (m)	Invert Level Point		EL (m)
				Point	EK	97.600
EK	EN	9.35	0.031		EN	97.569
EN	EO	20.60	0.069		EO	97.500
EO	EQ	6.00	0.020		EQ	97.480
EQ	FQ	4.90	0.016		FQ	97.464
ER	FQ	38.30	0.128		FQ	97.622
FQ	EP	3.50	0.012		EP	97.611

From	To	Distance (m)	Drop (m)	Invert Level Point		EL (m)
				Point	EK	97.650
ES	EP	91.45	0.305		EP	97.345
EP	FG	9.00	0.030		FG	97.315

From	To	Distance (m)	Drop (m)	Invert Level Point		EL (m)
				Point	FB	97.700
FB	BN	79.81	0.266		BN	97.434
FB	FC	24.05	0.080		FC	97.620
FC	FG	18.60	0.062		FG	97.558
FG	CL	79.17	0.264		CL	97.051

TO INLET POINT 1

From	To	Distance (m)	Drop (m)	Invert Level Point		EL (m)
				Point	ES	95.700
ES	EU	45.00	0.150		EU	95.550
EU	EW	27.70	0.092		EW	95.458
EY	EZ	53.50	0.178		EZ	95.522
From	**To**	**Distance (m)**	**Drop (m)**	Point	W	95.390
EZ	EB	45.70	0.152		EB	95.238
EB	EW	7.00	0.023		EW	95.214
EW	EX	86.50	0.288		EX	94.926
EX	IP-1	5.00	0.017		IP-1	94.909

From	To	Distance (m)	Drop (m)	Invert Level Point		EL (m)
				Point	CL	95.400
CL	CM	53.18	0.177		CM	95.223
CM	CN	36.22	0.121		CN	95.102
CN	CO	37.40	0.125		CO	94.977
CO	IP-2	50.40	0.168		IP-2	94.809

From	To	Distance (m)	Drop (m)	Invert Level	EL (m)
				FK	95.750
FK	EX	28.85	0.096	EX	95.654

From	To	Distance (m)	Drop (m)	Invert Level	EL (m)
				FL	95.600
FL	FM	38.60	0.129	FM	95.471

3.1.4 SEISMIC LOAD Calculation

~~(i) Seismic design based on~~ ASCE 7 -10

A) Soil Classification for Earthquake Design (As per soil report)

Site Class = **D**

B) Acceleration Parameters S_S and S_1

Seismic Ground Motion Values

S_S = **0.088** g

Parameter for acceleration response spectrum at 0.2 sec period

(or short period acceleration response spectrum)

S_1 = **0.042** g

Parameter for acceleration response spectrum at 1.0 sec period

(or short period acceleration response spectrum)

C) Adjusted Acceleration Response Spectrum

S_{MS} = Fa S_S (ASCE 7-10 Equation 11.4-1)

S_{M1} = Fv S_1 (ASCE 7-10 Equation 11.4-2)

where: Fa, Fv are Coefficients for Soil

Fa = **1.600** (ASCE 7-10 Table 11.4-1)

Fv = **2.400** (ASCE 7-10 Table 11.4-2)

Therefore,

S_{MS} = 0.141 g

S_{M1} = 0.101 g

D) Design Acceleration Response Spectra

S_{DS} = 2/3 S_{MS} (ASCE 7-10 Equation 11.4-3)

S_{D1} = 2/3 S_{M1} (ASCE 7-10 Equation 11.4-4)

Therefore,

S_{DS} = 0.094 g

S_{D1} = 0.067 g

Classification of Building and Importance Factor

I = **1.5** Importance Factor (ASCE 7-10 Table 1.5-2)

Classification of Structure and Limitations

R = **3** Response Modification Factor (Table 12.2-1)

Oscillation Period (Fundamental Period) (Section 12.8.2.1)

T = $0.0466\ H^{0.9}$ for Reinforced Concrete Structure (Table 12.8-2)

= $0.0724\ H^{0.8}$ for Steel Structure (Table 12.8-2)

= $0.0488\ H^{0.75}$ for other structural systems (Table 12.8-2)

where: H = **2.50** m Height measured from the ground

Structure Type = **C** *(Type S for Steel and C for Concrete, O for other structures)*

Therefore,

T = 0.11 sec Period

Seismic Response Coefficient

$C_S = \dfrac{S_a}{(R/I)}$ (Equation 12.8-2)

where: S_a = Design Spectral Response Acceleration (Section 11.4.3)

$T_S = S_{D1}/S_{DS}$

$= 0.716$

$T_0 = 0.2\, S_{D1} / S_{DS}$

$= 0.1432$

Design Spectrum value

$T < T_0$ (Eq.11.4-5 of ASCE 7-10)

if $T \leq T_0$

$S_a = S_{DS}\,(0.4 + 0.6\,[T/T0])$

$= 0.0794$

if $T > T_0 < T_S$

$S_a = S_{DS}$ (Eq.11.4-5 of ASCE 7-10)

$= 0.0939$

if $T > T_S$

$S_a = S_{D1}/T$

$= 0.632$

Design value $S_a = 0.079$

Therefore, $C_S = \dfrac{0.079}{(3 / 1.5)}$

$C_S = 0.040$ g

But $0.01\text{ g} \leq C_S \leq \text{max. } C_S$

Range for Cs:

$\text{max. } C_S = \dfrac{S_{D1}}{T\,(R/I)}$

$\text{max. } C_S = \dfrac{0.067}{0.106\,(3 / 1.5)}$

$= 0.316$ g

$\text{min. } C_S \geq 0.01$ g

Base Shear due to Earthquake (Section 3.2)

$V = C_S\, W$ (Equation 3.2-1)

$V =$ **0.040** W

ii) Seismic Design based on DPT 1301/1302-61

A) Soil Classification for Earthquake Design (As per soil report)

Site Class = **D**

B) Acceleration Parameters S_S and S_1 (Section 1.4.1)

Seismic Ground Motion Values

$S_S =$ **0.088** g (Table 1.4-1)

Parameter for acceleration response spectrum at 0.2 sec period
(or short period acceleration response spectrum)

S_1 = **0.042** g (Table 1.4-1)

Parameter for acceleration response spectrum at 1.0 sec period
(or short period acceleration response spectrum)

C) Adjusted Acceleration Response Spectrum (Section 1.4.3)

S_{MS} = Fa S_S (Equation 1.4-1)

S_{M1} = Fv S_1 (Equation 1.4-2)

where: Fa, Fv are Coefficients for Soil

Fa = **1.600** (Table 1.4-2)

Fv = **2.400** (Table 1.4-3)

Therefore,

S_{MS} = 0.141 g

S_{M1} = 0.101 g

D) Design Acceleration Response Spectra (Section 1.4.4)

S_{DS} = 2/3 S_{MS} (Equation 1.4-3)

S_{D1} = 2/3 S_{M1} (Equation 1.4-4)

Therefore,

S_{DS} = 0.094 g

S_{D1} = 0.067 g

Classification of Building and Importance Factor (Section 1.5)

I = **1.5** Importance Factor (Table 1.5-1)

Classification of Structure and Limitations

R = **3** Response Modification Factor (Table 2.3-1)

Oscillation Period (Fundamental Period) (Section 3.3)

T = 0.02 H for Reinforced Concrete Structure (Eqn 3.3-1)

= 0.03 H for Steel Structure (Eqn 3.3-2)

where: H = **2.50** m Height measured from the ground

Structure Type = **C** *(Type S for Steel and C for Concrete)*

Therefore T = 0.050 sec Period

Seismic Response Coefficient (Section 3.2.1)

$$C_S = \frac{S_a}{(R/I)}$$ (Equation 3.2-2)

where: S_a = Design Spectral Response Acceleration (Section 1.4.5)

Design Method = S *(Type S for Static and D for Dynamic)*

T_S = S_{D1}/S_{DS}

= 0.716

$T_0 = 0.2\ S_{D1} / S_{DS}$

$= 0.1432$

Design Spectrum value

$T < T_0$

if $T \le T_0$

$S_a = S_{DS} (0.4 + 0.6 [T/T_0])$

$= 0.0572$

if $T > T_0 < T_S$

$S_a = S_{DS}$

$= 0.0939$

if $T > T_S$

$S_a = S_{D1}/T$

$= 1.3440$

Design value $S_a = 0.0572$

Therefore, $C_S = \dfrac{0.0572}{(3 / 1.5)}$

$C_S = 0.029\ g$

But $0.01\ g \le C_S \le \text{max. } C_S$

Range for Cs:

$\text{max. } C_S = \dfrac{S_{D1}}{T\ (R/I)}$

$\text{max. } C_S = \dfrac{0.067}{0.05\ (3 / 1.5)}$

$= 0.672\ g$

$\text{min. } C_S \ge 0.01\ g$

<u>Base Shear due to Earthquake (Section 3.2)</u>

$V = C_S W$ (Equation 3.2-1)

$V = 0.0286\ W$ (As per DPT 1301/1302-61)

Therefore,

Governing Seismic Coefficient, = 0.0397 W (ASCE 7-05)

<u>Vertical Seismic Effect</u> (Section 12.4.2.2 of ASCE 7-10)

$E_V = 0.2S_{DS}\ DL$

$= 0.0188\ DL$

E_V = **0.0188 *selfweight**

Design of Strom Water Drain at Road side (1.00 m & below)

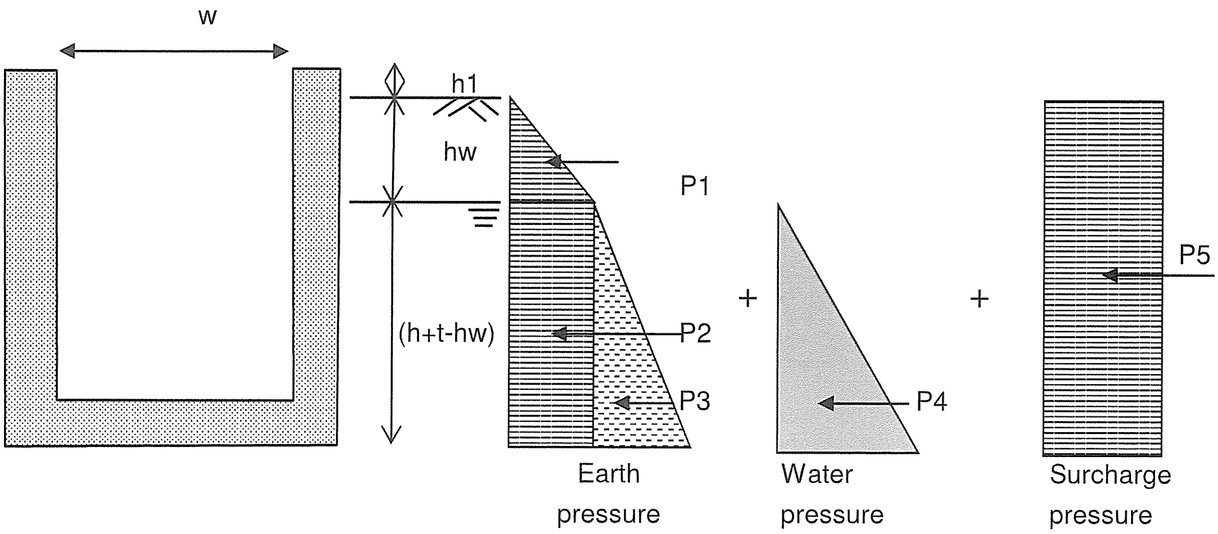
4.0 Design of storm water drain at road side

For the purpose of design the drain

a. Drain of Depth 1.00 m & Below

(The width of the drain 0.3m & 0.40 m. For the purpose of design we are considering 0.40m only)

4.1 For Depth of 1.00 m & Below



4.1.1 Soil Parameters

Unit weight of soil	=	**18.00**	kN/m^3
Angle of repose	=	**30**	ϕ
Unit weight of water	$\gamma\omega$ =	**10.00**	kN/m^3
Soil density,	γs =	**18.00**	kN/m^3
Soil submerged density,	$\gamma' s$ =	**8.00**	kN/m^3
Soil active pressure coefficient,	ka =	**0.33**	
Coefficient for surcharge,	k =	**0.50**	
Surcharge due to vehicle,	γ_{sur} =	**20**	kN/m^2
Ground water table	hw =	**1.50**	m

4.1.2 Drain Parameters

Height of trench below GL	h =	**1.000**	m
Height of trench above GL	$h1$ =	**0.150**	m
Width of trench	w =	**0.400**	m
Wall & base thickness,	t =	**0.150**	m

4.1.3 Material properties

Concrete strength,	(cylinder strength)	f'c =	**28**	N/mm^2
Rebar strength,		fy =	**400**	N/mm^2
Minimum concrete cover,		=	**75**	mm

4.1.5 EARTH PRESSURE LOAD

For calculating the earth pressure load on the side walls , it is assumed that the ground water table is at FGL conservatively.

Unit weight of soil	γ	=	18	kN/m^3	
Angle of repose		=	30	ϕ	
Unit weight of water	$\gamma\omega$	=	10	kN/m^3	
Soil submerged density,	$\gamma's$	=	8	kN/m^3	
coefficient for surcharge pressure	k_s	=	0.50		
Soil active pressure coefficient,	ka	=	0.33		

ka = $\tan^2(45 - ø/2)$ for ø =30deg

Ground water table	hw	=	1.50	m	assumed from FGL
The height of wall below GL	h	=	1.00	m	
Depth of the base slab	D_{bs}	=	0.15	m	
Surcharge load for heavy vehicles,	q	=	20.00	kN/m^2	
Total Height of wall	H	=	1.15	m	

(i)	Active pressure due to dry soil ,	$q's = ka \bullet \gamma s \bullet (h+t-hw)$ =	6.83	kN/m^2
(ii)	Inside Water Pressure	$q'w = \gamma w \bullet (h)$ =	10.00	kN/m^2
(iii)	Surcharge pressure	$qp = k \bullet \gamma_{sur}$ =	10.00	kN/m^2

4.1.6 SEISMIC EARTH PRESSURE LOAD

Mononobe-Okabe Method :

Dynamic active earth thrust Pda = Kae x γ x H

Where Kae = seismic active earth pressure coefficient

$$Kae = \frac{\cos^2(\Phi-\Psi-\theta)}{\cos(\Psi)\cos^2(\theta)\cos(\delta+\theta+\Psi) \times \left[\left[\frac{\sin(\Phi+\delta)\sin(\Phi-\Psi-\beta)}{1+\cos(\beta-\theta)\cos(\delta+\Psi+\theta)}\right]^{0.5}\right]^2}$$

Where	ϕ =	Angle of internal friction	=	30	deg
	δ =	Angle of friction between soil and wall	=	0	(Ref. Bowles book)
	Ψ =	$\tan^{-1}[k_h / (1-k_v)]$			
	k_h =	horizontal acceleration coefficient = 0.025 g			

g = gravitational accelaration = **9.810** m/s^2

k_h = 0.24525

k_v = vertical acceleration coefficient = 0.164 (Considering 2/3 of Horizontal)

Ψ = $\tan^{-1} [k_h / (1-k_v)]$ = 3.918

β = backfill slope angle = 20 deg

θ = angle of backface to the wall with the vertical = 0 deg (Uniform earth fill)

$$Kae = \frac{\cos^2(30-3.918-0)}{\cos(3.918)\cos^2(0)\cos(0+0+3.9 \times \left\{\left[1+\frac{\sin(30+0)\sin(30-3.918-0)}{\cos(0-0)\cos(0+3.918+0)}\right]^{0.5}\right\}^2}$$

$$Kae = \frac{0.807}{0.995 \times 1.545}$$

Kae = 0.52

Dynamic active earth thrust Pdae = Kae x γ x H

= 0.52 x 18 x 1.15

= 10.764 kN/m^2

Active Earth pressure Pae = Ka x γ x H

= 0.333 x 18 x 1.15

= 6.900 kN/m^2

Coefficient of active earth pressure is Ka = 0.33

Therefore, the dynamic increment, = Pdae - Pae

= 10.764 - 6.9

= 3.864 kN/m^2

Additional 3.864 kN/m^2 is applied on the trench walls as a dynamic increment due to earth pressure.

Seismic load on vertical direction (SL Y) (Section 12.4.2.2 of ASCE 7-10)

Ev = $0.2*S_{DS}*DL$

SDS = 0.094

Ev = 0.0188 DL

4.1.7 LOAD COMBINATION

(i) **Primary Loads**

LOAD 1 DEAD LOAD (DL)

LOAD 2 ACTIVE LOAD DUE TO DRY SOIL (DASP)

LOAD 3 SURCHARGE PRESSURE (SP)

LOAD 4 INSIDE WATER PRESSURE (IWP)

LOAD 5 SEISMIC LOAD (SL+X)

LOAD 6 SEISMIC LOAD (SL+Z)

LOAD 7 SEISMIC LOAD (SL+Y)

ii) **Service Loads**

LOAD COMB 11 DL+DASP+SP+0.75 IWP

LOAD COMB 12 DL+DASP+SP +0.70SL(+X)+0.70SL(+Y)

LOAD COMB 13 DL+DASP+SP -0.70SL(+X)+0.70SL(+Y)

LOAD COMB 14 DL+DASP+SP +0.70SL(+Z)+0.70SL(+Y)

LOAD COMB 15 DL+DASP+SP -0.70SL(-Z)+0.70SL(+Y)

LOAD COMB 16 DL+DASP+SP+IWP+0.70SL(+X)+0.70SL(+Y)

LOAD COMB 17 DL+DASP+SP+IWP-0.70SL(+X)+0.70SL(+Y)

LOAD COMB 18 DL+DASP+SP+IWP+0.70SL(+Z)+0.70SL(+Y)

LOAD COMB 19 DL+DASP+SP+IWP-0.70SL(+Z)+0.70SL(+Y)

LOAD COMB 20 0.60 DL+0.70SL+X+0.70SL(+Y)

LOAD COMB 21 0.60 DL-0.70SL+X+0.70SL(+Y)

LOAD COMB 22 0.60 DL+0.70SL+Z+0.70SL(+Y)

LOAD COMB 23 0.60 DL-0.70SL+Z+0.70SL(+Y)

iii) **Ultimate Loads**

LOAD COMB 101 1.4DL

LOAD COMB 102 1.2DL+1.6DASP+1.6SP

LOAD COMB 103 1.2DL+1.6DASP+1.6SP+1.6IWP

LOAD COMB 105 1.2DL+DASP+SP+1.0SL+X +1.0SL(-Y)

LOAD COMB 106 1.2DL+DASP+SP-1.0SL+X +1.0SL(-Y)

LOAD COMB 107 1.2DL+DASP+SP+1.0SL+Z +1.0SL(-Y)

LOAD COMB 108 1.2DL+DASP+SP-1.0SL+Z +1.0SL(-Y)

LOAD COMB 109 0.9DL+1.6DASP+1.6SP+1.0SL+X+1.0SL(-Y)

LOAD COMB 110 0.9DL+1.6DASP+1.6SP-1.0SL+X+1.0SL(-Y)

LOAD COMB 111 0.9DL+1.6DASP+1.6SP+1.0SL+Z+1.0SL(-Y)

LOAD COMB 112 0.9DL+1.6DASP+1.6SP-1.0SL+Z+1.0SL(-Y)

LOAD COMB 113 1.2DL+DASP+SP+IWP+1.0SL+X +1.0SL(-Y)

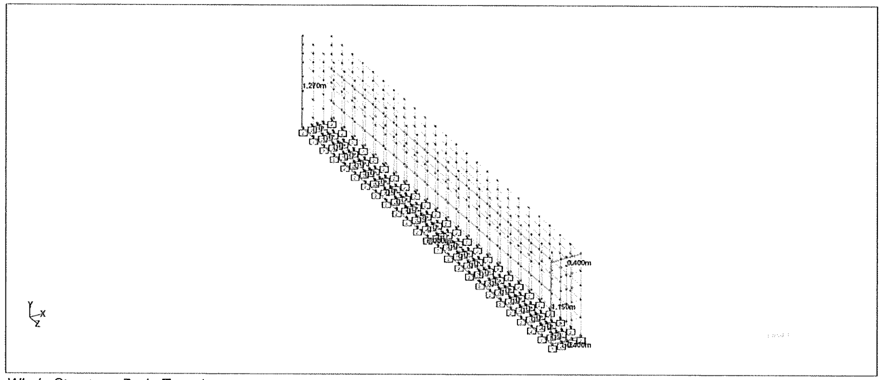
LOAD COMB 114 1.2DL+DASP+SP+IWP-1.0SL+X +1.0SL(-Y)

LOAD COMB 115 1.2DL+DASP+SP+IWP+1.0SL+Z +1.0SL(-Y)

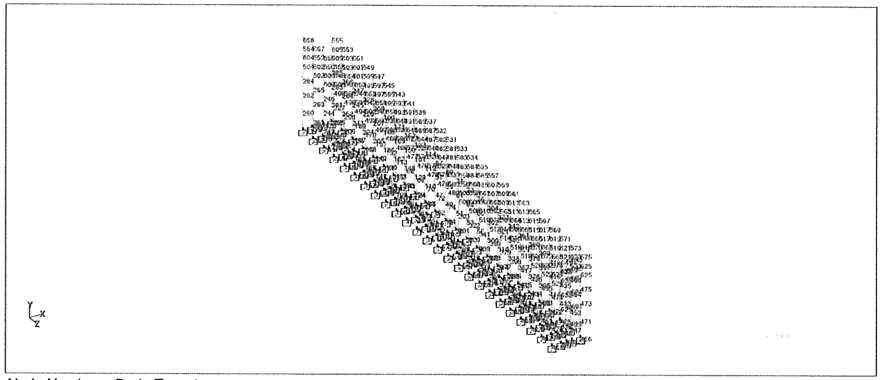
LOAD COMB 116 1.2DL+DASP+SP+IWP-1.0SL+Z +1.0SL(-Y)

The drain is analysed in STAAD pro

Software licensed to Jurong Engineering Limited CONNECTED User: kalyani rajmohan	Job No	Sheet No 1	Rev A
	Part PERIMETER DRAIN - 1.0m Deep		
Job Title BCC-2	Ref		
	By Mohan	Date 1/15/2021	Chd Diana
Client	File Type-1_ Drain design_40(	Date/Time 25-May-2021 00:18	



Whole Structure_Drain Type-1



Node Numbers_Drain Type-1

Print Time/Date: 25/05/2021 14:27 STAAD.Pro CONNECT Edition 22.04.00.40 Print Run 1 of 6

Software licensed to Jurong Engineering Limited CONNECTED User: kalyani rajmohan	Job No	Sheet No 2	Rev A
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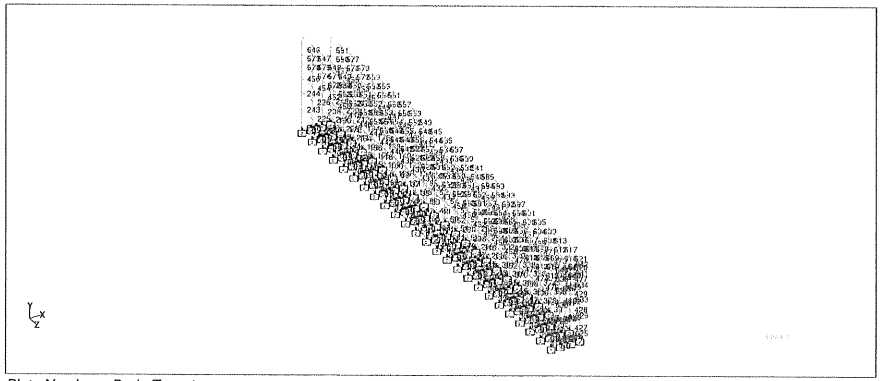
Job Title BCC-2	Ref		
	By Mohan	Date 1/15/2021	Chd Diana
Client	File Type-1_ Drain design_40(	Date/Time 25-May-2021 00:18	



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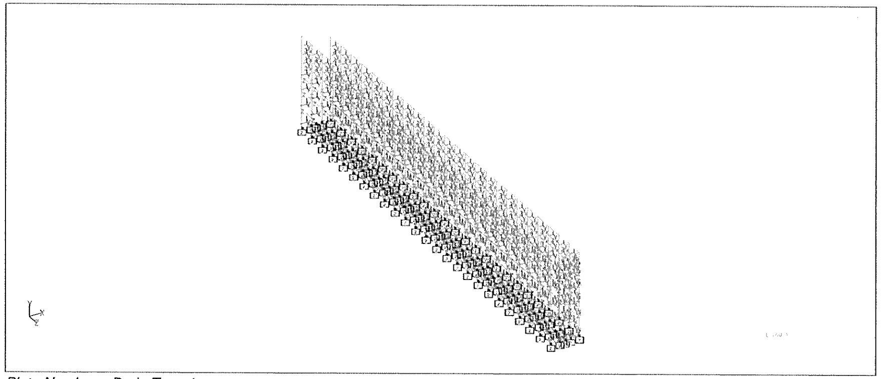

Plate Numbers_Drain Type-1

Print Time/Date: 25/05/2021 14:27 STAAD.Pro CONNECT Edition 22.04.00.40 Print Run 2 of 6

Software licensed to Jurong Engineering Limited CONNECTED User: kalyani rajmohan	Job No	Sheet No 3	Rev A
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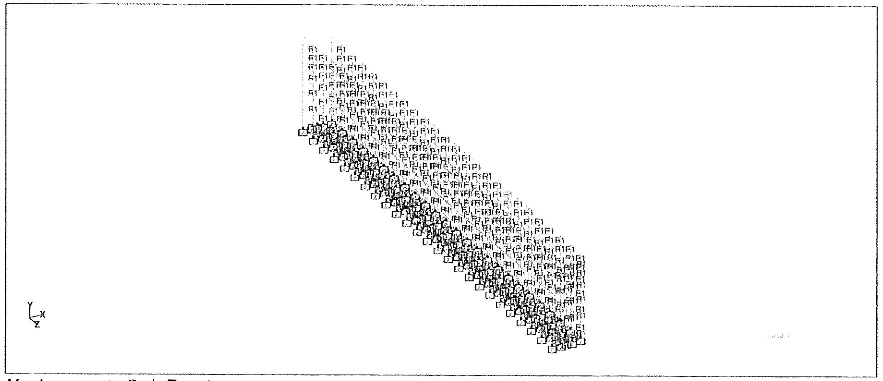
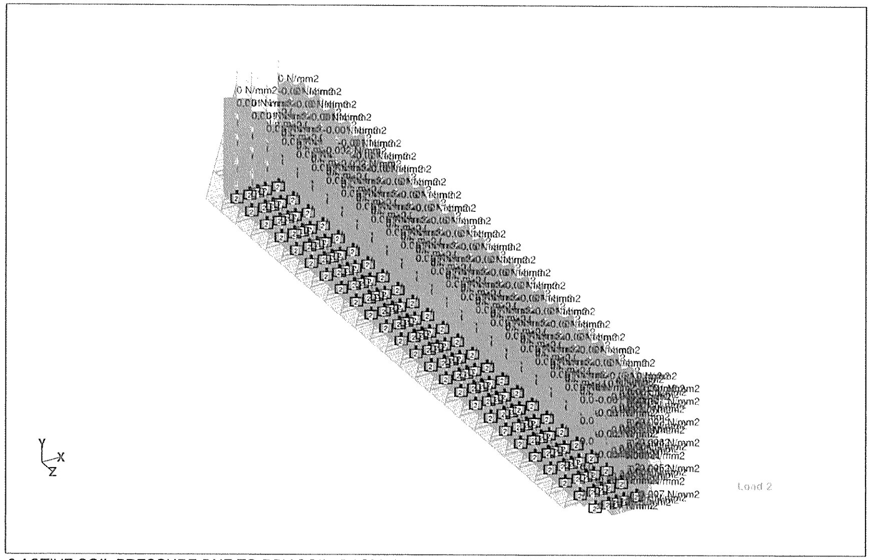
Job Title BCC-2	Ref		
	By Mohan	Date 1/15/2021	Chd Diana
Client	File Type-1_ Drain design_40	Date/Time 25-May-2021 00:18	



Member property_Drain Type-1



2 ACTIVE SOIL PRESSURE DUE TO DRY SOIL (DASP)_Drain Type-1

Print Time/Date: 25/05/2021 14:27 STAAD.Pro CONNECT Edition 22.04.00.40 Print Run 3 of 6

Software licensed to Jurong Engineering Limited CONNECTED User: kalyani rajmohan	Job No	Sheet No 4	Rev A
	Part PERIMETER DRAIN - 1.0m Deep		
Job Title BCC-2	Ref		
	By Mohan	Date 1/15/2021	Chd Diana
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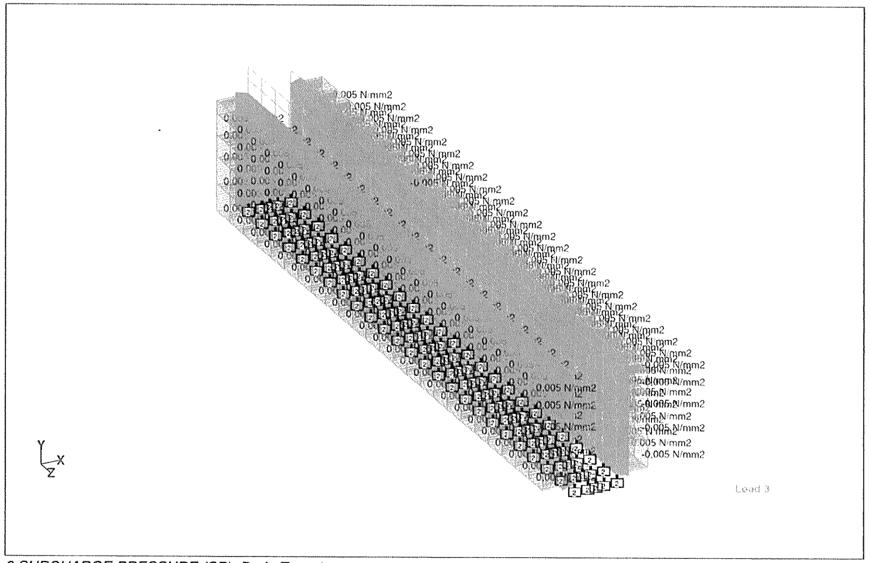
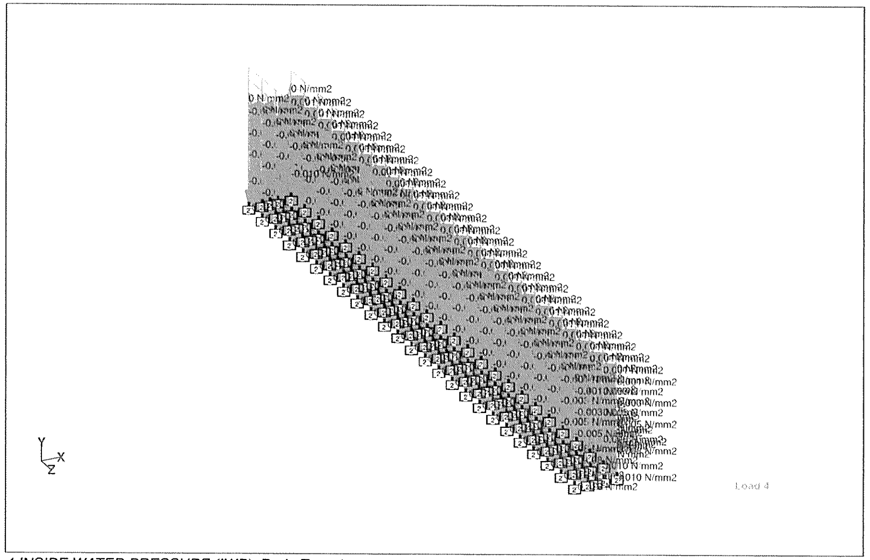


3 SURCHARGE PRESSURE (SP)_Drain Type-1



4 INSIDE WATER PRESSURE (IWP)_Drain Type-1

Print Time/Date: 25/05/2021 14:27 STAAD.Pro CONNECT Edition 22.04.00.40 Print Run 4 of 6

Software licensed to Jurong Engineering Limited CONNECTED User: kalyani rajmohan	Job No	Sheet No 5	Rev A
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Job Title BCC-2	Ref		
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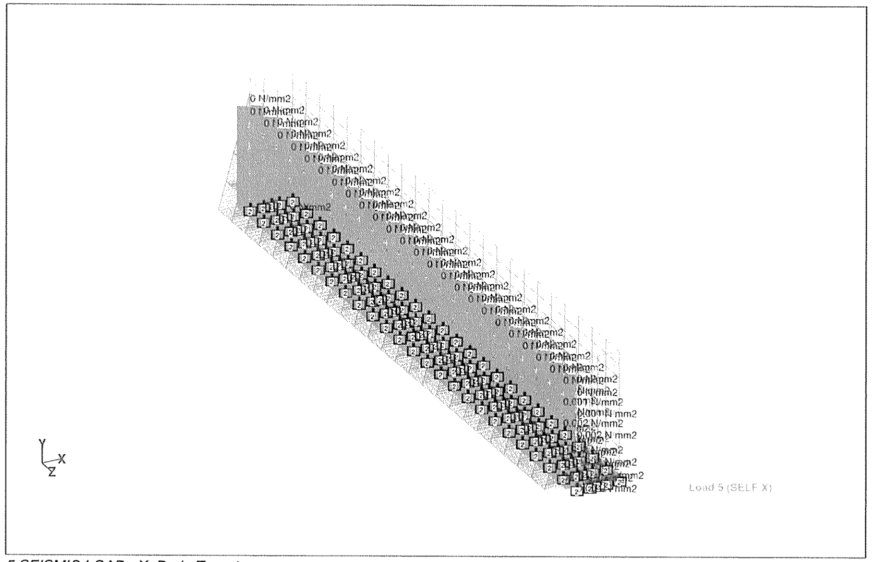
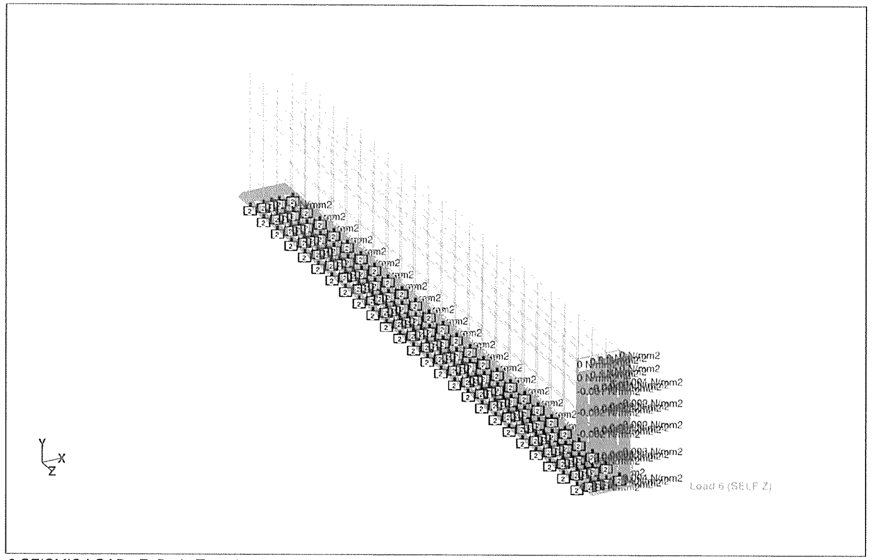


5 SEISMIC LOAD +X_Drain Type-1



6 SEISMIC LOAD +Z_Drain Type-1

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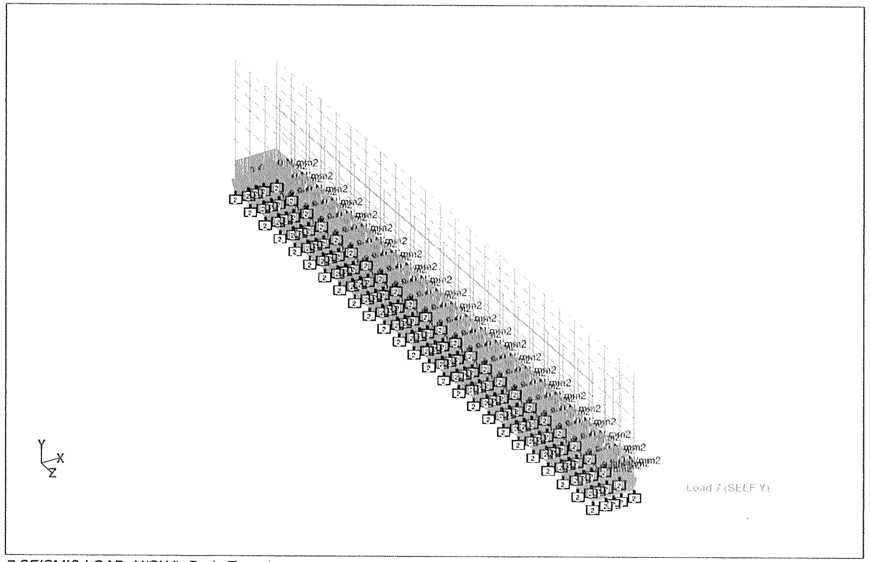
	Part PERIMETER DRAIN - 1.0m Deep		
Job Title BCC-2	Ref		
	By Mohan	Date 1/15/2021	Chd Diana
Client	File Type-1_ Drain design_40	Date/Time 25-May-2021 00:18	



7 SEISMIC LOAD -Y(SLY)_Drain Type-1

4.1.8 Check for Base pressure

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	Part PERIMETER DRAIN - 1.0m Deep		
Job Title BCC-2	Ref		
	By Mohan	Date 1/15/2021	Chd Diana
Client	File Type-1_ Drain design_40	Date/Time 05-May-2021 15:26	

Base Pressure Summary

	Node	L/C	FX (N/mm^2)	FY (N/mm^2)	FZ (N/mm^2)
Max FX	1	10:DL+IWP	**0**	0.038	0
Min FX	1	10:DL+IWP	**0**	0.038	0
Max FY	461	17:DL+DASP+:	0	**0.060**	0
Min FY	276	13:DL+DASP+:	0	**0.002**	0
Max FZ	1	10:DL+IWP	0	0.038	**0**
Min FZ	1	10:DL+IWP	0	0.038	**0**

Actual pressure = 60 kN/m^2

Allowable pressure = 75 kN/m^2

Hence the actual pressure is less than the alllowable pressure.

4.1.9 Design of wall

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	Part PERIMETER DRAIN - 1.0m Deep		
Job Title BCC-2	Ref		
	By Mohan	Date 1/15/2021	Chd Diana
Client	File Type-1_ Drain design_40	Date/Time 05-May-2021 15:26	

Plate Center Stress Summary

			Shear		Membrane			Bending		
	Plate	L/C	Qx (N/mm²)	Qy (N/mm²)	Sx (N/mm²)	Sy (N/mm²)	Sxy (N/mm²)	Mx (kN·m/m)	My (kN·m/m)	Mxy (kN·m/m)
Max Qx	619	109:0.9DL+1.6	**0.074**	0.017	-0.000	0.014	0.014	1.913	0.780	-0.908
Min Qx	621	109:0.9DL+1.6	**-0.106**	-0.005	0.021	0.004	0.011	-2.504	-0.110	0.509
Max Qy	229	110:0.9DL+1.6I	-0.002	**0.082**	0.001	-0.028	-0.002	-0.779	-4.705	-0.022
Min Qy	224	109:0.9DL+1.6	0.002	**-0.093**	0.001	-0.032	-0.004	0.867	5.226	0.035
Max Sx	593	105:1.2DL+DA:	-0.023	-0.002	**0.023**	-0.002	-0.000	0.381	0.021	0.285
Min Sx	428	111:0.9DL+1.6I	-0.021	-0.030	**-0.014**	-0.019	-0.010	-0.841	-0.180	0.756
Max Sy	619	109:0.9DL+1.6	0.074	0.017	-0.000	**0.014**	0.014	1.913	0.780	-0.908
Min Sy	386	101:1.4DL	0.000	-0.002	-0.004	**-0.042**	-0.003	0.024	0.104	0.036
Max Sxy	619	109:0.9DL+1.6	0.074	0.017	-0.000	0.014	**0.014**	1.913	0.780	-0.908
Min Sxy	427	109:0.9DL+1.6	0.001	-0.019	-0.009	-0.028	**-0.021**	-0.323	-0.299	0.577
Max Mx	618	109:0.9DL+1.6	0.071	0.045	-0.007	0.011	0.007	**2.083**	0.667	-0.858
Min Mx	621	109:0.9DL+1.6	-0.106	-0.005	0.021	0.004	0.011	**-2.504**	-0.110	0.509
Max My	224	109:0.9DL+1.6	0.002	-0.093	0.001	-0.032	-0.004	0.867	**5.226**	0.035
Min My	211	110:0.9DL+1.6I	0.000	0.078	-0.003	-0.023	-0.002	-0.796	**-4.706**	0.003
Max Mxy	393	109:0.9DL+1.6	-0.010	0.004333	-0.002	-0.012	-0.008	0.149	0.083	**1.337**
Min Mxy	388	109:0.9DL+1.6	0.009	-0.006	-0.002	-0.011	-0.001	-0.246	-0.105	**-1.297**

Maximum Moment in X-Dir	Mx	=	**2.504**	kNm/m
Corresponding Moment	Mxy	=	**0.509**	kNm/m
Maximum Moment in Y-Dir	My	=	**5.226**	kNm/m
Corresponding Moment	Mxy	=	**0.035**	kNm/m
Corresponding Moment in X or Y-Dir	My	=	**1.34**	kNm/m
Maximum Moment in XY-Dir	Mxy	=	**0.149**	kNm/m
Maximum Shear Stess in X-Dir	S_{QX}	=	**0.106**	N/mm^2
Maximum Shear Stess in X-Dir	S_{Qy}	=	**0.093**	N/mm^2
Max. Ultimate bending moment	Mu = My+Mxy	=	5.261	kNm/m
Depth of section	h	=	**150**	mm
Width of Section	b	=	**1000**	mm
Concrete Cover	cc	=	**75**	mm
Concrete Grade	f'_c	=	**28**	N/mm^2
Steel Reinforcement Grade	f_y	=	**400**	N/mm^2
Diameter of Reinforcement	dia	=	**12**	mm
Spacing of Reinforcement	S	=	**200**	mm

Design Moment	Muz/φ	=	5.85	kNm
Width considered	b	=	**1000**	mm
Effective Depth	(tb-c-0.5f)=d	=	69	mm
z assumed =d		=	69	mm
As reqd = M/fy*z		=	212	mm^2/m

Provide	DB 12-200	As prov.	=	565 mm^2 /m
Distribution bar	DB 12-200	As prov.	=	565 mm^2 /m

Minimum area of reinforcement in ver dir req. = 0.0015 * b*D (Table 11.6.1,ACI -318-14)

= 225 mm^2/m

< 565 mm^2/m

Hence OK

Minimum area of reinforcement in Hor dir req. = 0.0025 * b*D (Table 11.6.1,ACI -318-14)

= 375 mm^2/m

< 565 mm^2/m

Hence OK

Maximum area of reinforcement req. As_{max} = 0.75 * ρ_b * b * d

ρ_b = 0.85 * β1 * fc' * 600 / [fy * (600+fy)]

= 0.0232

As_{max} = 1201 mm^2/m

As_{min} < $As_{prov.}$ < As_{max} **Hence OK**

Check for Shear

Actual shear stress = Vu = 0.106 N/mm^2

Allowable shear stress =

a) $\varphi V_c = \varphi 0.17 \lambda \mathrm{sqrt}(f_c')$ = 0.67 N/mm^2

λ=1.0 (Modification factor for normal wt of concrete)

Actual Shear stress Vu < φVc **Hence Ok**

Hence shear reinforcement is not required.

4.1.10 Design of Slab

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	Ref		
Job Title BCC-2	By Mohan	Date 1/15/2021	Chd Diana
	File Type-1_ Drain design_40	Date/Time 05-May-2021 15:26	
Client			

Plate Center Stress Summary

	Plate	L/C	Shear Qx (N/mm^2)	Shear Qy (N/mm^2)	Membrane Sx (N/mm^2)	Membrane Sy (N/mm^2)	Membrane Sxy (N/mm^2)	Bending Mx (kN·m/m)	Bending My (kN·m/m)	Bending Mxy (kN·m/m)
Max Qx	218	105:1.2DL+DA:	**0.039**	0.004	0	0	0	-4.249	-0.698	-0.043
Min Qx	221	106:1.2DL+DA:	**-0.037**	0.004	0	0	0	-3.554	-0.585	0.033
Max Qy	236	109:0.9DL+1.6	0.025	**0.024**	0	0	0	-6.499	-0.651	0.075
Min Qy	399	109:0.9DL+1.6	0.015	**-0.026**	0	0	0	-1.054	-0.127	0.038
Max Sx	419	101:1.4DL	-0.013	0.005	**0**	0	0	0.032	-0.017	0.042
Min Sx	419	101:1.4DL	-0.013	0.005	**0**	0	0	0.032	-0.017	0.042
Max Sy	419	101:1.4DL	-0.013	0.005	0	**0**	0	0.032	-0.017	0.042
Min Sy	419	101:1.4DL	-0.013	0.005	0	**0**	0	0.032	-0.017	0.042
Max Sxy	419	101:1.4DL	-0.013	0.005	0	0	**0**	0.032	-0.017	0.042
Min Sxy	419	101:1.4DL	-0.013	0.005	0	0	**0**	0.032	-0.017	0.042
Max Mx	21	101:1.4DL	0.007	-0.000	0	0	0	**0.569**	0.102	0.001
Min Mx	200	109:0.9DL+1.6	0.031	0.000	0	0	0	**-6.592**	-1.125	-0.028
Max My	399	101:1.4DL	0.007	0.002	0	0	0	0.401	**0.125**	-0.019
Min My	200	109:0.9DL+1.6	0.031	0.000	0	0	0	-6.592	**-1.125**	-0.028
Max Mxy	398	110:0.9DL+1.6	0.015	0.001	0	0	0	-0.892	-0.098	**0.212**
Min Mxy	401	109:0.9DL+1.6	-0.014	0.003	0	0	0	-1.033	-0.123	**-0.273**

Maximum Moment in X-Dir	Mx	=	**6.59**	kNm/m
Corresponding Moment	Mxy	=	**0.028**	kNm/m
Maximum Moment in Y-Dir	My	=	**1.125**	kNm/m
Corresponding Moment	Mxy	=	**0.028**	kNm/m
Corresponding Moment in X or Y-Dir	My	=	**0.273**	kNm/m
Maximum Moment in XY-Dir	Mxy	=	**1.033**	kNm/m
Maximum Shear Stess in X-Dir	S_{QX}	=	**0.039**	N/mm^2
Maximum Shear Stess in X-Dir	S_{Qy}	=	**0.026**	N/mm^2
Max. Ultimate bending moment	Mu = My+Mxy	=	6.618	kNm/m
Depth of section	h	=	**150**	mm
Width of Section	b	=	**1000**	mm
Concrete Cover	cc	=	**75**	mm
Concrete Grade	f'_c	=	**28**	N/mm^2
Steel Reinforcement Grade	f_y	=	**400**	N/mm^2
Diameter of Reinforcement	dia	=	**12**	mm
Spacing of Reinforcement	S	=	**200**	mm
Design Moment	Muz/φ	=	7.35	kNm
Width considered	b	=	**1000**	mm
Effective Depth	(tb-c-0.5f)=d	=	69	mm

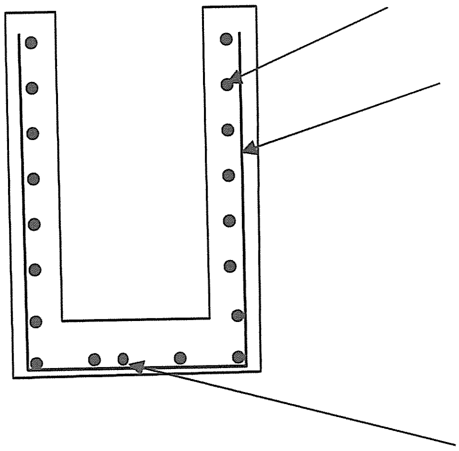
z assumed =d		=	69 mm
As reqd = M/fy*z		=	266 mm^2/m
Provide DB 12-200	As prov.	=	565 mm^2/m
Distribution bar DB 12-200	As prov.	=	565 mm^2/m

Minimum area of reinforcement	=	0.002 * b*D	(7.6.1.1,ACI 318-14)
	=	300 mm^2/m	
	<	565 mm^2/m	
		Hence OK	

Check for Shear

Actual shear stress =	Vu	=	0.039 N/mm^2	
Allowable shear stress =				
a)	$\varphi V_c = \varphi 0.17 \lambda \mathrm{sqrt}(f_c')$	=	0.67 N/mm^2	
λ=1.0 (Modification factor for normal wt of concrete)				
Actual Shear stress	Vu	<	φVc	**Hence Ok**

Hence shear reinforcement is not required.



4.1.11 Design of Grating For Maintenance access

(i)	Live Load	W	=	7.5 kN/m2	
	Max. Width of Drain (0.40+0.06)	L	=	0.46 m	
	Safe working stress of steel	fy	=	155.1 N/mm2	(0.66*fy)
	Load bar thickness	B	=	5 mm	
	Section Modulus	S	=	$B*H^2/6$	
	Pitch of load bar	p	=	100 mm	
	Width of grating	W	=	500 mm	
	No. of load bars	n	=	5.50 Nos	
	Moment	Ma	=	$wl^2/8$	
			=	0.198375 kNm	

Bending moment of section M= fy*S		=	fy*n*B*H^2/6	
	Ms	=	710.875 H^2	
	Ms	=	Ma	
	H	=	17	mm
		<	35	mm

ii) Check for deflection

Deflection due to load	d	=	$5wL^4/384EI$	
		=	0.11	mm
Allowable deflection L/200 or 10 mm		=	2.30	mm

Hence safe in deflection.

Provide 35 x 5mm thk grating

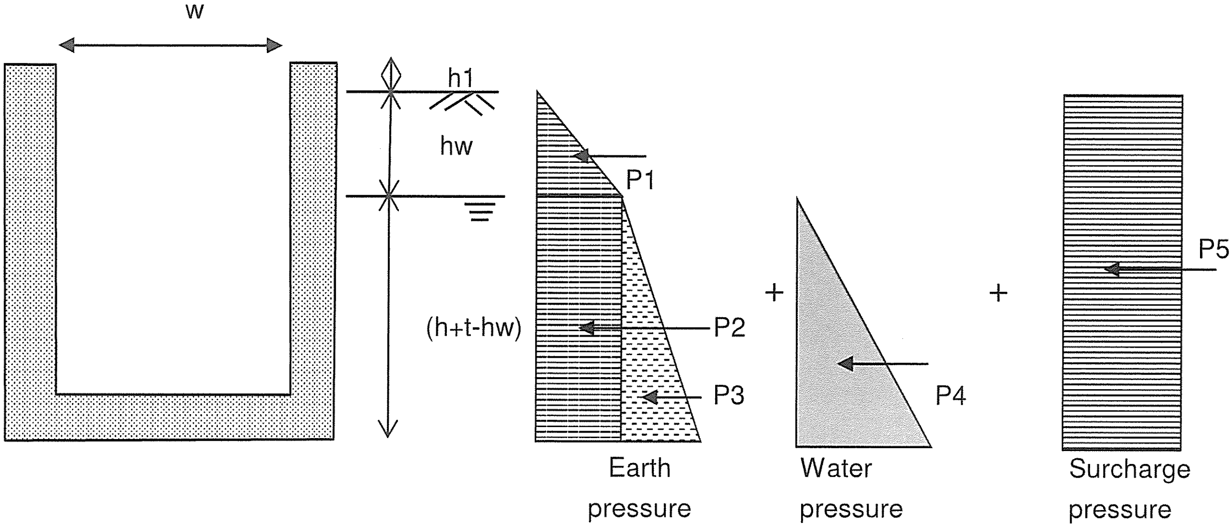
Design of Strom Water Drain at Road side (1.50 m & below)

5.0 Design of storm water drain at road side

a. Drain of Depth 1.50 m & Below

(The width of the drain 0.40m) .

5.2 For Depth of 1.50 m



5.2.1 Soil Parameters

Unit weight of soil	=	**18.00**	kN/m^3
Angle of repose	=	**30**	ϕ
Unit weight of water	$\gamma\omega$ =	**10.00**	kN/m^3
Soil density,	γs =	**18.00**	kN/m^3
Soil submerged density,	$\gamma' s$ =	**8.00**	kN/m^3
Soil active pressure coefficient,	ka =	**0.33**	
Coefficient for surcharge,	k =	**0.50**	
Surcharge load due to heavy vehicle,	γ_{sur} =	**20**	kN/m^2
Surcharge load in other areas ,	$\gamma_{sur\,\ni}$ =	**5**	kN/m^2
Ground water table	hw =	**1.50**	m

5.2.2 Drain Parameters

Height of trench below GL	h =	**1.500**	m
Height of trench above GL	$h1$ =	**0.150**	m
Width of trench	w =	**0.400**	m
Wall & base thickness,	t =	**0.150**	m
Concrete density,	γ_c =	**24.00**	kN/m^3

5.2.3 Material properties

Concrete strength, (cylinder strength)	f'c =	**28**	N/mm^2
Rebar strength,	fy =	**400**	N/mm^2
Minimum concrete cover,	=	**75**	mm

5.2.4 Design of wall

For 1.50m depth of drain

(i)	Active pressure due to dry soil ,	$qa = ka \cdot \gamma \cdot (hw)$ =	8.91	kN/m²
(ii)	Inside Water Pressure	$q'w = \gamma w \cdot (h)$ =	15.00	kN/m²
(iii)	Surcharge pressure due to heavy vehicles qp =	$k \cdot \gamma_{sur}$ =	10.00	kN/m²

5.1.5 EARTH PRESSURE LOAD

For calculating the earth pressure load on the side walls , it is assumed that the ground water table is at FGL conservatively.

Unit weight of soil	γ	=	**18**	kN/m³	
Angle of repose		=	**30**	ϕ	
Unit weight of water	$\gamma\omega$	=	**10**	kN/m³	
Soil submerged density,	$\gamma's$	=	8	kN/m³	
coefficient for surcharge pressure	k_s	=	**0.50**		
Soil active pressure coefficient,	ka =		**0.33**		

ka = tan² (45 - ø/2) for ø =30deg

Ground water table	hw	=	**1.50**	m	from FGL
The height of wall below GL	h	=	**1.50**	m	
Depth of the base slab	D_{bs}	=	**0.15**	m	
Total Height of wall inside Ground water table	H	=	0.150	m	

a. Active pressure due to ground water, qw = $\gamma\omega$ *(H)

= 1.50 kN/m²

b. Active pressure due to submerged soil , q's = ka* γ's * (H)

= 0.4 kN/m²

Total Lateral pressure due to submerged soil on drain wall = 1.9 kN/m²

(v) Buoyancy force on slab qp = =gw •(h) = 1.50 kN/m²
(In Staad Applied under as seperate load case)

2.6.5 SEISMIC EARTH PRESSURE LOAD

Mononobe-Okabe Method :

Dynamic active earth thrust Pdae = Kae x γ x H

Where Kae = seismic active earth pressure coefficient

$$Kae = \frac{\cos^2(\Phi-\Psi-\theta)}{\cos(\Psi)\cos^2(\theta)\cos(\delta+\theta+\Psi) \times \left[1+\left[\frac{\sin(\Phi+\delta)\sin(\Phi-\Psi-\beta)}{1+\cos(\beta-\theta)\cos(\delta+\Psi+\theta)}\right]^{0.5}\right]^2}$$

Where ϕ = Angle of internal friction = 30 deg

δ = Angle of friction between soil and wall = 0

Ψ = $\tan^{-1}[k_h/(1-k_v)]$ (Ref. Bowles book)

k_h = horizontal acceleration coefficient = 0.025g

g = gravitational accelaration = 9.810 m/s^2

k_h = 0.24525

k_v = vertical acceleration coefficient = 0.16 (Considering 2/3 of Horizontal)

Ψ = $\tan^{-1}[k_h/(1-k_v)]$ = 3.918

β = backfill slope angle = 20 deg

θ = angle of backface to the wall with the vertical = **0** deg (Uniform earth fill)

$$Kae = \frac{\cos^2(30-3.918-0)}{\cos(3.918)\cos^2(0)\cos(0+0+3.918) \times \left\{1+\left[\frac{\sin(30+0)\sin(30-3.918-0)}{\cos(0-0)\cos(0+3.918+0)}\right]^{0.5}\right\}^2}$$

$$Kae = \frac{0.807}{0.995 \quad x \quad 1.545}$$

Kae = 0.52

Dynamic active earth thrust Pdae = Kae x γ x H
= 0.52 x 18 x 1.5
= 14.040 kN/m^2

Active Earth pressure Pae = Ka x γ x H
= 0.333 x 18 x 1.5
= 9.000 kN/m^2

Coefficient of active earth pressure is Ka = 0.33

Therefore, the dynamic increment, = Pdae - Pae
= 14.04 - 9
= 5.040 kN/m^2

Additiona 5.040 kN/m^2 is applied on the trench walls as a dynamic increment due to earth pressure.

Seismic load on vertical direction (SL Y) (Section 12.4.2.2 of ASCE 7-10)

Ev = $0.2 * S_{DS} * DL$

SDS = 0.094

Ev = 0.0188 D

5.1.5 LOAD COMBINATION

(i) **Primary Loads**

LOAD 1 DEAD LOAD (DL)

LOAD 2 ACTIVE LOAD DUE TO DRY SOIL (DASP)

LOAD 3 SURCHARGE PRESSURE (SP)

LOAD 4 INSIDE WATER PRESSURE (IWP)

LOAD 5 SEISMIC LOAD (SL+X)

LOAD 6 SEISMIC LOAD (SL+Z)

LOAD 7 SEISMIC LOAD (SL-Y)

LOAD 8 UPLIFT LOAD

ii) **Service Loads**

LOAD COMB 11 DL

LOAD COMB 12 DL+DASP+SP+0.75 IWP

LOAD COMB 13 DL+DASP+SP +0.70SL(+X)+0.70SL(-Y)

LOAD COMB 14 DL+DASP+SP -0.70SL(+X)+0.70SL(-Y)

LOAD COMB 15 DL+DASP+SP +0.70SL(+Z)+0.70SL(-Y)

LOAD COMB 16 DL+DASP+SP -0.70SL(-Z)+0.70SL(-Y)

LOAD COMB 17 DL+DASP+SP+IWP+0.70SL(+X)+0.70SL(-Y)

LOAD COMB 18 DL+DASP+SP+IWP-0.70SL(+X)+0.70SL(-Y)

LOAD COMB 19 DL+DASP+SP+IWP+0.70SL(+Z)+0.70SL(-Y)

LOAD COMB 20 DL+DASP+SP+IWP-0.70SL(+Z)+0.70SL(-Y)

LOAD COMB 21 0.60 DL+0.70SL+X+0.70SL(-Y)

LOAD COMB 22 0.60 DL-0.70SL+X+0.70SL(-Y)

LOAD COMB 23 0.60 DL+0.70SL+Z+0.70SL(-Y)

LOAD COMB 24 0.60 DL-0.70SL+Z+0.70SL(-Y)

LOAD COMB 25 0.60 DL-0.70SL+Z+0.70SL(-Y)

iii) **Ultimate Loads**

LOAD COMB 101 1.4DL

LOAD COMB 102 1.2DL+1.6DASP+1.6SASP+1.6SP

LOAD COMB 103 1.2DL+1.6DASP+1.6SASP+1.6SP+1.6IWP

LOAD COMB 104 0.9DL+1.6DASP+1.6SASP+1.6SP

LOAD COMB 105 0.9DL+1.6DASP+1.6SASP+1.6SP+1.6IWP

LOAD COMB 105 1.2DL+DASP+SP+1.0SL+X +1.0SL(-Y)

LOAD COMB 106 1.2DL+DASP+SP-1.0SL+X +1.0SL(-Y)

LOAD COMB 107 1.2DL+DASP+SP+1.0SL+Z +1.0SL(-Y)

LOAD COMB 108 1.2DL+DASP+SP-1.0SL+Z +1.0SL(-Y)

LOAD COMB 108 0.9DL+1.6DASP+1.6SASP+1.6SP+1.0SL+X+1.0SL(-Y)

LOAD COMB 108 0.9DL+1.6DASP+1.6SASP+1.6SP-1.0SL+X+1.0SL(-Y)

LOAD COMB 109 0.9DL+1.6DASP+1.6SASP+1.6SP+1.0SL+Z+1.0SL(-Y)

LOAD COMB 109 0.9DL+1.6DASP+1.6SASP+1.6SP-1.0SL+Z+1.0SL(-Y)

LOAD COMB 110 1.2DL+DASP+SP+IWP+1.0SL+X +1.0SL(-Y)

LOAD COMB 111 1.2DL+DASP+SP+IWP-1.0SL+X +1.0SL(-Y)

LOAD COMB 112 1.2DL+DASP+SP+IWP+1.0SL+Z +1.0SL(-Y)

LOAD COMB 113 1.2DL+DASP+SP+IWP-1.0SL+Z +1.0SL(-Y)

The drain is analysed in STAAD pro

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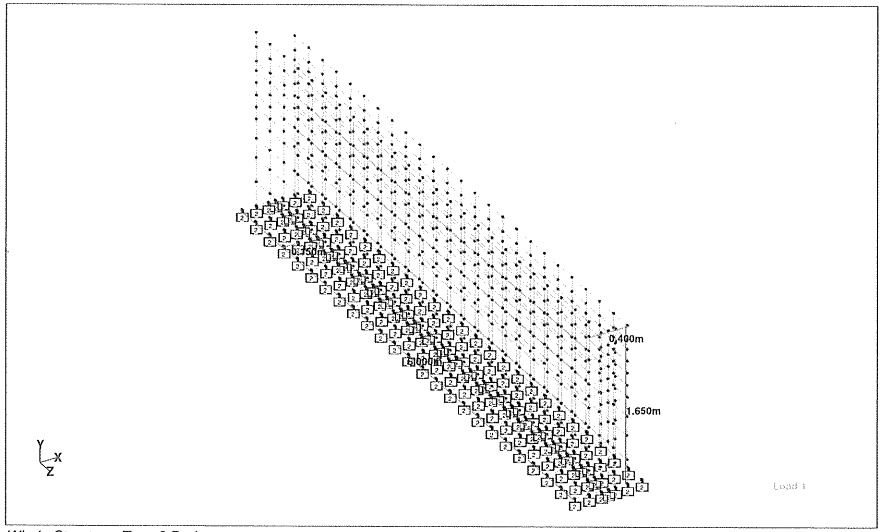
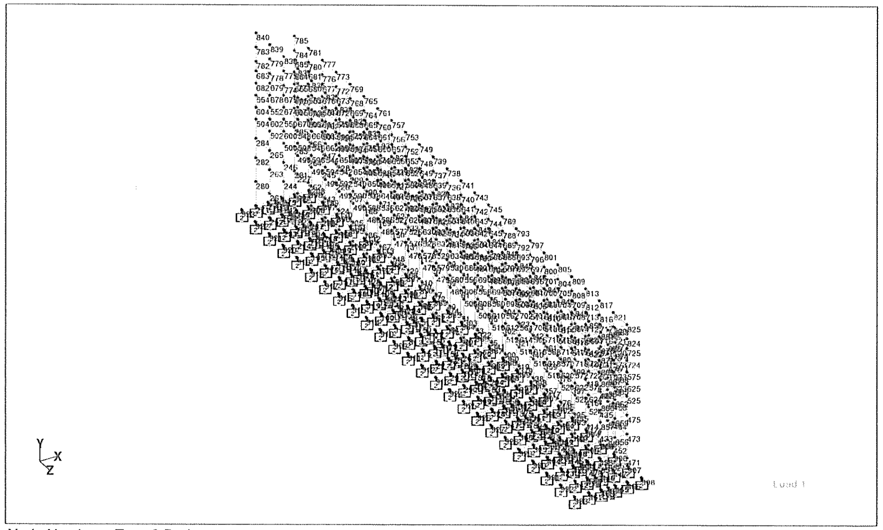
	Part PERIMETER DRAIN - 1.50m Deep		
Job Title BCC-2 PROJECT	Ref		
	By Mohan	Date 5/5/2021	Chd Diana
Client	File Type-2 Drain design_1.50	Date/Time 12-May-2021 11:34	



Whole Structure_Type 2 Drain



Node Numbers_Type 2 Drain

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	Part PERIMETER DRAIN - 1.50m Deep		
Job Title BCC-2 PROJECT	Ref		
	By Mohan	Date 5/5/2021	Chd Diana
Client	File Type-2 Drain design_1.50	Date/Time 12-May-2021 11:34	

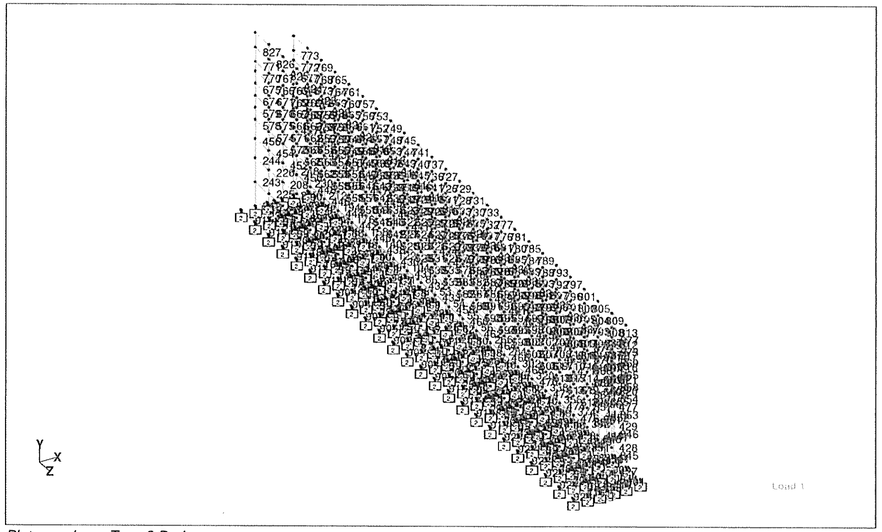

Plate numbers_Type 2 Drain

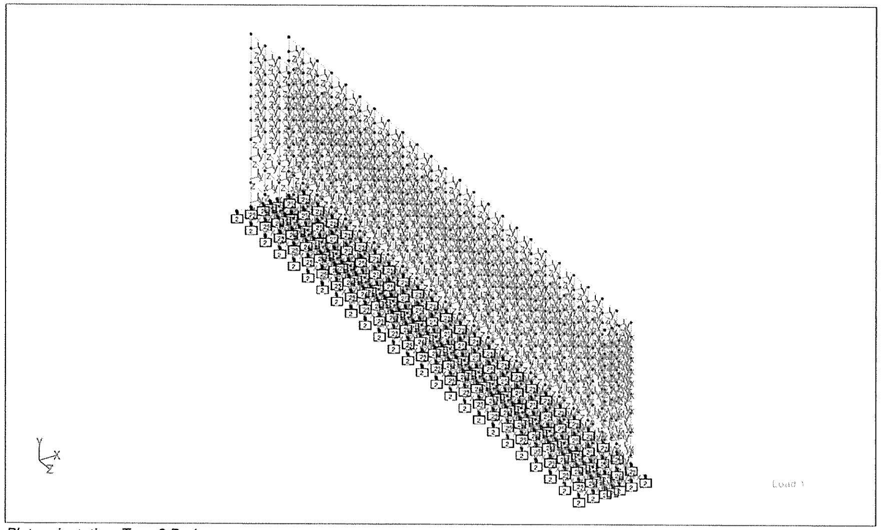

Plate orientation_Type 2 Drain

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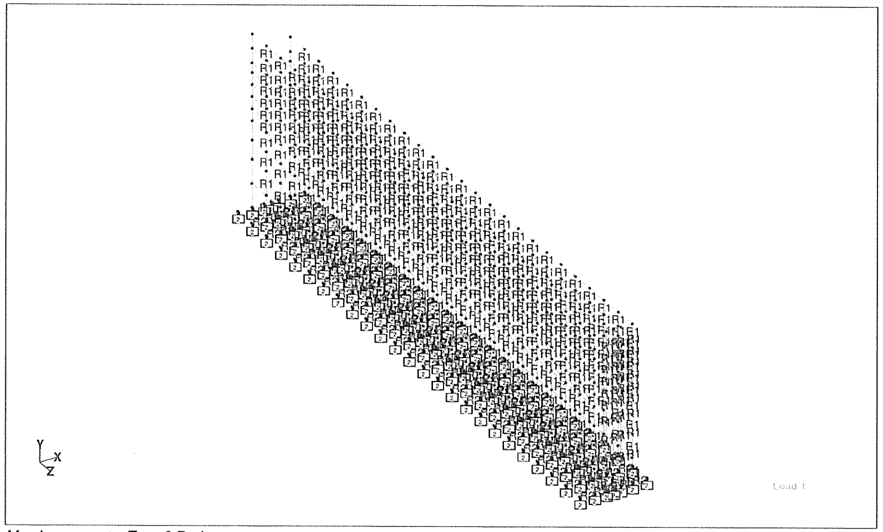
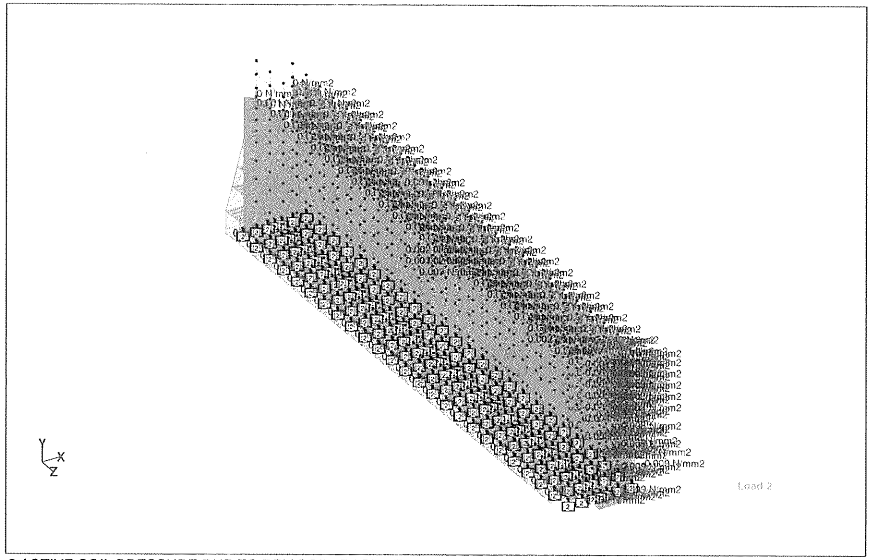
Job No	Sheet No 3	Rev A
Part PERIMETER DRAIN - 1.50m Deep		
Ref		
By Mohan	Date 5/5/2021	Chd Diana
File Type-2 Drain design_1.5(	Date/Time 12-May-2021 11:34	

Job Title BCC-2 PROJECT

Client



Member property_ Type 2 Drain



2 ACTIVE SOIL PRESSURE DUE TO DRY SOIL (DASP)_Type 2 Drain

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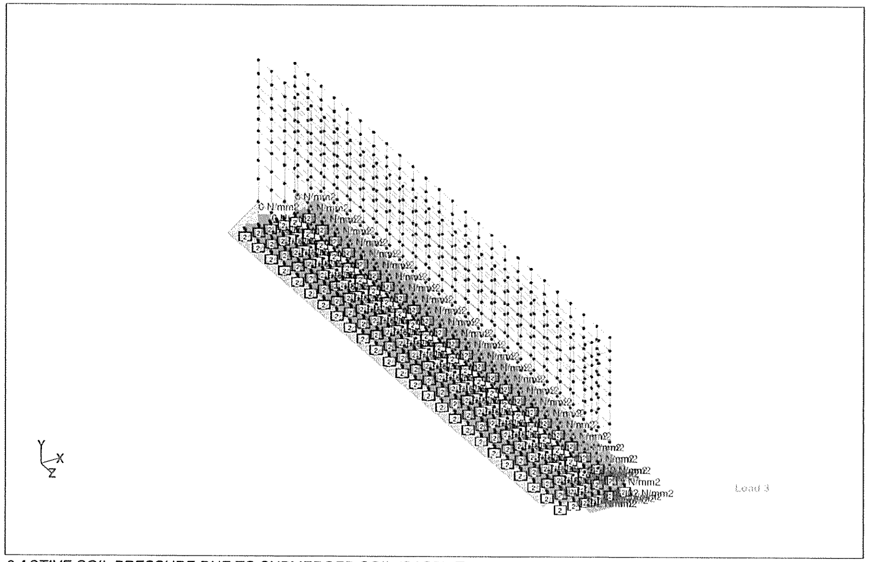
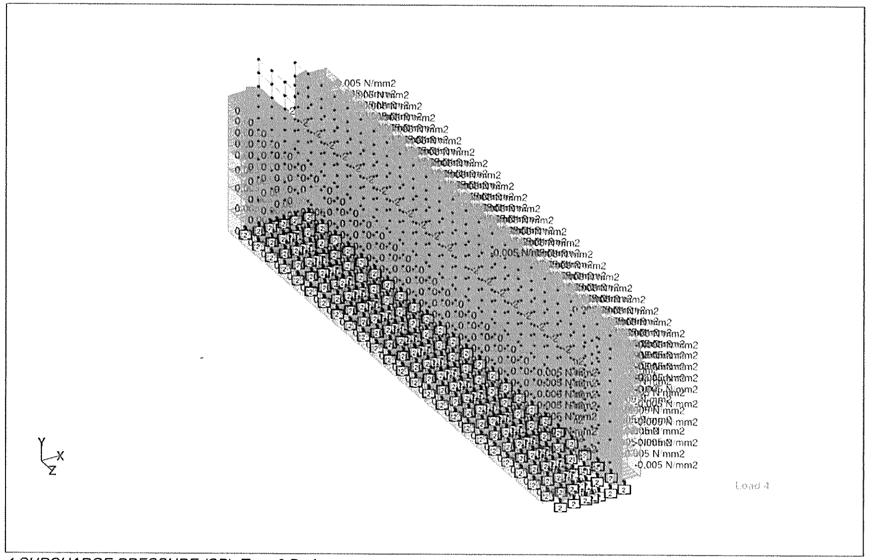
Job No	Sheet No 4	Rev A
Part PERIMETER DRAIN - 1.50m Deep		
Ref		
By Mohan	Date 5/5/2021	Chd Diana
File Type-2 Drain design_1.5(	Date/Time 12-May-2021 11:34	

Job Title BCC-2 PROJECT

Client



3 ACTIVE SOIL PRESSURE DUE TO SUBMERGED SOIL (SASP)_Type 2 Drain



4 SURCHARGE PRESSURE (SP)_Type 2 Drain

Software licensed to Jurong Engineering Limited
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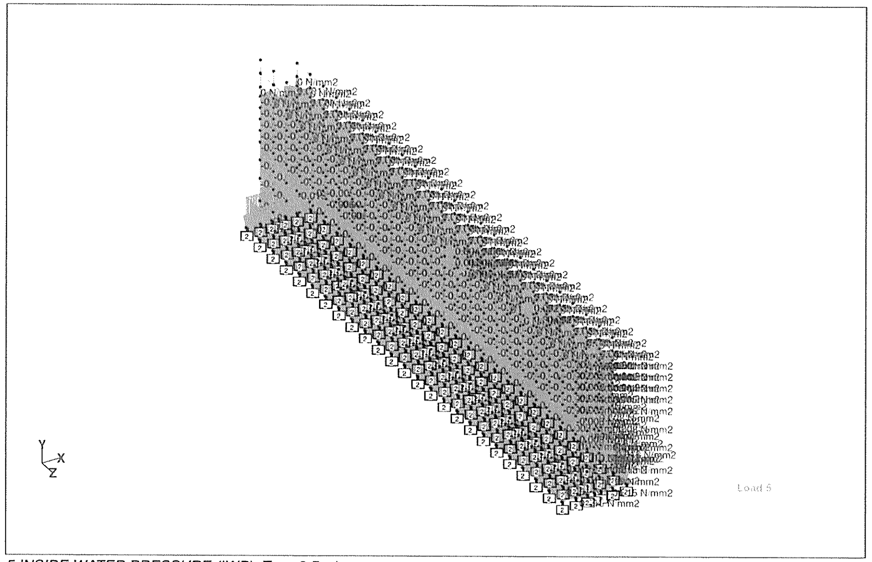
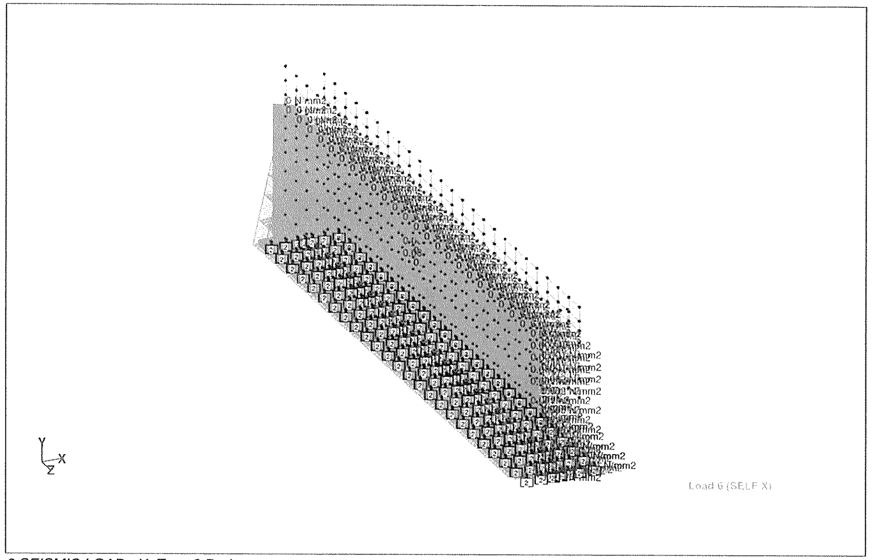
Job No	Sheet No 5	Rev A
Part PERIMETER DRAIN - 1.50m Deep		
Ref		
By Mohan	Date 5/5/2021	Chd Diana
File Type-2 Drain design_1.5(	Date/Time 12-May-2021 11:34	

Job Title BCC-2 PROJECT

Client



5 INSIDE WATER PRESSURE (IWP)_Type 2 Drain



6 SEISMIC LOAD +X_Type 2 Drain

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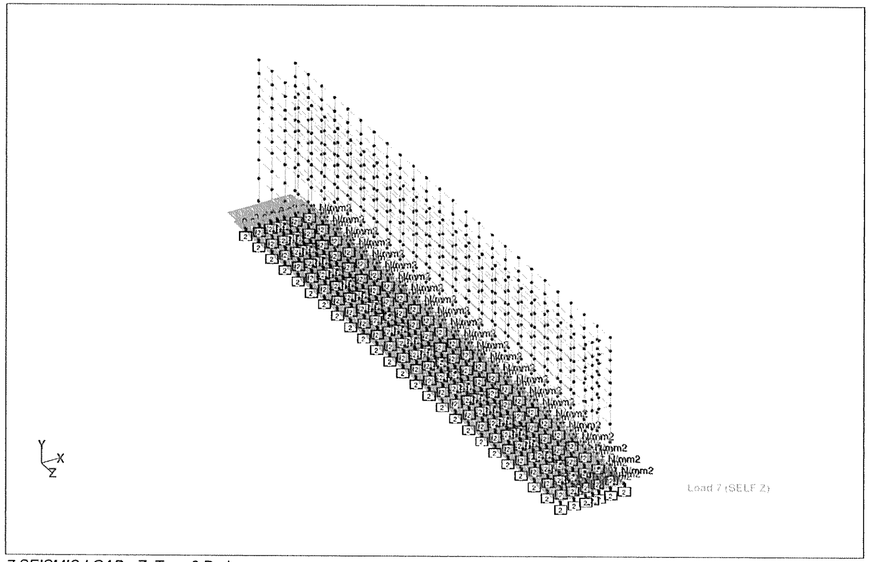
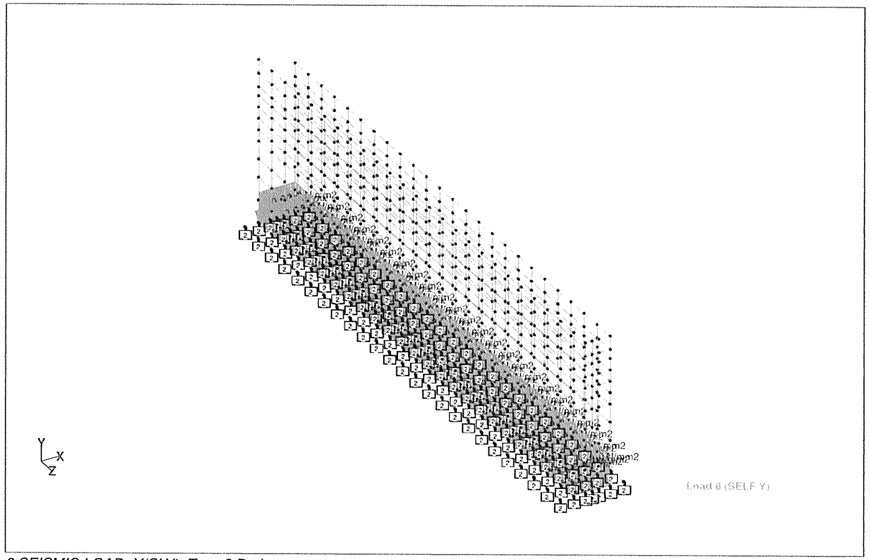
Job No	Sheet No 6	Rev A
Part PERIMETER DRAIN - 1.50m Deep		
Ref		
By Mohan	Date 5/5/2021	Chd Diana
File Type-2 Drain design_1.5(	Date/Time 12-May-2021 11:34	

Job Title BCC-2 PROJECT

Client

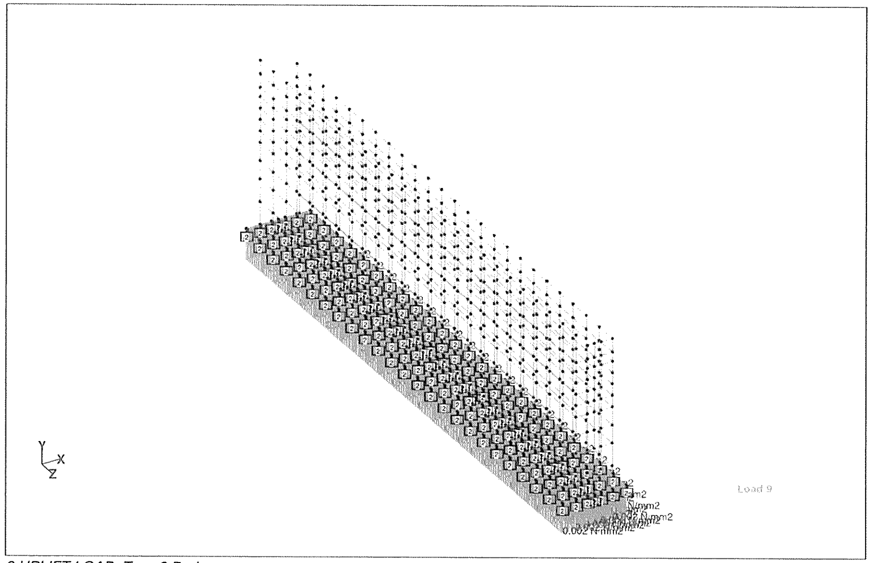


7 SEISMIC LOAD +Z_Type 2 Drain



8 SEISMIC LOAD -Y(SLY)_Type 2 Drain

Software licensed to Jurong Engineering Limited CONNECTED User: kalyani rajmohan	Job No	Sheet No 7	Rev A
	Part PERIMETER DRAIN - 1.50m Deep		
Job Title BCC-2 PROJECT	Ref		
	By Mohan	Date 5/5/2021	Chd Diana
Client	File Type-2 Drain design_1.5C	Date/Time 12-May-2021 11:34	



9 UPLIFT LOAD_Type 2 Drain

5.2.7 Check for Base pressure

Software licensed to Jurong Engineering Limited CONNECTED User: kalyani rajmohan	Job No	Sheet No 1	Rev A
	Part PERIMETER DRAIN - 1.50m Deep		
Job Title BCC-2 PROJECT	Ref		
	By Mohan	Date 5/5/2021	Chd Diana
Client	File Type-2 Drain design_1.5(	Date/Time 05-May-2021 17:47	

Base Pressure Summary

	Node	L/C	FX (N/mm^2)	FY (N/mm^2)	FZ (N/mm^2)
Max FX	1	11:DL+FL	**0**	0.049	0
Min FX	1	11:DL+FL	**0**	0.049	0
Max FY	271	19:DL+DASP+:	0	**0.051**	0
Min FY	276	23:0.60 DL-0.7	0	**0.020**	0
Max FZ	1	11:DL+FL	0	0.049	**0**
Min FZ	1	11:DL+FL	0	0.049	**0**

Actual pressure = 51 kN/m^2

Allowable pressure = 75 kN/m^2

Hence the actual pressure is less than the alllowable pressure.

5.2.8 Design of wall

Software licensed to Jurong Engineering Limited CONNECTED User: kalyani rajmohan	Job No	Sheet No 1	Rev A
	Part PERIMETER DRAIN - 1.50m Deep		
Job Title BCC-2 PROJECT	Ref		
	By Mohan	Date 5/5/2021	Chd Diana
Client	File Type-2 Drain design_1.5C	Date/Time 05-May-2021 17:47	

Plate Center Stress Summary

	Plate	L/C	Shear Qx (N/mm²)	Shear Qy (N/mm²)	Membrane Sx (N/mm²)	Membrane Sy (N/mm²)	Membrane Sxy (N/mm²)	Bending Mx (kN·m/m)	Bending My (kN·m/m)	Bending Mxy (kN·m/m)
Max Qx	810	109:0.9DL+1.6	**0.498**	0.099	-0.255	-0.016	-0.056	14.148	4.561	-1.076
Min Qx	717	106:1.2DL+DA	**-0.355**	-0.067	-0.420	-0.005	-0.068	-12.545	-3.220	0.981
Max Qy	715	109:0.9DL+1.6	0.192	**0.231**	-0.227	-0.027	-0.043	10.998	2.832	0.112
Min Qy	716	106:1.2DL+DA	-0.157	**-0.189**	-0.315	-0.019	-0.128	-9.689	-2.107	-0.106
Max Sx	810	106:1.2DL+DA	0.366	0.060	**0.674**	0.004	0.092	9.327	3.142	-0.688
Min Sx	717	114:1.2DL+DA	-0.104	-0.027	**-0.484**	-0.019	-0.071	-4.178	-1.007	0.402
Max Sy	811	110:0.9DL+1.6	0.137	-0.096	0.384	**0.043**	-0.157	6.663	1.793	-2.167
Min Sy	224	105:1.2DL+DA	0.007	-0.178	0.005	**-0.073**	-0.009	2.139	13.188	-0.236
Max Sxy	715	106:1.2DL+DA	0.141	0.167	0.347	0.029	**0.287**	6.956	1.817	0.291
Min Sxy	812	109:0.9DL+1.6	-0.195	0.126	0.349	0.023732	**-0.185**	-8.849	-1.982	2.277
Max Mx	810	109:0.9DL+1.6	0.498	0.099	-0.255	-0.016	-0.056	**14.148**	4.561	-1.076
Min Mx	717	106:1.2DL+DA	-0.355	-0.067	-0.420	-0.005	-0.068	**-12.545**	-3.220	0.981
Max My	206	105:1.2DL+DA	0.001	-0.170	-0.006	-0.062	-0.012	2.217	**13.233**	-0.349
Min My	229	109:0.9DL+1.6	-0.004	0.165	0.006	-0.046	-0.007	-2.093	**-12.879**	-0.357
Max Mxy	796	106:1.2DL+DA	-0.010	-0.008	-0.209	-0.007	-0.029	0.593	0.153	**3.582**
Min Mxy	602	109:0.9DL+1.6	0.016	-0.004	-0.083	-0.019	-0.048	-0.615	-0.688	**-3.477**

Maximum Moment in X-Dir	Mx	=	**14.15**	kNm/m
Corresponding Moment	Mxy	=	**1.076**	kNm/m
Maximum Moment in Y-Dir	My	=	**13.233**	kNm/m
Corresponding Moment	Mxy	=	**0.35**	kNm/m
Corresponding Moment in X or Y-Dir	My	=	**3.582**	kNm/m
Maximum Moment in XY-Dir	Mxy	=	**0.593**	kNm/m
Maximum Shear Stess in X-Dir	S_{QX}	=	**0.498**	N/mm^2
Maximum Shear Stess in X-Dir	S_{Qy}	=	**0.231**	N/mm^2
Max. Ultimate bending moment	Mu = My+Mxy	=	15.226	kNm/m

Depth of section	h	=	**150**	mm
Width of Section	b	=	**1000**	mm
Concrete Cover	cc	=	**75**	mm
Concrete Grade	f'_c	=	**28**	N/mm^2
Steel Reinforcement Grade	f_y	=	**400**	N/mm^2
Diameter of Reinforcement	dia	=	**12**	mm
Spacing of Reinforcement	S	=	**150**	mm

Design Moment		Muz/φ	=	16.92 kNm
Width considered		b	=	**1000** mm
Effective Depth		(tb-c-0.5f)=d	=	144 mm
z assumed =d			=	144 mm
As reqd = M/fy*z			=	294 mm^2/m
Provide	**DB** 12-150	As prov.	=	754 mm^2/m
Distribution bar	DB 12-150	As prov.	=	754 mm^2/m

Minimum area of reinforcement in ver dir req. = 0.0015 * b*D (Table 11.6.1,ACI -318-14)

= 225 mm^2/m

< 754 mm^2/m

Hence OK

Minimum area of reinforcement in Hor dir req. = 0.0025 * b*D (Table 11.6.1,ACI -318-14)

= 375 mm^2/m

< 754 mm^2/m

Hence OK

Check for Shear

Actual shear stress = Vu = 0.498 N/mm^2

Allowable shear stress =

a) $\varphi V_c = \varphi 0.17 \lambda sqrt(f_c')$ = 0.67 N/mm^2

λ=1.0 (Modification factor for normal wt of concrete)

Actual Shear stress Vu < φVc **Hence Ok**

Hence shear reinforcement is not required.

5.2.9 Design of Slab

Software licensed to Jurong Engineering Limited CONNECTED User: kalyani rajmohan	Job No	Sheet No 1	Rev A
	Part PERIMETER DRAIN - 1.50m Deep		
Job Title BCC-2 PROJECT	Ref		
	By Mohan	Date 5/5/2021	Chd Diana
Client	File Type-2 Drain design_1.5(	Date/Time 05-May-2021 17:47	

Plate Center Stress Summary

			Shear		Membrane			Bending		
	Plate	L/C	Qx (N/mm²)	Qy (N/mm²)	Sx (N/mm²)	Sy (N/mm²)	Sxy (N/mm²)	Mx (kN·m/m)	My (kN·m/m)	Mxy (kN·m/m)
Max Qx	218	105:1.2DL+DA!	**0.060**	0.036	0	0	0	-15.838	-2.586	0.101
Min Qx	17	106:1.2DL+DA!	**-0.064**	0.035	0	0	0	-12.993	-2.225	-0.443
Max Qy	236	109:0.9DL+1.6I	0.005	**0.073**	0	0	0	-15.604	-1.550	0.433
Min Qy	381	109:0.9DL+1.6I	0.007	**-0.047**	0	0	0	-3.244	-0.543	0.502
Max Sx	419	101:1.4DL+1.4I	-0.011	0.013013	**0**	0	0	0.428	-0.097	0.178
Min Sx	419	101:1.4DL+1.4I	-0.011	0.013013	**0**	0	0	0.428	-0.097	0.178
Max Sy	419	101:1.4DL+1.4I	-0.011	0.013013	0	**0**	0	0.428	-0.097	0.178
Min Sy	419	101:1.4DL+1.4I	-0.011	0.013013	0	**0**	0	0.428	-0.097	0.178
Max Sxy	419	101:1.4DL+1.4I	-0.011	0.013013	0	0	**0**	0.428	-0.097	0.178
Min Sxy	419	101:1.4DL+1.4I	-0.011	0.013013	0	0	**0**	0.428	-0.097	0.178
Max Mx	202	101:1.4DL+1.4I	-0.009	-0.000	0	0	0	**8.477**	1.464	-0.020
Min Mx	200	109:0.9DL+1.6I	0.040619	0.022	0	0	0	**-15.999**	-2.738	0.197
Max My	202	101:1.4DL+1.4I	-0.009	-0.000	0	0	0	8.477	**1.464**	-0.020
Min My	200	109:0.9DL+1.6I	0.040619	0.022	0	0	0	-15.999	**-2.738**	0.197
Max Mxy	362	109:0.9DL+1.6I	0.030	0.027	0	0	0	-5.250	-0.911	**0.585**
Min Mxy	310	106:1.2DL+DA!	-0.030	-0.032	0	0	0	-8.334	-1.457	**-0.685**

Maximum Moment in X-Dir	Mx	=	**16**	kNm/m
Corresponding Moment	Mxy	=	**0.197**	kNm/m
Maximum Moment in Y-Dir	My	=	**2.74**	kNm/m
Corresponding Moment	Mxy	=	**0.197**	kNm/m
Corresponding Moment in X or Y-Dir	Mx	=	**8.334**	kNm/m
Maximum Moment in XY-Dir	Mxy	=	**0.685**	kNm/m
Maximum Shear Stess in X-Dir	S_{QX}	=	**0.06**	N/mm²
Maximum Shear Stess in X-Dir	S_{Qy}	=	**0.073**	N/mm²
Max. Ultimate bending moment	Mu = My+Mxy	=	16.197	kNm/m
Depth of section	h	=	**150**	mm
Width of Section	b	=	**1000**	mm
Concrete Cover	cc	=	**75**	mm
Concrete Grade	f'_c	=	**28**	N/mm²
Steel Reinforcement Grade	f_y	=	**400**	N/mm²
Diameter of Reinforcement	dia	=	**12**	mm
Spacing of Reinforcement	S	=	**150**	mm
Design Moment	Muz/φ	=	18.00	kNm
Width considered	b	=	**1000**	mm

Effective Depth		(tb-c-0.5f)=d	=	69 mm	
z assumed =d			=	69 mm	
As reqd = M/fy*z			=	652 mm^2/m	
Provide	DB 12-150	As prov.	=	754 mm^2/m	
Distribution bar	DB 12-150	As prov.	=	754 mm^2/m	
Minimum area of reinforcement			=	0.002 * b*D	(7.6.1.1,ACI 318-14)
			=	300 mm^2/m	
			<	754 mm^2/m	Hence OK

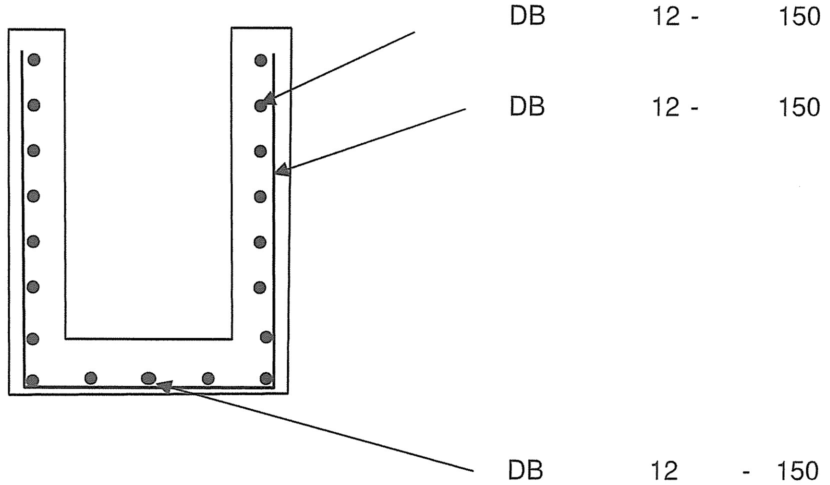
Check for Shear

Actual shear stress =		Vu	=	0.073 N/mm^2	
Allowable shear stress =					
a)	$\varphi V_c = \varphi 0.17 \lambda \mathrm{sqrt}(f_c')$		=	0.67 N/mm^2	

λ=1.0 (Modification factor for normal wt of concrete)

Actual Shear stress Vu < φVc **Hence Ok**

Hence shear reinforcement is not required.



5.2.10 Design of Grating For Maintenance access

(i)	Live Load	W	=	7.5 kN/m2	
	Max. Width of Drain (0.6+0.06)	L	=	0.66 m	
	Safe working stress of steel	fy	=	155.1 N/mm2	(0.66*fy)
	Load bar thickness	B	=	5 mm	
	Section Modulus	S	=	$B*H^2/6$	
	Pitch of load bar	p	=	100 mm	
	Width of grating	W	=	500 mm	
	No. of load bars	n	=	5.50 Nos	
	Moment	Ma	=	$wl^2/8$	
			=	0.408375 kNm	

Bending moment of section M= fy*S		=	155*n*B*H^2/6
	Ms	=	710.875 H^2
	Ms	=	Ma
	H	=	24 mm
		<	**35** mm

ii) <u>Check for deflection</u>

Deflection due to load	d	=	$5wL^4/384EI$
		=	0.47 mm
Allowable deflection L/200 or 10 mm		=	3.30 mm

Hence safe in deflection.

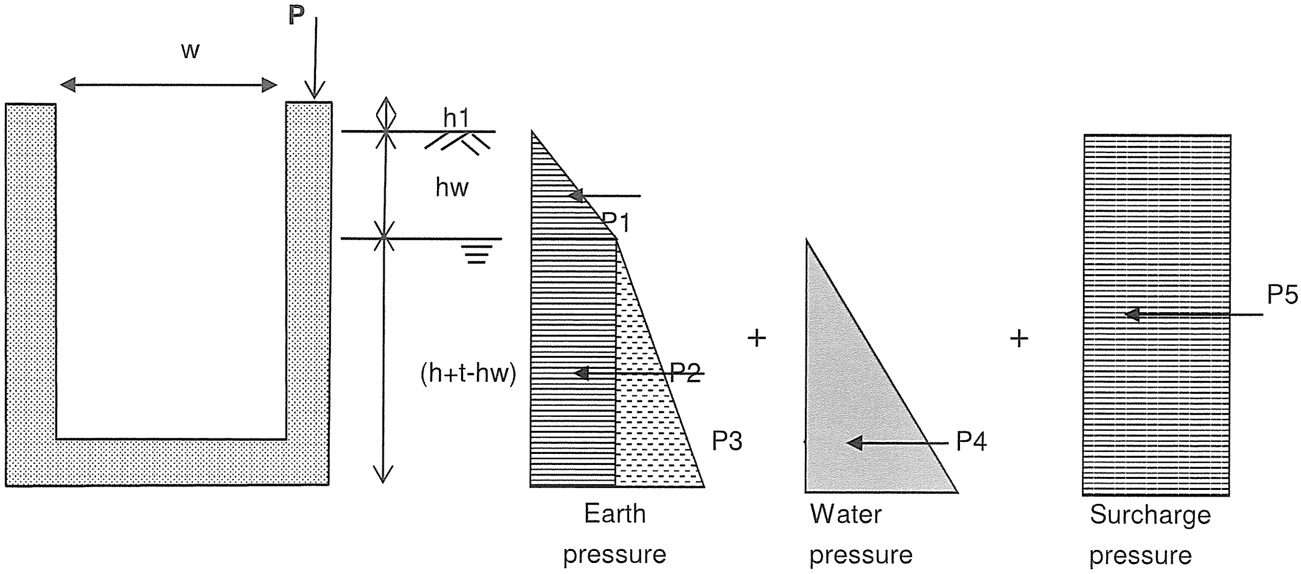
Provide 35 x 5mm thk grating

DESIGN OF STORM WATER DRAIN AT ROAD CROSSING

5.0 Design of storm water drain at road crossing

5.1 For Depth of 1.50 m

The drain at road crossing is designed for maximum depth of 1.50 m and minimum width of 0.40 m wide.



5.1.1 Soil Parameters

Unit weight of soil	=	18.00	kN/m^3	
Angle of repose	=	30	ϕ	
Unit weight of water	$\gamma\omega$ =	10.00	kN/m^3	
Soil density,	γs =	18.00	kN/m^3	
Soil submerged density,	$\gamma's$ =	8.00	kN/m^3	
Soil active pressure coefficient,	ka =	0.33		
Coefficient for surcharge,	k =	0.50		
Surcharge due to vehicle,	γ_{sur} =	10	kN/m^2	
Ground water table	hw =	1.50	m	Below GL

5.1.2 Drain Parameters

Height of trench below GL	h =	1.500	m
Height of trench above GL	$h1$ =	0.150	m
Width of drain	w =	0.400	m
Wall & base thickness,	t =	0.250	m

5.1.3 Material properties

Concrete strength,	(cylinder strength)	f'c =	28	N/mm^2
Rebar strength,		fy =	400	N/mm^2
Minimum concrete cover,		=	75	mm

5.1.4 Design of wall

For 1.50 m depth of drain

(i)	Soil Load on Projected area of base slab		=g •(h) =	27.00	kN/m²
(ii)	Active pressure due to dry soil ,		qa =ka•g •(hw) =	8.91	kN/m²
(iii)	Inside Water Pressure		q'w =gw •(h) =	15.00	kN/m²
(iv)	Surcharge pressure	qp =	$k \cdot g_{sur}$ =	5.00	kN/m²
(v)	Buoyancy force on slab	qp =	=gw •(h) =	2.50	kN/m²

(In Staad Applied under as seperate load case)

H20-44 Vehicle load on each wheel P = 48 kN

(please refer to vehicle loading calcultion in the next page)

5.1.5 EARTH PRESSURE LOAD

For calculating the earth pressure load on the side walls , it is assumed that the ground water table is at FGL conservatively.

Unit weight of soil	γ	=	**18**	kN/m³
Angle of repose		=	**30**	ϕ
Unit weight of water	$\gamma\omega$	=	**10**	kN/m³
Soil submerged density,	$\gamma's$	=	8	kN/m³
coefficient for surcharge pressure	k_s	=	**0.50**	
Soil active pressure coefficient,	ka	=	**0.33**	

ka = $\tan^2(45 - ø/2)$ for ø =30deg

Ground water table	hw	=	**1.50**	m
The height of wall below GL	h	=	**1.50**	m
Depth of the base slab	D_{bs}	=	**0.25**	m
Surcharge load,	q	=	**20.00**	kN/m²
Total Height of wall	H	=	1.75	m

5.1.6 SEISMIC EARTH PRESSURE LOAD

Mononobe-Okabe Method :

Dynamic active earth thrust Pdae = Kae x γ x H

Where Kae = seismic active earth pressure coefficient

$$Kae = \frac{\cos^2(\Phi-\Psi-\theta)}{\cos(\Psi)\cos^2(\theta)\cos(\delta+\theta+\Psi) \times \left[1+\left[\frac{\sin(\Phi+\delta)\sin(\Phi-\Psi-\beta)}{\cos(\beta-\theta)\cos(\delta+\Psi+\theta)}\right]^{0.5}\right]^2}$$

5.1.7 Seismic load on vertical direction (SL Y)

(Section 12.4.2.2 of ASCE 7-10)

$Ev = 0.2*S_{DS}*DL$

SDS = 0.094

Ev = 0.0188 D

5.1.8 LOAD COMBINATION

(i) **Primary Loads**

LOAD 1 DEAD LOAD (DL)

LOAD 2 ACTIVE LOAD DUE TO DRY SOIL (DASP)

LOAD 4 SURCHARGE PRESSURE (SP)

LOAD 5 INSIDE WATER PRESSURE (IWP)

LOAD 6 SEISMIC LOAD (SL+X)

LOAD 7 SEISMIC LOAD (SL+Z)

LOAD 8 SEISMIC LOAD (SL-Y)

LOAD 9 UPLIFT LOAD (UL)

ii) **Service Loads**

LOAD COMB 11 DL

LOAD COMB 12 DL+DASP+SP+VL

LOAD COMB 13 DL+DASP+SP+0.75IWP+VL

LOAD COMB 14 DL+DASP+SP +0.70SL(+X)+0.70SL(-Y)

LOAD COMB 15 DL+DASP+SP -0.70SL(+X)+0.70SL(-Y)

LOAD COMB 16 DL+DASP+SP +0.70SL(+Z)+0.70SL(-Y)

LOAD COMB 17 DL+DASP+SP -0.70SL(-Z)+0.70SL(-Y)

LOAD COMB 18 DL+DASP+SP+IWP+0.70SL(+X)+0.70SL(-Y)

LOAD COMB 19 DL+DASP+SP+IWP-0.70SL(+X)+0.70SL(-Y)

LOAD COMB 20 DL+DASP+SP+IWP+0.70SL(+Z)+0.70SL(-Y)

LOAD COMB 21 DL+DASP+SP+IWP-0.70SL(+Z)+0.70SL(-Y)

LOAD COMB 21 0.60 DL+0.70SL+X+0.70SL(-Y)

LOAD COMB 22 0.60 DL-0.70SL+X+0.70SL(-Y)

LOAD COMB 23 0.60 DL+0.70SL+Z+0.70SL(-Y)

LOAD COMB 24 0.60 DL-0.70SL+Z+0.70SL(-Y)

LOAD COMB 24 0.80 DL+UL

iii) **Ultimate Loads**

LOAD COMB 101 1.4DL

LOAD COMB 102 1.2DL+1.6DASP+1.6SP+1.6VL

LOAD COMB 103 1.2DL+1.6DASP+1.6SP+1.6IWP+1.6VL

LOAD COMB 104 1.2DL+1.0DASP+1.0SP+1.0SL+X +1.0SL(-Y)
LOAD COMB 105 1.2DL+DASP+SP-1.0SL+X +1.0SL(-Y)
LOAD COMB 106 1.2DL+DASP+SP+1.0SL+Z +1.0SL(-Y)
LOAD COMB 107 1.2DL+DASP+SP-1.0SL+Z +1.0SL(-Y)
LOAD COMB 108 0.9DL+1.6DASP+1.6SP+1.0SL+X+1.0SL(-Y)
LOAD COMB 109 0.9DL+1.6DASP+1.6SP-1.0SL+X+1.0SL(-Y)
LOAD COMB 110 0.9DL+1.6DASP+1.6SP+1.0SL+Z+1.0SL(-Y)
LOAD COMB 111 0.9DL+1.6DASP+1.6SP-1.0SL+Z+1.0SL(-Y)
LOAD COMB 112 1.2DL+DASP+SP+IWP+1.0SL+X +1.0SL(-Y)
LOAD COMB 113 1.2DL+DASP+SP+IWP-1.0SL+X +1.0SL(-Y)
LOAD COMB 114 1.2DL+DASP+SP+IWP+1.0SL+Z +1.0SL(-Y)
LOAD COMB 115 1.2DL+DASP+SP+IWP-1.0SL+Z +1.0SL(-Y)
LOAD COMB 116 1.4DL+1.4UL

The drain is analysed in STAAD pro

Vehicle Loading

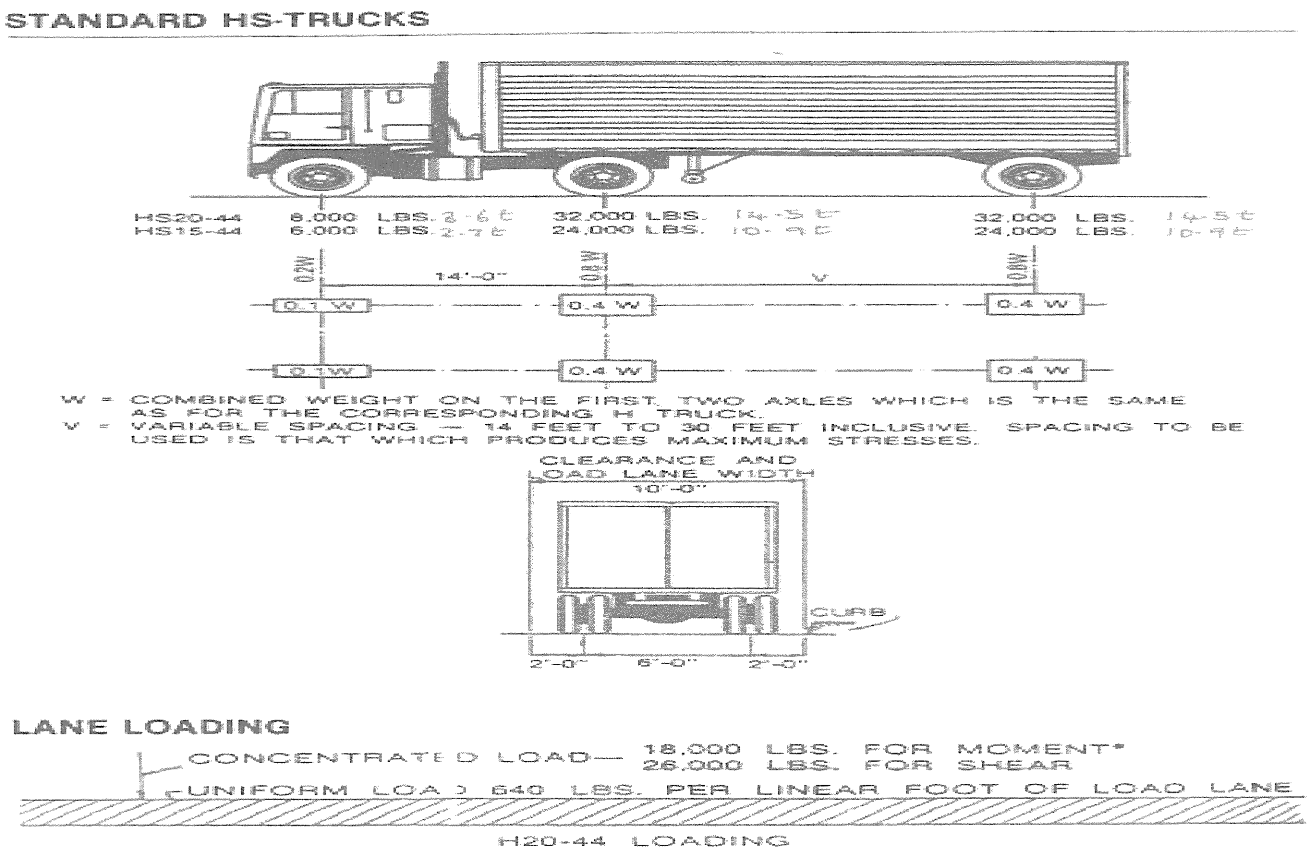
As per the department of Highways (Thailand) Regulation and as per the specification

The Maximum wheel load is for H20-44 where the load is transferred by two wheels on each axle.

The maximum load is 14.5 T (32000 LBS on Each axle) transferred from the dual type tyre

Therefore the load transferred through one wheel = 14.5/4 = 3.625t

Considering the 30% impact load = 3.625x(1+0.3) = 4.7125 T



5.1.9 Check for Base pressure

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	Part DRAIN - Road crossing			
Job Title BCC-2 PROJECT	Ref			
	By Mohan	Date 24-Jun-19	Chd Diana	
Client BCC-2	File Type -3 Drain Design- Ro	Date/Time 12-May-2021 13:22		

Base Pressure Summary

	Node	L/C	FX (N/mm^2)	FY (N/mm^2)	FZ (N/mm^2)
Max FX	1	101:DL+IWP	**0**	0.046	0
Min FX	1	101:DL+IWP	**0**	0.046	0
Max FY	314	110:DL+DASP-	0	**0.073**	0
Min FY	678	111:0.6DL+DA!	0	**0.020635**	0
Max FZ	1	101:DL+IWP	0	0.046	**0**
Min FZ	1	101:DL+IWP	0	0.046	**0**

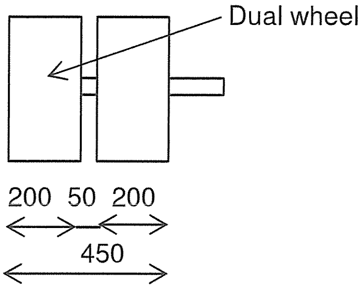
Actual pressure = 73 kN/m^2

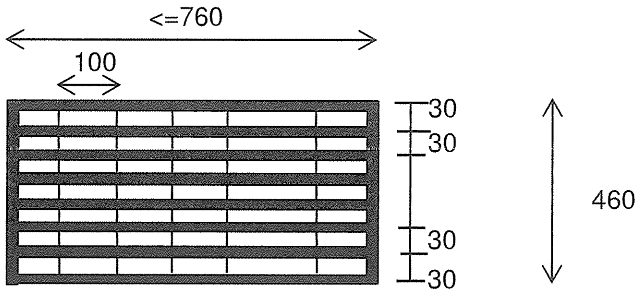
Allowable pressure = 75 kN/m^2

Hence the actual pressure is less than the alllowable pressure.

5.5 Design of Grating

(i)	Load on Wheel	P	=	48	kN
	Width of Drain (0.4+0.06)	L	=	0.46	m
	Safe working stress of steel	fy	=	155.1	N/mm2
	Impact factor (30%)	I	=	0.3	
	Load bar thickness	B	=	6	mm
	Section Modulus	S	=	$B*H^2/6$	
	Pitch of load bar	p	=	**30**	mm
	Tyre contact Width	X	=	500	mm
	Tyre contact length(dual wheel)	Y	=	450	mm
	Width of grating	W	=	450	mm
	No. of load bars	n	=	15.50	Nos





The width of load transferred is more than 450mm and hence 700mm wide grating is considered for the design. 55X6 Flat bars are interconnected by cross bars and 700 width act as one element.

	Moment	Ma	=	P*(1+I)*(L/4-X/8)	
			=	3.276	kNm
	Bending moment of section M= fy*S		=	155*n*B*H^2/6	
		Ms	=	2404.05 H^2	
		Ms	=	Ma	
		H	=	37	mm
			<	**55**	mm
ii)	Check for deflection				
	Deflection due to point load	d	=	$PL^3/48EI$	
			=	0.38	mm
	Allowable deflection L/200 or 10 mm		=	2.30	mm

Hence safe in deflection.

Provide 65 x 5mm thk grating

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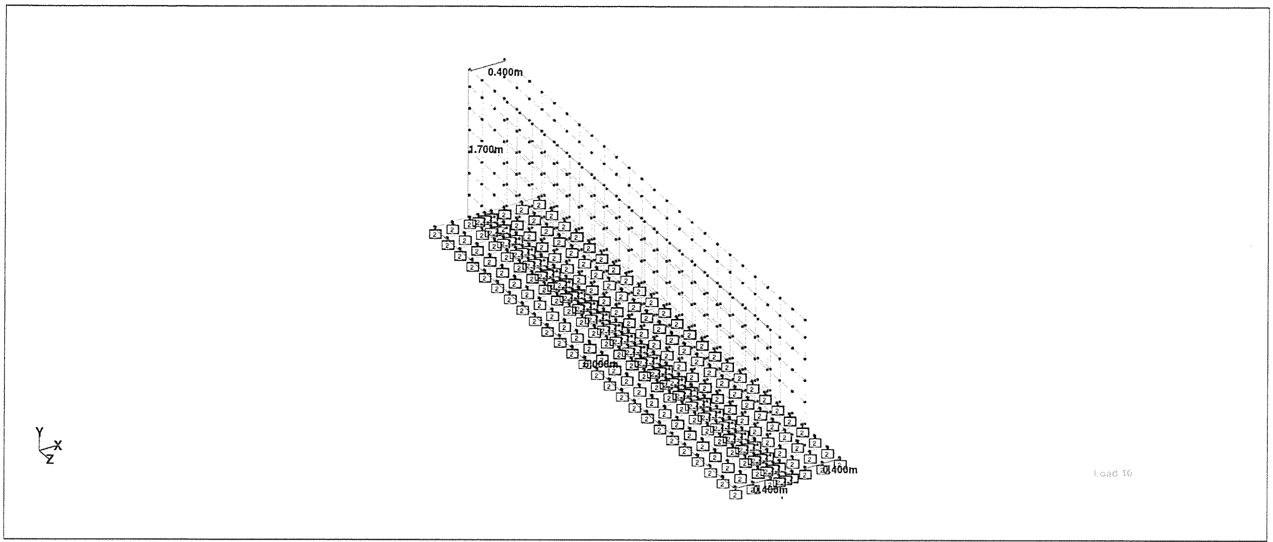
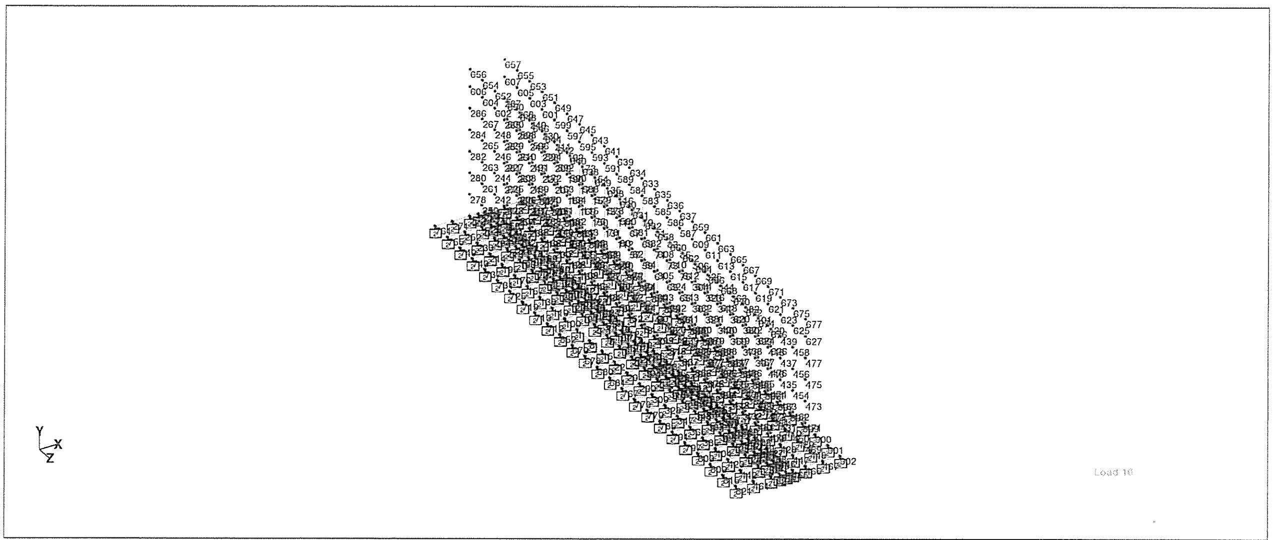
	By Mohan	Date 24-Jun-19	Chd Diana	
Client BCC-2	File Type -3 Drain Design- Ro	Date/Time 12-May-2021 13:22		



Whole Structure_Type-3 Drain(Road Crossing)



Node Numbers_Type-3 Drain(Road Crossing)

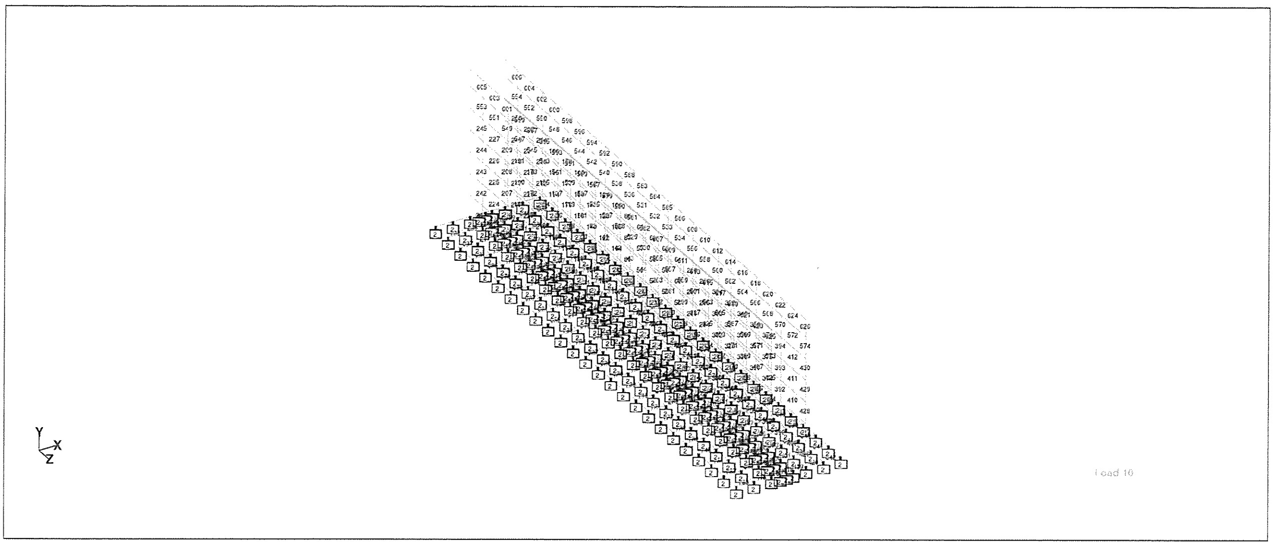


Plate Numbers_Type-3 Drain(Road Crossing)

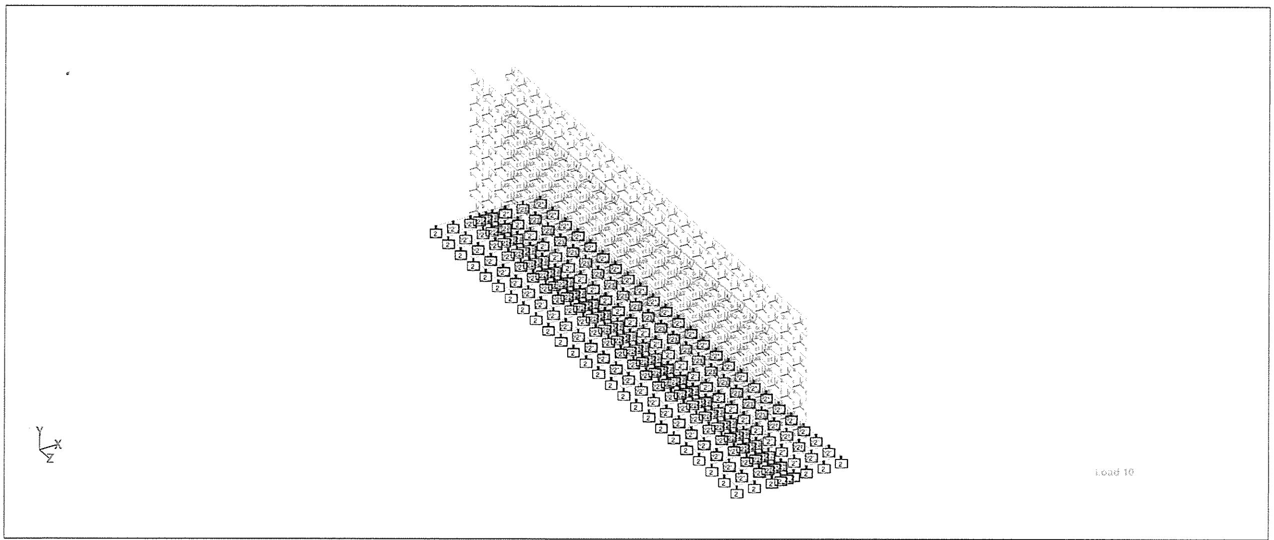


Plate orientation_Type-3 Drain(Road Crossing)

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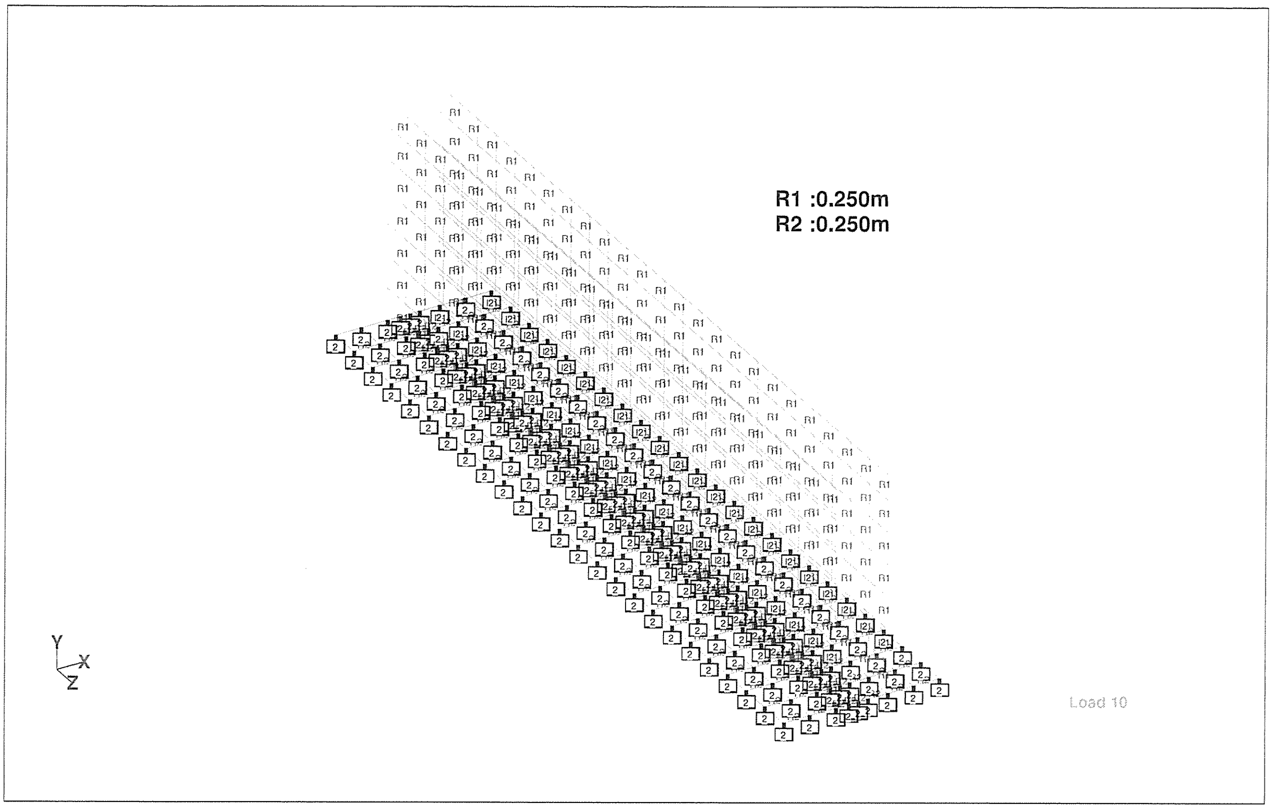
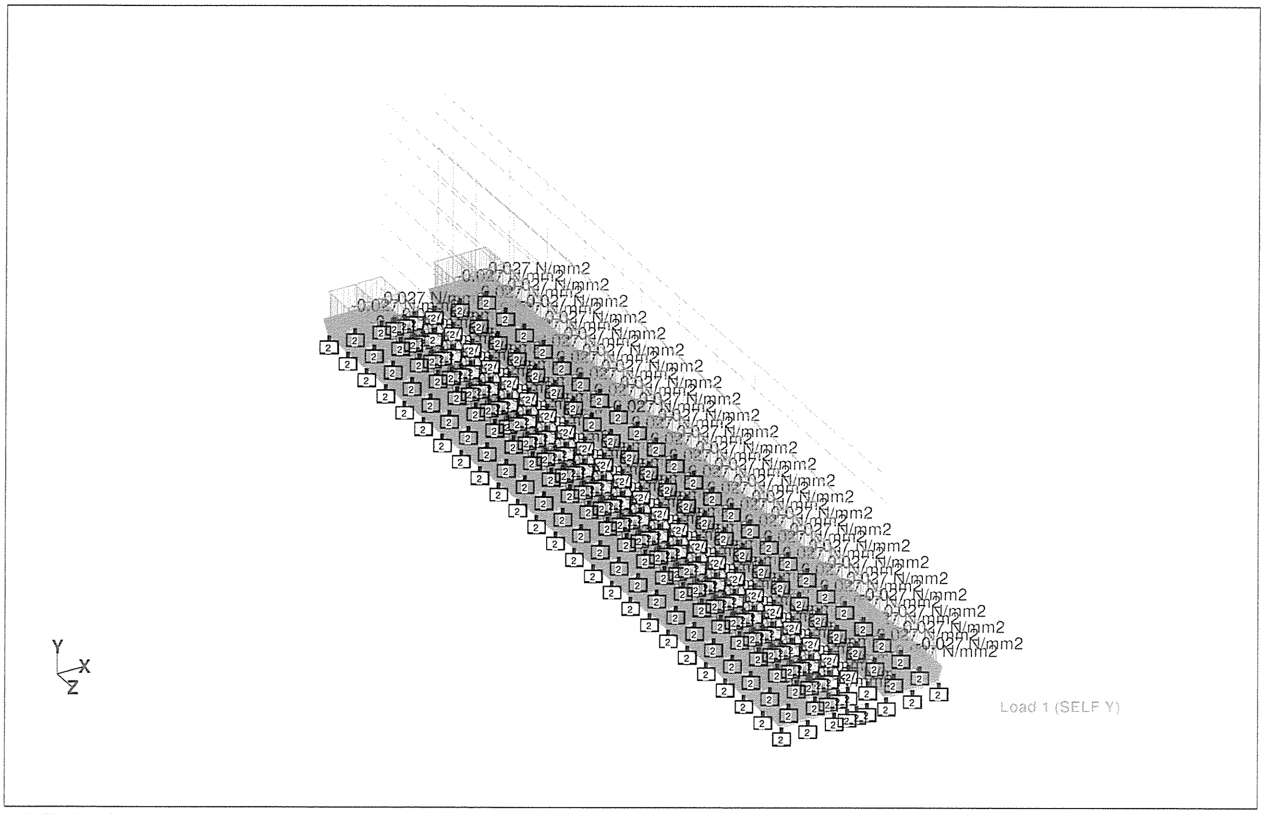
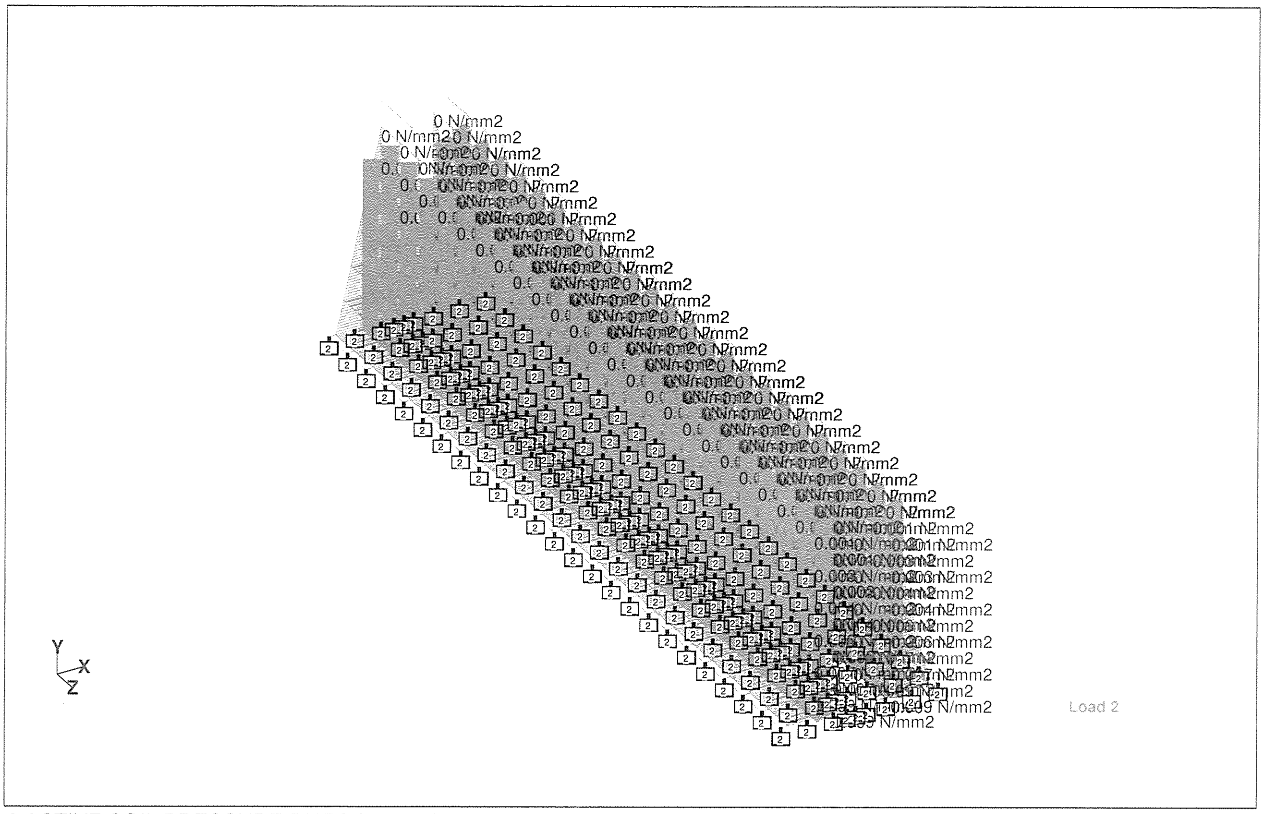
	Part DRAIN - Road crossing		
Job Title BCC-2 PROJECT	Ref		
	By Mohan	Date 24-Jun-19	Chd Diana
Client BCC-2	File Type -3 Drain Design- Ro	Date/Time 12-May-2021 13:22	



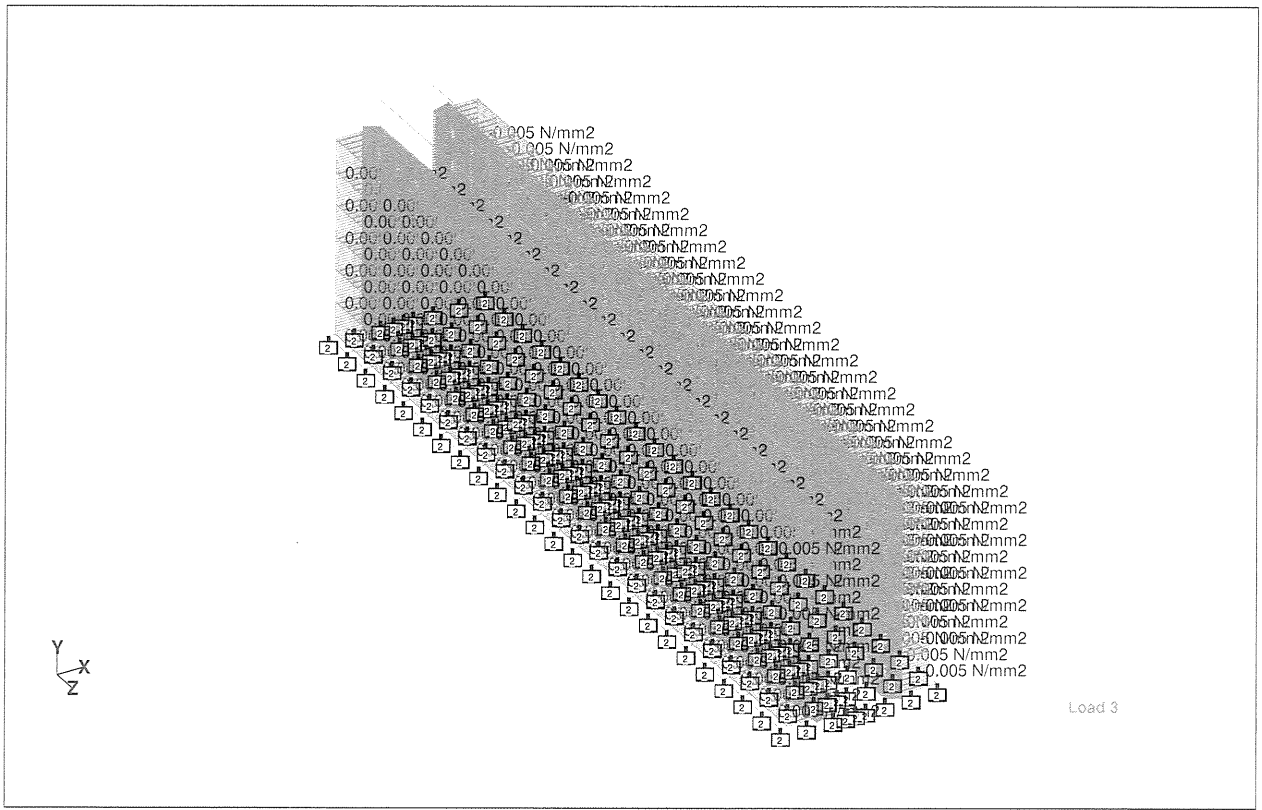
Member property



1 DEAD LOAD



2 ACTIVE SOIL PRESSURE DUE TO DRY SOIL (DASP)



3 SURCHARGE PRESSURE (SP)

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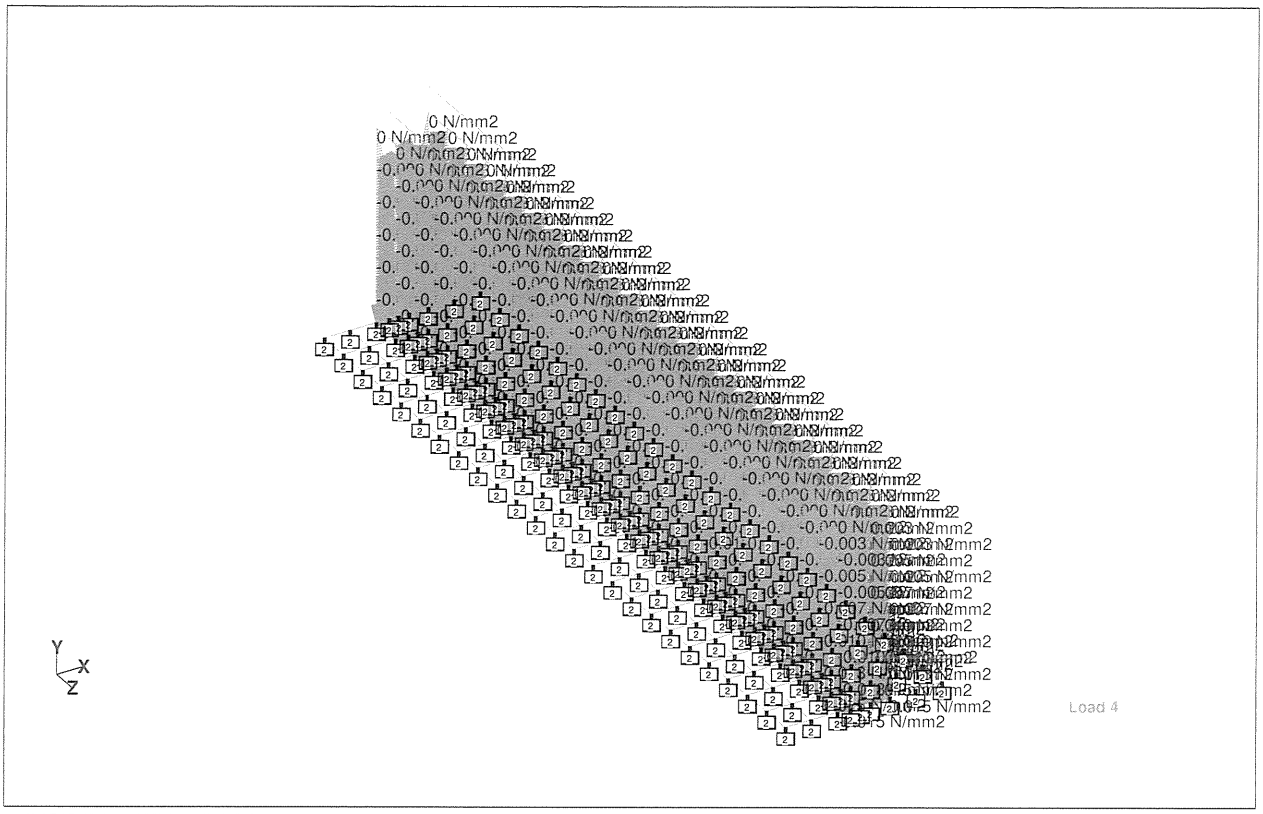
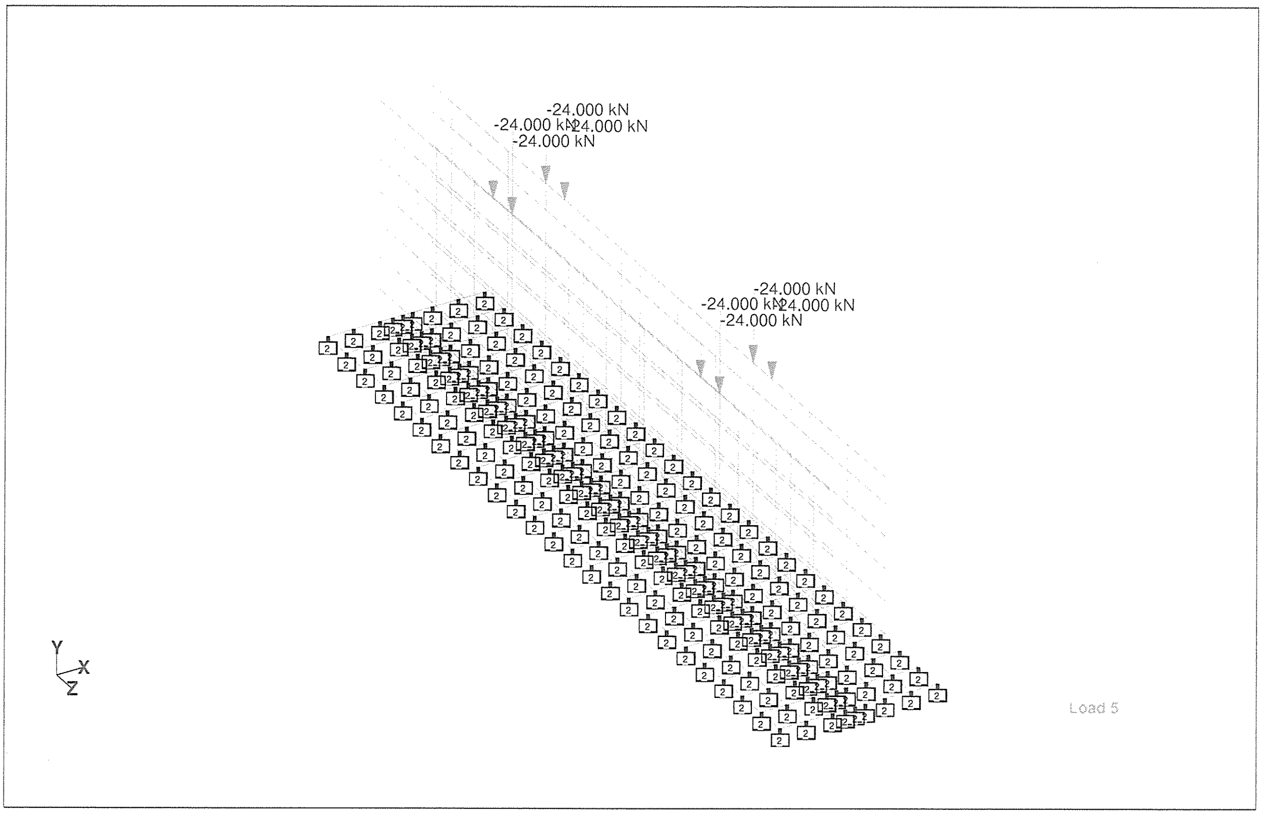
	Part DRAIN - Road crossing		
Job Title BCC-2 PROJECT	Ref		
	By Mohan	Date 24-Jun-19	Chd Diana
Client BCC-2	File Type -3 Drain Design- Ro	Date/Time 12-May-2021 13:22	



4 INSIDE WATER PRESSURE (IWP)



5 VEHICLE LOAD (VL)

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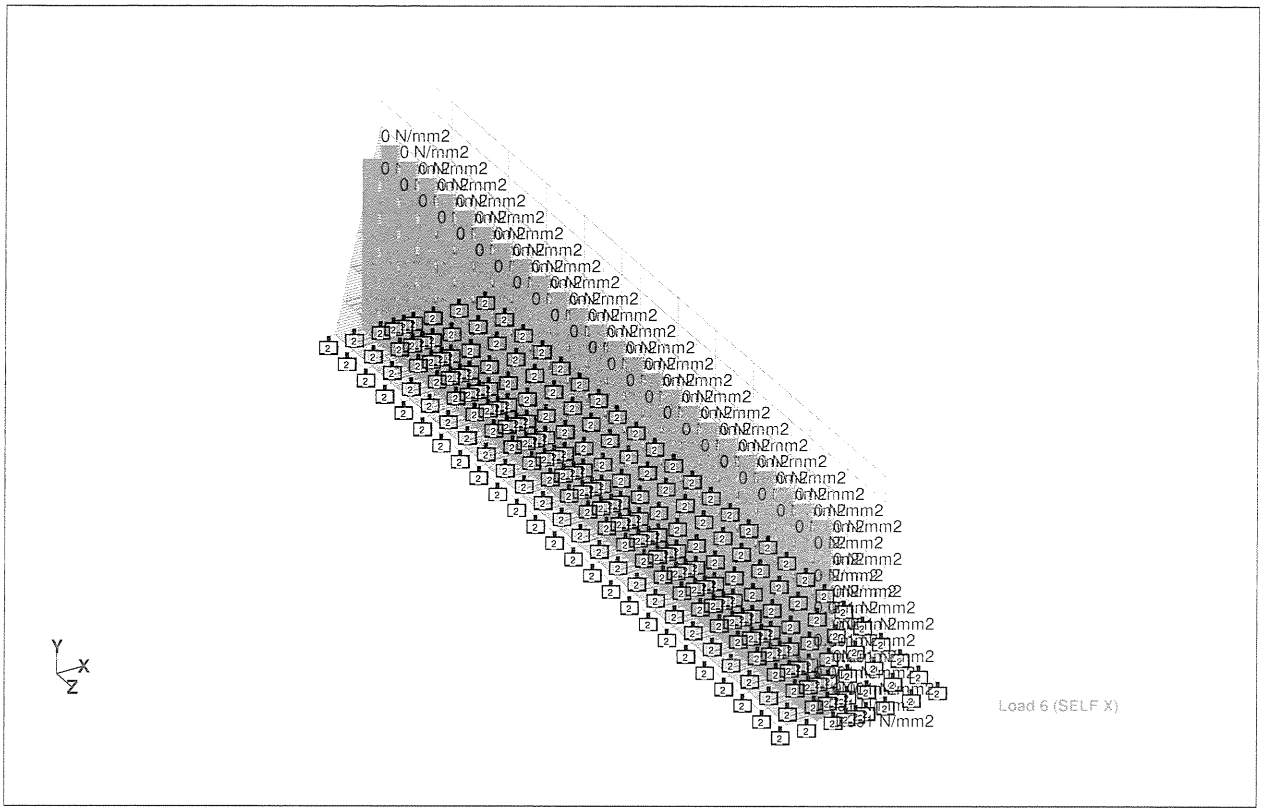
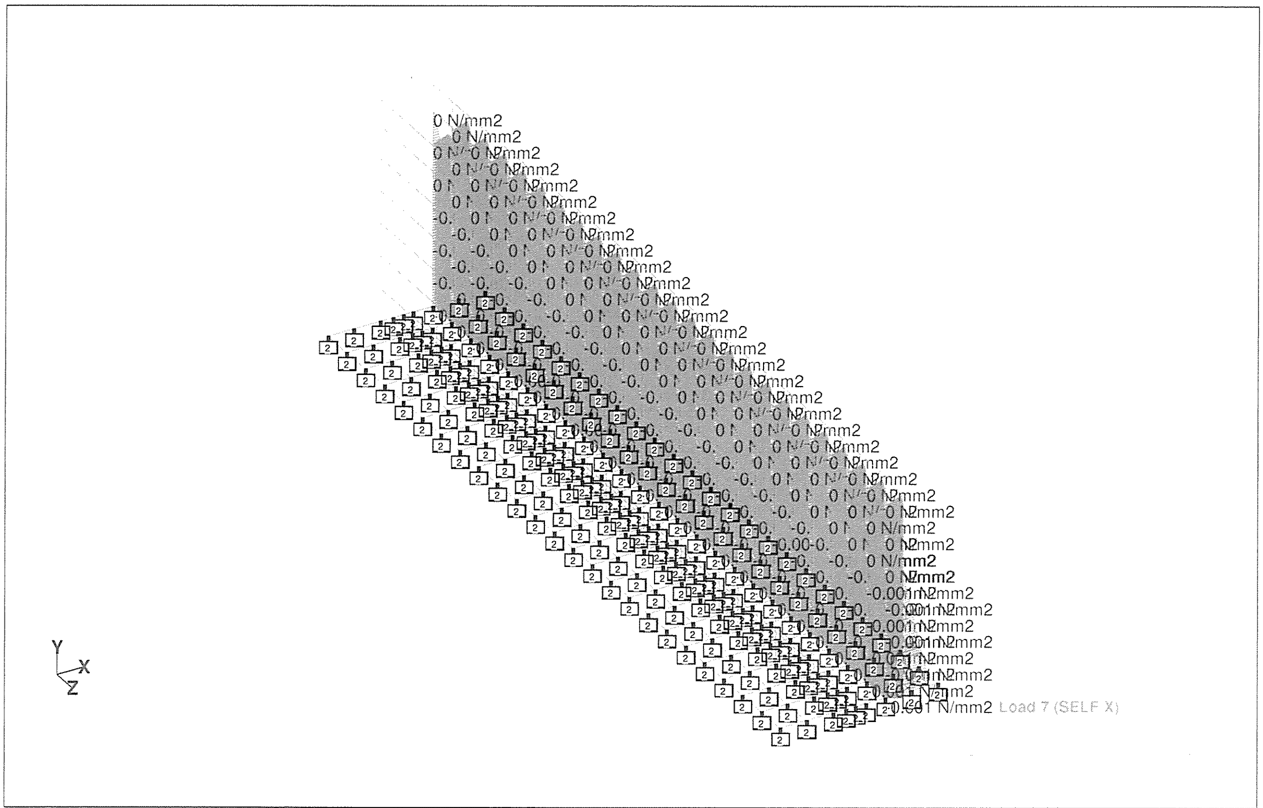
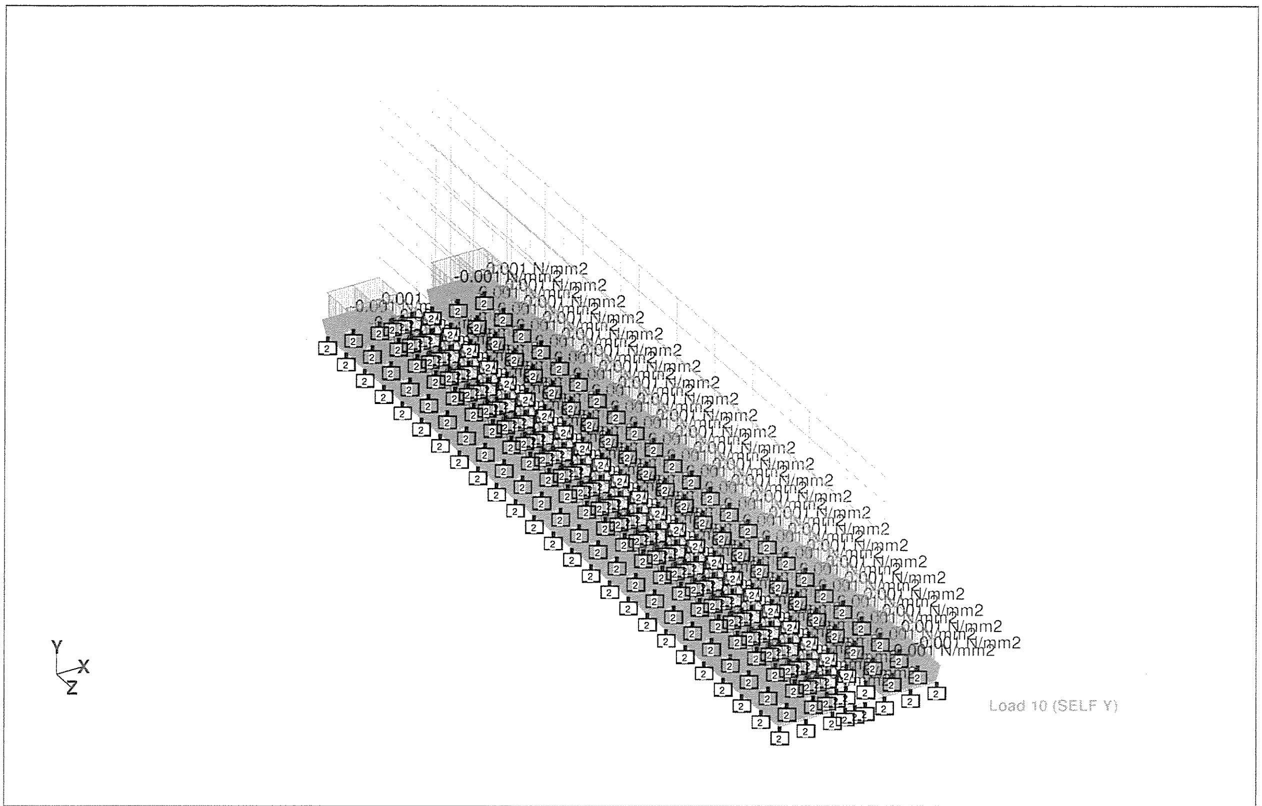
	Part DRAIN - Road crossing		
Job Title BCC-2 PROJECT	Ref		
	By Mohan	Date 24-Jun-19	Chd Diana
Client BCC-2	File Type -3 Drain Design- Ro	Date/Time 12-May-2021 13:22	



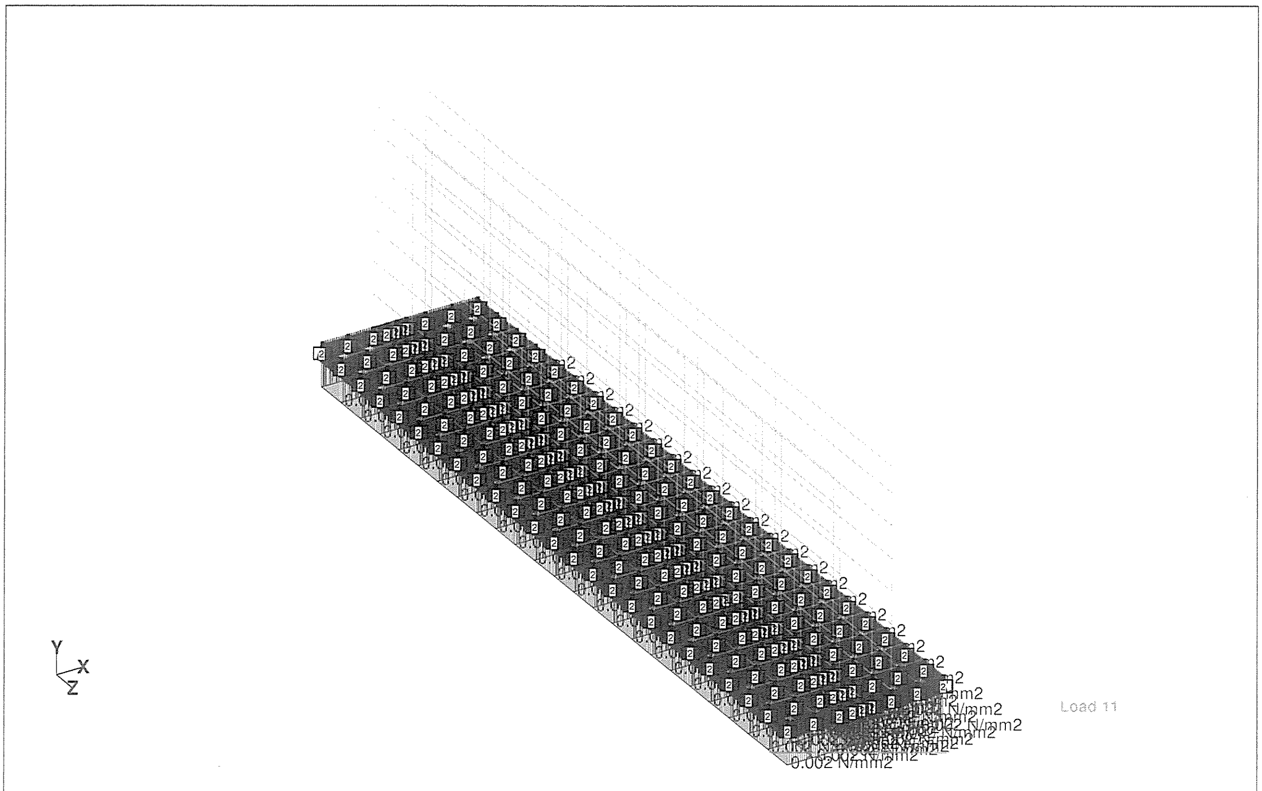
6 SEISMIC LOAD X DIR



7 SEISMIC LOAD -X DIR



10 SEISMIC VERTICAL LOAD(SL-Y)



11 UPLIFT LOAD (UL)

5.2 DESIGN OF BASE SLAB

Software licensed to Jurong Engineering Limited CONNECTED User: kalyani rajmohan	Job No 20054	Sheet No 1	Rev A
	Part DRAIN - Road crossing		
Job Title BCC-2 PROJECT	Ref		
	By Mohan	Date 24-Jun-19	Chd Diana
Client BCC-2	File Type -3 Drain Design- Ro	Date/Time 12-May-2021 13:22	

Plate Center Stress Summary

			Shear		Membrane			Bending		
	Plate	L/C	Qx (N/mm²)	Qy (N/mm²)	Sx (N/mm²)	Sy (N/mm²)	Sxy (N/mm²)	Mx (kN·m/m)	My (kN·m/m)	Mxy (kN·m/m)
Max Qx	420	203:1.2DL+1.2	**0.071**	-0.004	0	0	0	-2.893	-0.066	0.287
Min Qx	415	203:1.2DL+1.2	**-0.071**	-0.004	0	0	0	-2.895	-0.074	-0.282
Max Qy	237	209:0.9DL+1.6	0.008	**0.018**	0	0	0	-14.326	-0.928	0.128
Min Qy	417	209:0.9DL+1.6	0.008	**-0.018**	0	0	0	-14.326	-0.928	-0.128
Max Sx	842	201:1.4DL	0.004	0.000	**0**	0	0	-0.108	-0.045	0.008
Min Sx	842	201:1.4DL	0.004	0.000	**0**	0	0	-0.108	-0.045	0.008
Max Sy	842	201:1.4DL	0.004	0.000	0	**0**	0	-0.108	-0.045	0.008
Min Sy	842	201:1.4DL	0.004	0.000	0	**0**	0	-0.108	-0.045	0.008
Max Sxy	842	201:1.4DL	0.004	0.000	0	0	**0**	-0.108	-0.045	0.008
Min Sxy	842	201:1.4DL	0.004	0.000	0	0	**0**	-0.108	-0.045	0.008
Max Mx	184	211:0.9DL+1.6	-0.001	0.000	0	0	0	**2.764**	0.473	-0.000
Min Mx	344	209:0.9DL+1.6	0.023	-0.000	0	0	0	**-15.141**	-2.574	0.006
Max My	184	211:0.9DL+1.6	-0.001	0.000	0	0	0	2.764	**0.473**	-0.000
Min My	344	209:0.9DL+1.6	0.023	-0.000	0	0	0	-15.141	**-2.574**	0.006
Max Mxy	236	209:0.9DL+1.6	0.013	0.018	0	0	0	-14.624	-1.441	**0.379**
Min Mxy	416	209:0.9DL+1.6	0.013	-0.018	0	0	0	-14.624	-1.441	**-0.379**

DESIGN FOR BENDING MOMENT

Maximum Moment in X-Dir		Mxx =	**15.147**	kNm/m
Mxx = |Max Mx| + |Mxy| =	15.141 + 0.006			
Maximum Moment in Y-Dir		Myy =	**2.580**	kNm/m
Myy = |Max My| + |Mxy| =	2.574 + 0.006			
Maximum Moment in XY-Dir		Mxy =	**15.004**	kNm/m
Mxy = |Max Mxy| + |Mx or My| =	0.380 + 14.624			
Maximum Shear Stress in X-Dir		S_{QX} =	**0.071**	N/mm^2
Maximum Shear Stress in Y-Dir		S_{Qy} =	**0.018**	N/mm^2
Max. Ultimate Shear Stress		Vu = max (S_{QX}, S_{QY}) =	0.071	N/mm^2
Max. Ultimate Bending Moment		Mu = max(Mxx, Myy, Mxy) =	15.147	kNm/m
Depth of section		h =	**250**	mm
Width of Section		b =	**1000**	mm
Concrete Cover		cc =	**75**	mm
Concrete Grade		f'_c =	**28**	N/mm^2
Steel Reinforcement Grade		f_y =	**400**	N/mm^2
Diameter of Reinforcement		dia =	**12**	mm
Spacing of Reinforcement		S =	**150**	mm

DESIGN FOR THICKNESS AND REINFORCEMENT

Strength reduction factor (ϕ)	Flexure		=	**0.9**	(Table 21.2.1 , ACI 318-14)
	Shear		=	**0.75**	(Table 21.2.1 , ACI 318-14)
Factor	Use $\beta 1$		=	**0.850**	
where:	$\beta 1$	(if fc'≤ 28MPa)	=	0.85	
	$\beta 1$	(if fc'> 28MPa)	=	0.85	- 0.05/7(fc'-28)
	$\beta 1$		>	0.65	

Design Moment		Muz/ϕ	=	16.83	kNm
Width considered		b	=	**1000**	mm
Effective Depth		(h-cc-dia-0.5dia) = d	=	157	mm
z assumed			=	least of 0.9*d or d - 0.5*a	
		0.9*d	=	141.3	mm
		a	=	As_{prov}*fy / (0.85*fc'*b)	
			=	12.672	mm
		d - 0.5*a =		150.664	mm
therefore, z assumed			=	141	mm
As reqd = M/fy*z			=	298	mm^2/m
Provided steel reinf.	**DB 12-150**	$As_{prov.}$	=	**754**	mm^2 /m
			>	298	**Hence OK**
Minimum area of reinforcement req.		As_{min}	=	0.002 * b * d	(7.6.1.1,ACI 318-14)
			=	500	mm^2/m
Maximum area of reinforcement req.		As_{max}	=	0.75 * ρ_b * b * d	
		ρ_b	=	0.85 * $\beta 1$ * fc' * 600 / [fy * (600+fy)]	
			=	0.0303	
		As_{max}	=	3573	mm^2/m

As_{min} < $As_{prov.}$ < As_{max} **Hence OK**

CHECK FOR ONE-WAY SHEAR

Actual shear stress	Vu	=	0.071	N/mm^2
Strength reduction factor for Shear	ϕ_v	=	**0.75**	
	d	=	157	mm
Shear strength	ϕV_c	=	$\phi_v\ 0.17\sqrt{f'c}$	
	ϕV_c	=	0.67	N/mm^2

Shear force is less than Shear strength, O.K.

5.3 DESIGN OF WALL

Software licensed to Jurong Engineering Limited CONNECTED User: kalyani rajmohan	Job No 20054	Sheet No 1	Rev A
	Part DRAIN - Road crossing		
Job Title BCC-2 PROJECT	Ref		
	By Mohan	Date 24-Jun-19	Chd Diana
Client BCC-2	File Type -3 Drain Design- Ro	Date/Time 12-May-2021 13:22	

Plate Center Stress Summary

	Plate	L/C	Shear		Membrane			Bending		
			Qx (N/mm^2)	Qy (N/mm^2)	Sx (N/mm^2)	Sy (N/mm^2)	Sxy (N/mm^2)	Mx (kN m/m)	My (kN m/m)	Mxy (kN m/m)
Max Qx	242	209:0.9DL+1.6l	**0.007**	-0.058	0.000	-0.018	0.004	0.257	7.801	-0.000
Min Qx	422	209:0.9DL+1.6l	**-0.007**	-0.058	0.000	-0.018	-0.004	0.257	7.801	0.000
Max Qy	228	209:0.9DL+1.6l	-0.004	**0.084**	-0.001	-0.040	-0.001	-1.808	-11.527	-0.175
Min Qy	223	209:0.9DL+1.6l	0.005	**-0.090**	-0.000	-0.040	-0.001	1.939	12.364	0.191
Max Sx	585	203:1.2DL+1.2l	0.000	0.000	**0.027**	-0.003	-0.000	-0.005	-0.000	-0.000
Min Sx	594	203:1.2DL+1.2l	-0.000	-0.000	**-0.339**	-0.609	0.000	0.019	0.001	-0.003
Max Sy	587	203:1.2DL+1.2	0.000	-0.000	0.009	**0.003**	0.000	0.001	-0.000	0.000
Min Sy	594	203:1.2DL+1.2l	-0.000	-0.000	-0.339	**-0.609**	0.000	0.019	0.001	-0.003
Max Sxy	592	203:1.2DL+1.2l	-0.000	-0.000	-0.192	-0.315	**0.196**	0.010	0.001	-0.002
Min Sxy	612	203:1.2DL+1.2l	0.000	-0.000	-0.192	-0.315	**-0.196**	0.010	0.001	0.002
Max Mx	295	209:0.9DL+1.6l	0.000	-0.085	-0.005	-0.033	0.000	**2.125**	12.495	0.005
Min Mx	300	209:0.9DL+1.6l	-0.000	0.079	-0.005	-0.033	0.000	**-1.981**	-11.649	-0.005
Max My	331	209:0.9DL+1.6l	-0.000	-0.085	-0.005	-0.033	0.001	2.124	**12.499**	0.004
Min My	336	209:0.9DL+1.6l	0.000	0.079435	-0.005	-0.033	0.001	-1.980	**-11.653**	-0.005
Max Mxy	241	209:0.9DL+1.6l	0.007	-0.071	0.008	-0.018	0.009	1.376	12.161	**0.526**
Min Mxy	421	209:0.9DL+1.6l	-0.007	-0.071	0.008	-0.018	-0.009	1.376	12.161	**-0.526**

DESIGN FOR BENDING MOMENT

Maximum Moment in X-Dir		Mxx	=	**2.135**	kNm/m
Mxx = |Max Mx| + |Mxy| =	2.130 + 0.005				
Maximum Moment in Y-Dir		Myy	=	**12.504**	kNm/m
Myy = |Max My| + |Mxy| =	12.500 + 0.004				
Maximum Moment in XY-Dir		Mxy	=	**12.687**	kNm/m
Mxy = |Max Mxy| + |Mx or My| =	0.526 + 12.161				
Maximum Shear Stress in X-Dir		S_{QX}	=	**0.007**	N/mm^2
Maximum Shear Stress in Y-Dir		S_{Qy}	=	**0.09**	N/mm^2
Max. Ultimate Shear Stress	Vu = max (S_{QX}, S_{QY})		=	0.09	N/mm^2
Max. Ultimate Bending Moment	Mu = max(Mxx, Myy, Mxy)		=	12.687	kNm/m
Depth of section		h	=	**250**	mm
Width of Section		b	=	**1000**	mm
Concrete Cover		cc	=	**75**	mm
Concrete Grade		f'_c	=	**28**	N/mm^2
Steel Reinforcement Grade		f_y	=	**400**	N/mm^2
Diameter of Reinforcement		dia	=	**12**	mm
Spacing of Reinforcement		S	=	**150**	mm

DESIGN FOR THICKNESS AND REINFORCEMENT

Strength reduction factor (ϕ)	Flexure		=	**0.9**	(Table 21.2.1 , ACI 318-14)
	Shear		=	**0.75**	(Table 21.2.1 , ACI 318-14)
Factor	Use β1		=	**0.8500**	
where:	β1	(if fc'≤ 28MPa)	=	0.85	
	β1	(if fc'> 28MPa)	=	0.85 - 0.05/7(fc'-28)	
	β1		>	0.65	

Design Moment	Muz/ϕ	=	14.10	kNm
Width considered	b	=	**1000**	mm
Effective Depth	(h-cc-dia-0.5dia) = d	=	157	mm
z assumed		=	least of 0.9*d or d - 0.5*a	
	0.9*d	=	141.3	mm
	a	=	As_{prov}*fy / (0.85*fc'*b)	
		=	12.672	mm
	d - 0.5*a =		150.664	mm
therefore, z assumed		=	141	mm
As reqd = M/fy*z		=	249	mm^2/m
Provided steel reinf. **DB 12-150**	$As_{prov.}$	=	**754**	mm^2 /m
		>	249	**Hence OK**

Minimum area of reinforcement in ver dir req.	=	0.0015 * b*D/2	(Table 11.6.1,ACI -318-14)
	=	188	mm^2/m
	<	754	mm^2/m
		Hence OK	
Minimum area of reinforcement in Hor dir req.	=	0.0025 * b*D/2	(Table 11.6.1,ACI -318-14)
	=	313	mm^2/m
	<	754	mm^2/m
		Hence OK	

Maximum area of reinforcement req.	As_{max}	=	0.75 * ρ_b * b * d	
	ρ_b	=	0.85 * β1 * fc' * 600 / [fy * (600+fy)]	
		=	0.0303	
	As_{max}	=	3573	mm^2/m

As_{min} < $As_{prov.}$ < As_{max} **Hence OK**

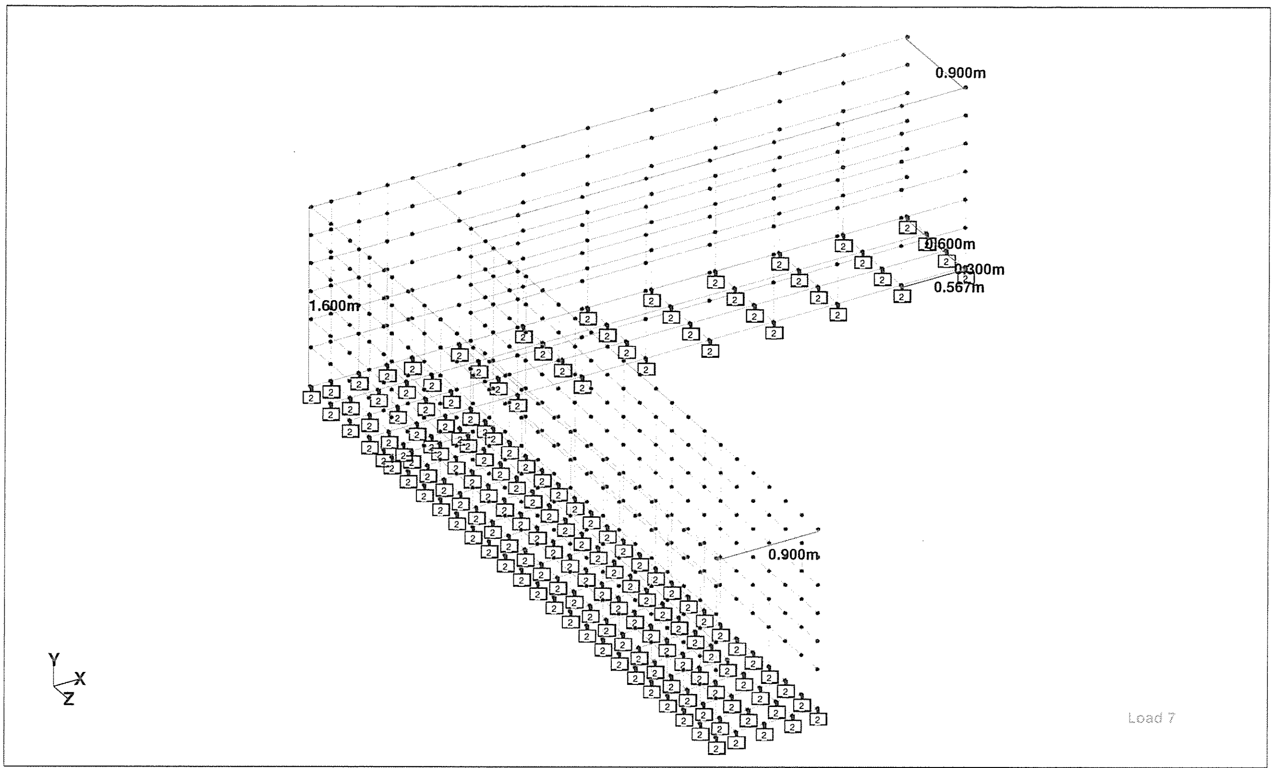
CHECK FOR ONE-WAY SHEAR

Actual shear stress	Vu	=	0.09	N/mm^2
Strength reduction factor for Shear	ϕ_v	=	**0.75**	
	d	=	157	mm
Shear strength	ϕV_c	=	$\phi_v\ 0.17\sqrt{f'c}$	
	ϕV_c	=	0.67	N/mm^2

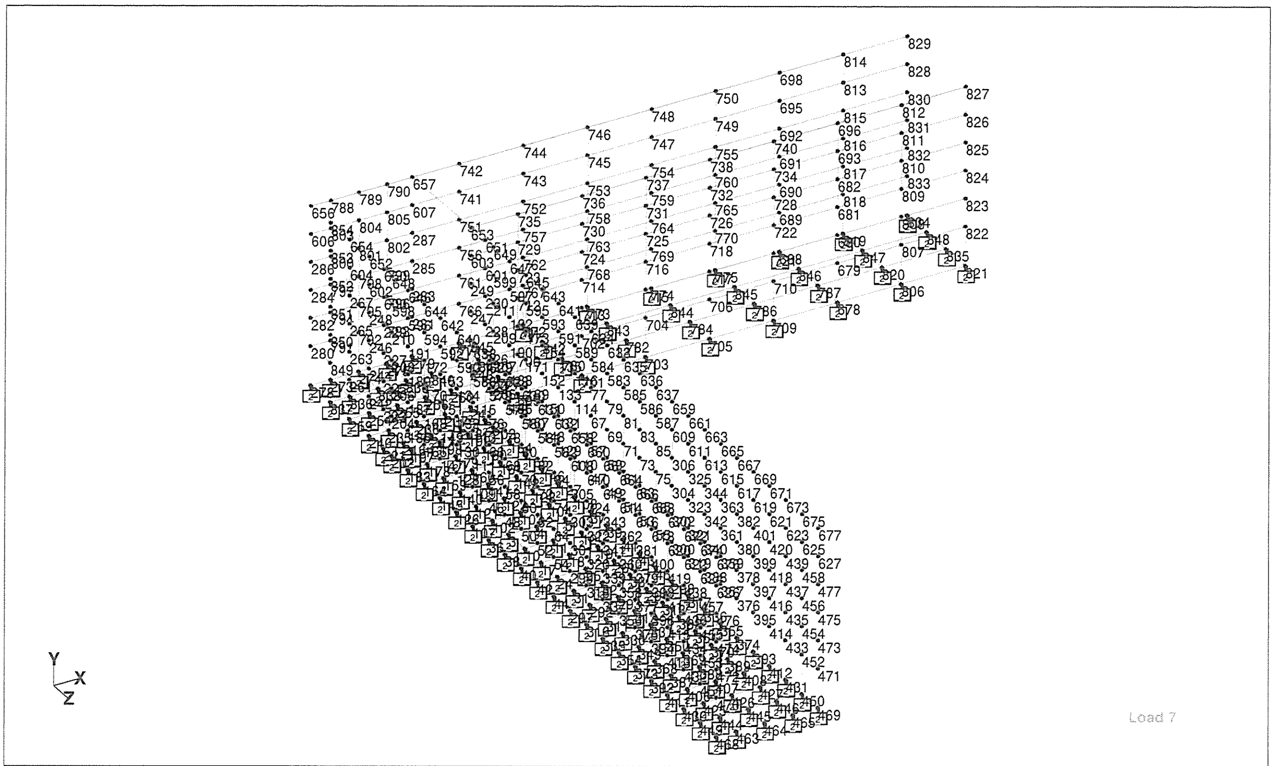
Shear force is less than Shear strength, O.K.

DESIGN OF 900mm WIDE DRAIN

	Job No	Sheet No	Rev
Software licensed to Jurong Engineering Limited CONNECTED User: kalyani rajmohan	20054	1	A
	Part INLET DRAIN -2 750mm wide		
Job Title BCC 2 PROJECT	Ref		
	By Mohan	Date 3/24/2021	Chd AS
Client BCC 2	File Drain width 0.900 m _Rev	Date/Time 19-Jul-2021 20:01	



Whole Structure_900 Wide Drain



Node Numbers_900 Wide Drain

Software licensed to Jurong Engineering Limited CONNECTED User: kalyani rajmohan	Job No **20054**	Sheet No **2**	Rev A
	Part INLET DRAIN -2 750mm wide		
Job Title BCC 2 PROJECT	Ref		
	By Mohan	Date 3/24/2021	Chd AS
Client BCC 2	File Drain width 0.900 m _Rev	Date/Time 19-Jul-2021 20:01	

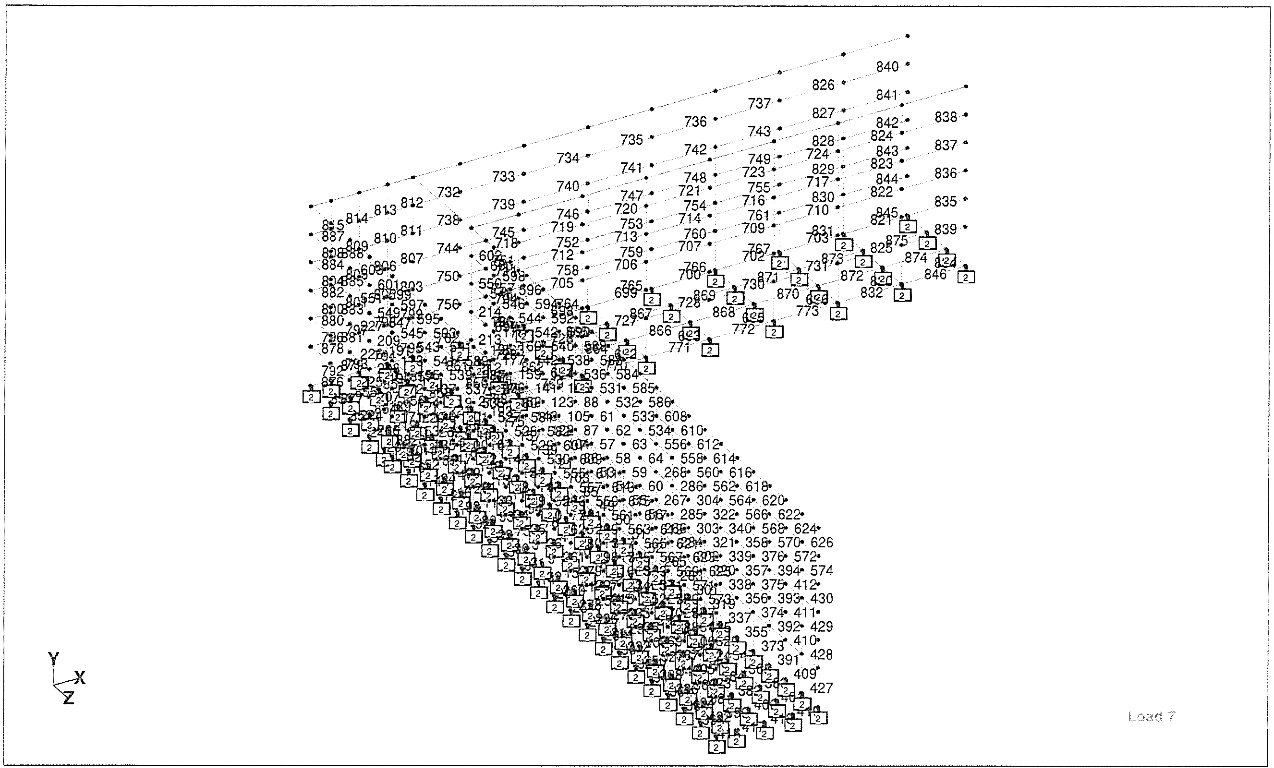


Plate number_900 Wide Drain

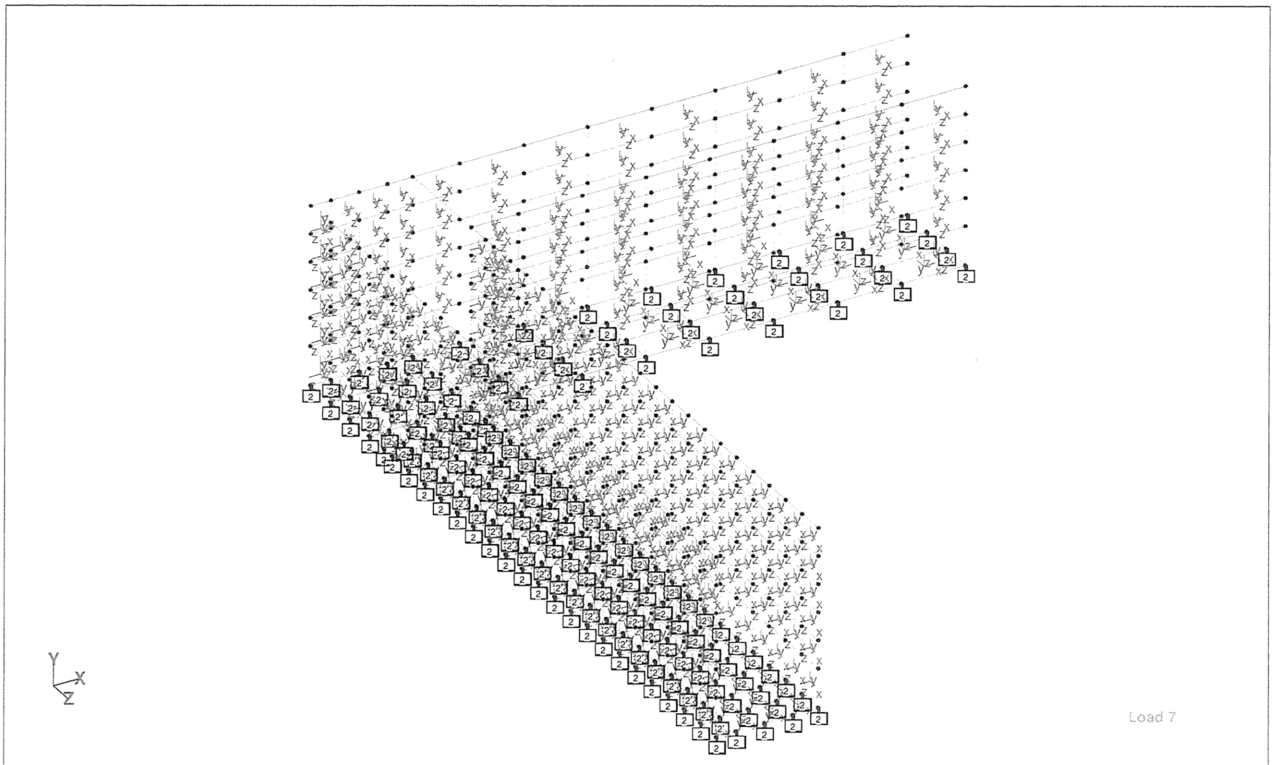
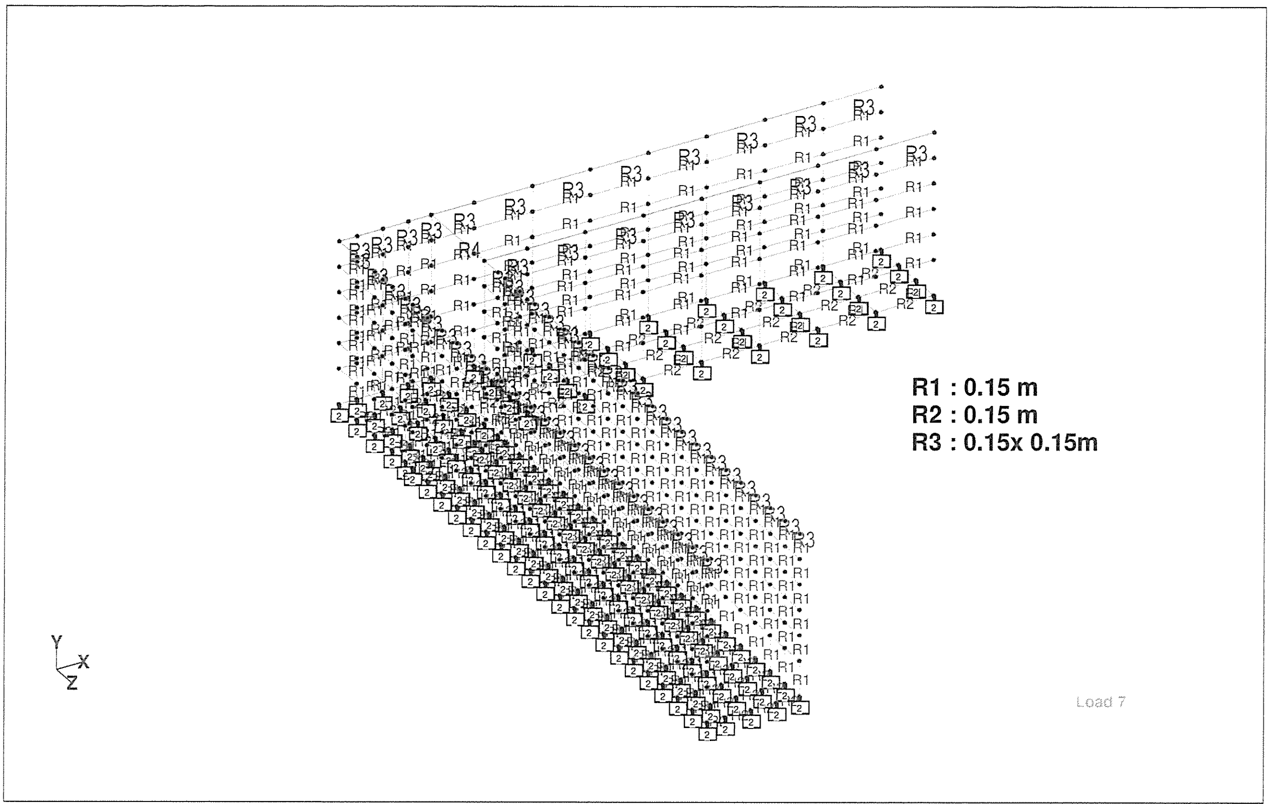
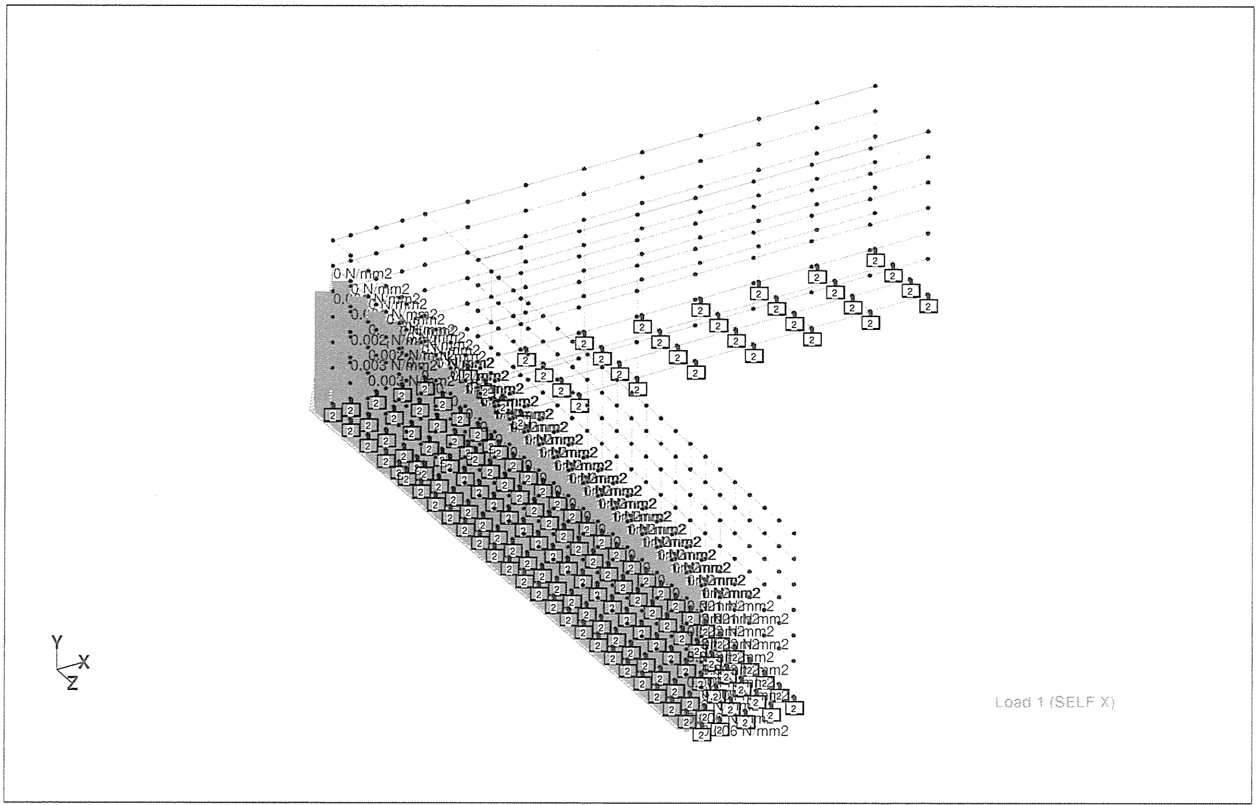


Plate Numbers_900 Wide Drain

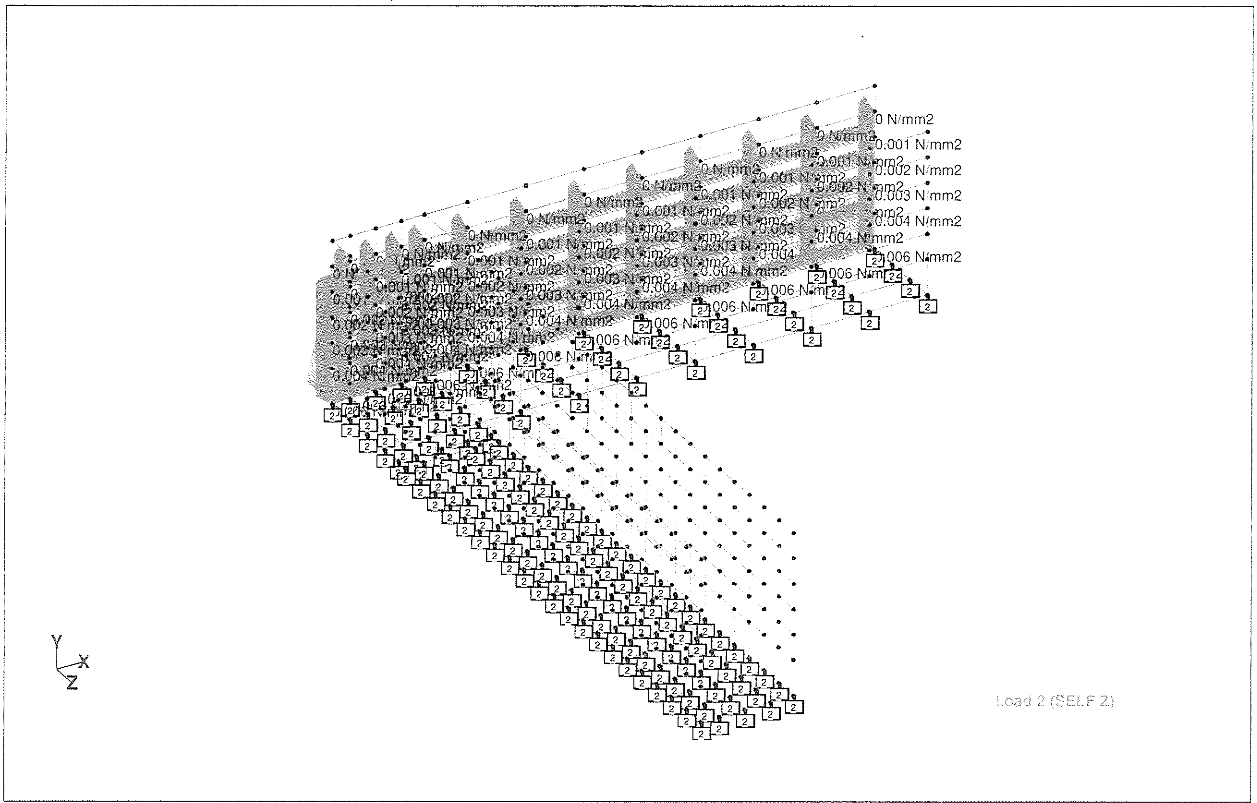
Software licensed to Jurong Engineering Limited CONNECTED User: kalyani rajmohan	Job No 20054	Sheet No 3	Rev A
	Part INLET DRAIN -2 750mm wide		
Job Title BCC 2 PROJECT	Ref		
	By Mohan	Date 3/24/2021	Chd AS
Client BCC 2	File Drain width 0.900 m _Rev	Date/Time 19-Jul-2021 20:01	



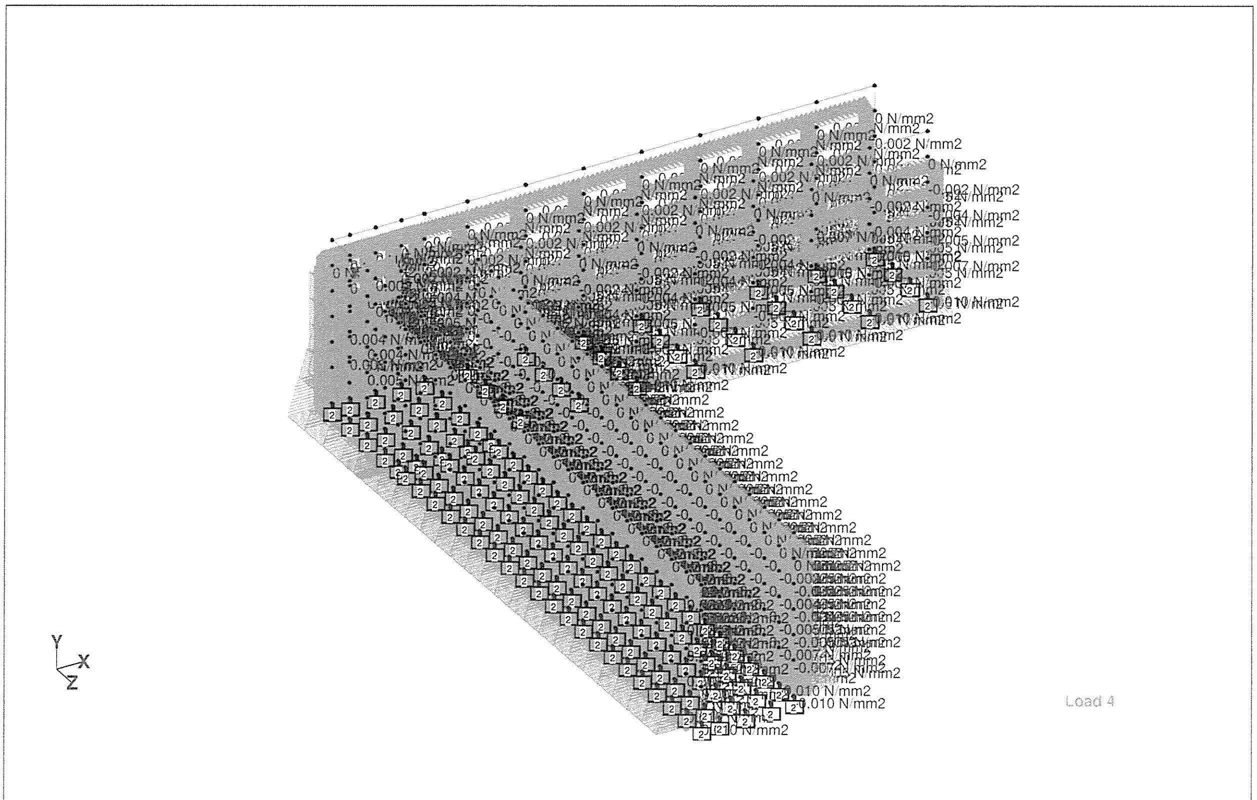
Member property _900 Wide Drain



1 SEISMIC LOAD X DIR_900 Wide Drain

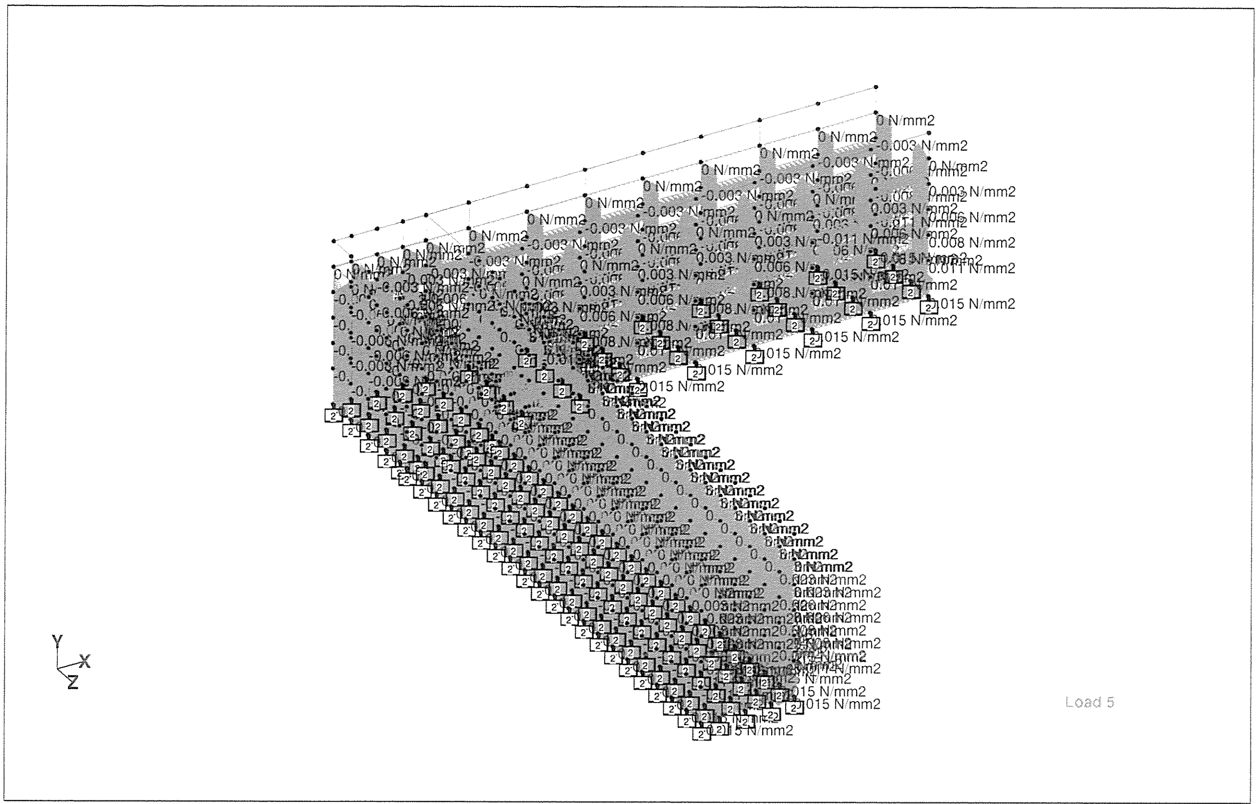


2 SEISMIC LOAD Z DIR_900 Wide Drain

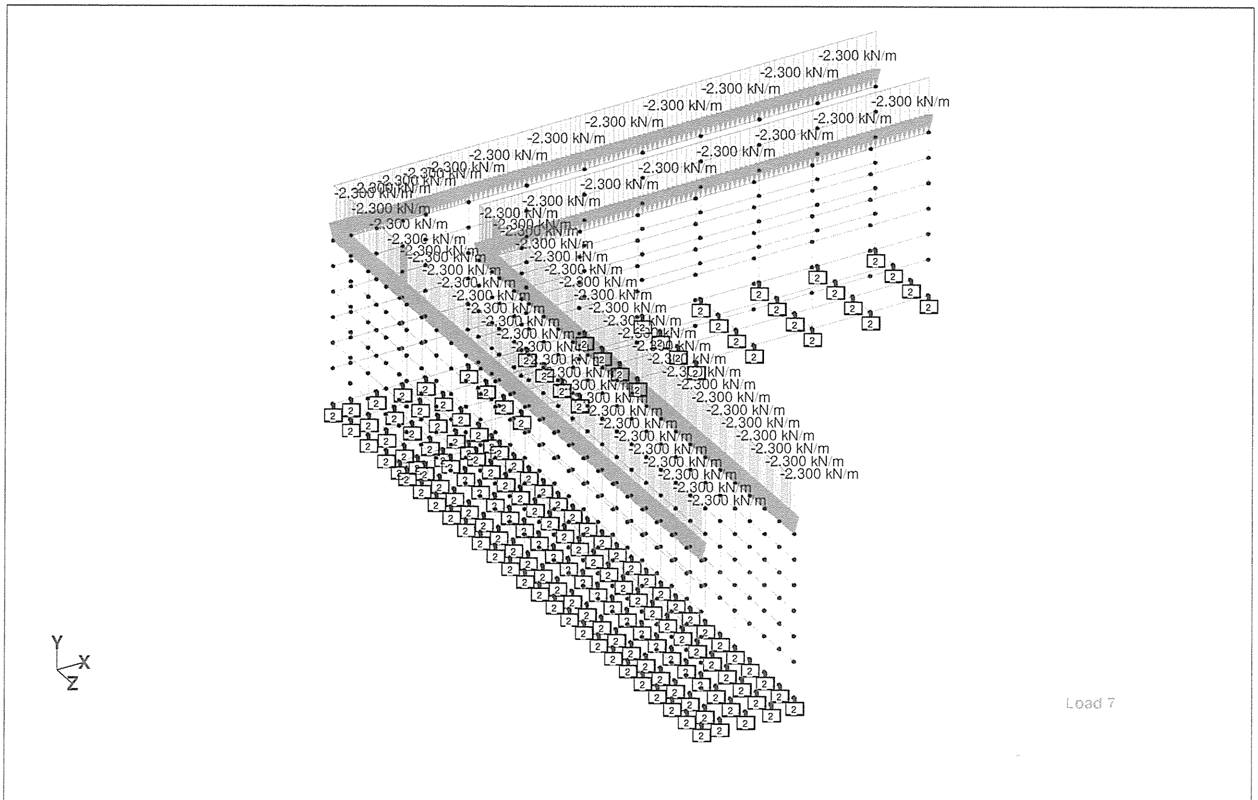


4 ACTIVE SOIL PRESSURE DUE TO DRY SOIL (DASP)_900 Wide Drain

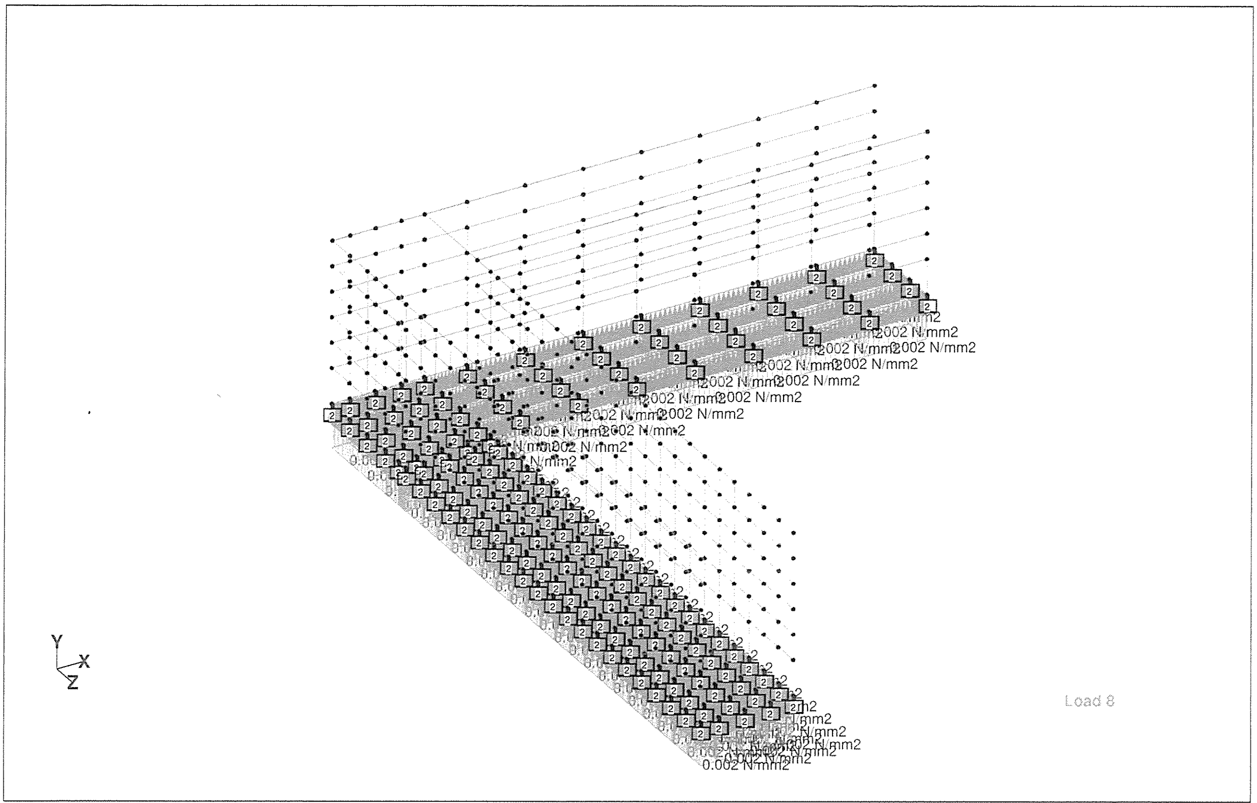
	Job No	Sheet No	Rev
Software licensed to Jurong Engineering Limited CONNECTED User: kalyani rajmohan	20054	5	A
	Part INLET DRAIN -2 750mm wide		
Job Title BCC 2 PROJECT	Ref		
	By Mohan	Date 3/24/2021	Chd AS
Client BCC 2	File Drain width 0.900 m _Rev	Date/Time 19-Jul-2021 20:01	



5 INSIDE WATER PRESSURE (IWP)_900 Wide Drain



7 LIVE LOAD_900 Wide Drain



8 UPLIFT LOAD_900 Wide Drain

6.3 CHECK FOR BASE PRESSURE

Job Title BCC 2 PROJECT	Ref		
	By Mohan	Date 3/24/2021	Chd AS
Client BCC 2	File Drain width 0.900 m _Re\	Date/Time 19-Jul-2021 19:39	

Base Pressure Summary

	Node	L/C	FX (N/mm^2)	FY (N/mm^2)	FZ (N/mm^2)
Max FX	3	101:1DL+1FL1	**0**	0.030	0
Min FX	3	101:1DL+1FL1	**0**	0.030	0
Max FY	469	108:DL+SP+IW	0	**0.043**	0
Min FY	278	112:0.60 DL+S	0	**0.005**	0
Max FZ	3	101:1DL+1FL1	0	0.030	**0**
Min FZ	3	101:1DL+1FL1	0	0.030	**0**

From the above Base Pressure Summary Table

Maximum Base pressure on foundation = 43.000 kN/m^2 < 75 kN/m^2

Minimum Base pressure on foundation = 5.000 kN/m^2 > 0 kN/m^2

Hence the base pressure on the foundation is with in the allowable bearing capacity of soil and there is no tension exist. Hence safe

6.4 DESIGN OF BASE SLAB

Job Title BCC 2 PROJECT	Ref		
	By Mohan	Date 3/24/2021	Chd AS
Client BCC 2	File Drain width 0.900 m _Rev	Date/Time 19-Jul-2021 20:01	

Plate Center Stress Summary

	Plate	L/C	Shear		Membrane			Bending		
			Qx (N/mm^2)	Qy (N/mm^2)	Sx (N/mm^2)	Sy (N/mm^2)	Sxy (N/mm^2)	Mx (kN m/m)	My (kN m/m)	Mxy (kN m/m)
Max Qx	768	208:0.9DL+1.6	**0.096**	0.053782	0	0	0	-1.707	-2.268	0.995
Min Qx	203	212:1.2DL+SP	**-0.111**	-0.016	0	0	0	-2.587	-1.667	-0.553
Max Qy	221	208:0.9DL+1.6	-0.075	**0.130**	0	0	0	-4.024	-2.000	0.031
Min Qy	182	208:0.9DL+1.6	0.022	**-0.089**	0	0	0	-5.006	-1.065	-1.667
Max Sx	875	201:1.4DL+1.4	-0.007	-0.003	**0**	0	0	0.729	7.237	-0.098
Min Sx	875	201:1.4DL+1.4	-0.007	-0.003	**0**	0	0	0.729	7.237	-0.098
Max Sy	875	201:1.4DL+1.4	-0.007	-0.003	0	**0**	0	0.729	7.237	-0.098
Min Sy	875	201:1.4DL+1.4	-0.007	-0.003	0	**0**	0	0.729	7.237	-0.098
Max Sxy	875	201:1.4DL+1.4	-0.007	-0.003	0	0	**0**	0.729	7.237	-0.098
Min Sxy	875	201:1.4DL+1.4	-0.007	-0.003	0	0	**0**	0.729	7.237	-0.098
Max Mx	418	201:1.4DL+1.4	-0.022	0.010067	0	0	0	**7.836**	0.175	-0.165
Min Mx	344	208:0.9DL+1.6	0.046	-0.034	0	0	0	**-13.392**	-2.294	-0.597
Max My	875	201:1.4DL+1.4	-0.007	-0.003	0	0	0	0.729	**7.237**	-0.098
Min My	875	210:0.9DL+1.6	0.019	-0.057	0	0	0	-1.553	**-11.830**	-0.072
Max Mxy	770	211:0.9DL+1.6	0.023	0.022	0	0	0	-0.723	-4.196	**1.167**
Min Mxy	854	208:0.9DL+1.6	-0.010	0.048	0	0	0	-1.061	-0.017	**-2.216**

DESIGN FOR BENDING MOMENT

Maximum Moment in X-Dir		Mxx	=	**13.997**	kNm/m
Mxx = |Max Mx| + |Mxy| =	13.400 + 0.597				
Maximum Moment in Y-Dir		Myy	=	**11.902**	kNm/m
Myy = |Max My| + |Mxy| =	11.830 + 0.072				
Maximum Moment in XY-Dir		Mxy	=	**3.277**	kNm/m
Mxy = |Max Mxy| + |Mx or My| =	2.216 + 1.061				
Maximum Shear Stress in X-Dir		S_{QX}	=	**0.111**	N/mm^2
Maximum Shear Stress in Y-Dir		S_{Qy}	=	**0.13**	N/mm^2
Max. Ultimate Shear Stress		Vu = max (S_{QX}, S_{QY})	=	0.13	N/mm^2
Max. Ultimate Bending Moment		Mu = max(Mxx, Myy, Mxy)	=	13.997	kNm/m
Depth of section		h	=	**150**	mm
Width of Section		b	=	**1000**	mm
Concrete Cover		cc	=	**75**	mm
Concrete Grade		f'_c	=	**28**	N/mm^2
Steel Reinforcement Grade		f_y	=	**400**	N/mm^2
Diameter of Reinforcement		dia	=	**12**	mm
Spacing of Reinforcement		S	=	**150**	mm

DESIGN FOR THICKNESS AND REINFORCEMENT

Strength reduction factor (ϕ)		Flexure		=	**0.9**	(Table 21.2.1 , ACI 318-14)
		Shear		=	**0.75**	(Table 21.2.1 , ACI 318-14)
Factor	Use	$\beta1$		=	**0.8500**	
where:		$\beta1$	(if fc'≤ 28MPa)	=	0.85	
		$\beta1$	(if fc'> 28MPa)	=	0.85	- 0.05/7(fc'-28)
		$\beta1$		>	0.65	

Design Moment	Muz/ϕ	=	15.55	kNm
Width considered	b	=	**1000**	mm
Effective Depth	(h-cc-0.5dia) = d	=	69	mm
z assumed		=	least of 0.9*d or d - 0.5*a	
	0.9*d	=	62.1	mm
	a	=	As_{prov}*fy / (0.85*fc'*b)	
		=	12.672	mm
	d - 0.5*a =		62.664	mm
therefore, z assumed		=	62	mm
As reqd = M/fy*z		=	626	mm^2/m
Provided steel reinf. **DB 12-150**	$As_{prov.}$	=	**754**	mm^2/m
		>	626	**Hence OK**
Minimum area of reinforcement req.	As_{min}	=	0.002 * b * d	(7.6.1.1,ACI 318-14)
		=	300	mm^2/m
Maximum area of reinforcement req.	As_{max}	=	0.75 * ρ_b * b * d	
	ρ_b	=	0.85 * $\beta1$ * fc' * 600 / [fy * (600+fy)]	
		=	0.0303	
	As_{max}	=	1570	mm^2/m

As_{min} < $As_{prov.}$ < As_{max} **Hence OK**

CHECK FOR ONE-WAY SHEAR

Actual shear stress	Vu	=	0.13	N/mm^2
Strength reduction factor for Shear	ϕ_v	=	**0.75**	
	d	=	69	mm
Shear strength	ϕV_c	=	ϕ_v 0.17√ f'c	
	ϕV_c	=	0.67	N/mm^2

Shear force is less than Shear strength, O.K.

6.5 DESIGN OF WALL

Job Title BCC 2 PROJECT	Ref
	By Mohan Date 3/24/2021 Chd AS
Client BCC 2	File Drain width 0.900 m _Rev Date/Time 19-Jul-2021 20:01

Plate Center Stress Summary

	Plate	L/C	Shear		Membrane			Bending		
			Qx (N/mm²)	Qy (N/mm²)	Sx (N/mm²)	Sy (N/mm²)	Sxy (N/mm²)	Mx (kN m/m)	My (kN m/m)	Mxy (kN m/m)
Max Qx	732	210:0.9DL+1.6	**0.192**	-0.188	-0.165	-0.042	0.041	-5.792	-2.757	-0.282
Min Qx	887	208:0.9DL+1.6	**-0.163**	0.036	-0.126	0.007	0.002	9.605	1.316	1.560
Max Qy	845	210:0.9DL+1.6	-0.000	**0.147**	0.017789	-0.060	0.003	-1.556	-9.224	-0.353
Min Qy	732	210:0.9DL+1.6	0.192	**-0.188**	-0.165	-0.042	0.041	-5.792	-2.757	-0.282
Max Sx	602	208:0.9DL+1.6	0.054	0.064	**0.164**	0.032	-0.061	-4.215	-0.034	-1.409
Min Sx	813	208:0.9DL+1.6	0.091	0.013	**-0.200**	-0.014	-0.019	-3.719	-1.009	-1.123
Max Sy	718	210:0.9DL+1.6	-0.105	-0.001	0.156	**0.107**	-0.043	6.878	-0.326	0.685
Min Sy	211	204:1.2DL+SP	-0.051	0.126	-0.156	**-0.239**	-0.084	-0.541	-2.032	0.358
Max Sxy	600	209:0.9DL+1.6	0.103	0.001	-0.130	-0.060	**0.122**	-6.131	-0.604	-1.464
Min Sxy	194	208:0.9DL+1.6	0.003	0.004	-0.014	-0.078	**-0.116**	-1.536	-0.408	-0.527
Max Mx	887	208:0.9DL+1.6	-0.163	0.036	-0.126	0.007	0.002	**9.605**	1.316	1.560
Min Mx	815	208:0.9DL+1.6	0.134	0.026	-0.197	-0.029	-0.001	**-10.996**	-1.490	0.406
Max My	350	208:0.9DL+1.6	0.000	-0.154	-0.004	-0.045	0.006	1.649	**9.986**	0.809
Min My	409	208:0.9DL+1.6	0.001	0.135	0.006	-0.059	0.009	-1.550	**-9.525**	0.418
Max Mxy	208	208:0.9DL+1.6	-0.015	-0.005	-0.074	0.001	0.036	-0.562	-0.929	**4.353**
Min Mxy	739	210:0.9DL+1.6	0.023	-0.025	-0.111	-0.01124	0.033	-0.337	0.806	**-3.279**

DESIGN FOR BENDING MOMENT

Maximum Moment in X-Dir		Mxx	=	**11.402**	kNm/m
Mxx = |Max Mx| + |Mxy| =	10.996 + 0.406				
Maximum Moment in Y-Dir		Myy	=	**10.795**	kNm/m
Myy = |Max My| + |Mxy| =	9.986 + 0.809				
Maximum Moment in XY-Dir		Mxy	=	**5.282**	kNm/m
Mxy = |Max Mxy| + |Mx or My| =	4.353 + 0.929				
Maximum Shear Stress in X-Dir		S_{QX}	=	**0.192**	N/mm²
Maximum Shear Stress in Y-Dir		S_{Qy}	=	**0.188**	N/mm²
Max. Ultimate Shear Stress	Vu = max (S_{QX}, S_{QY})		=	0.192	N/mm²
Max. Ultimate Bending Moment	Mu = max(Mxx, Myy, Mxy)		=	11.402	kNm/m
Depth of section		h	=	**150**	mm
Width of Section		b	=	**1000**	mm
Concrete Cover		cc	=	**75**	mm
Concrete Grade		f'_c	=	**28**	N/mm²
Steel Reinforcement Grade		f_y	=	**400**	N/mm²
Diameter of Reinforcement		dia	=	**12**	mm
Spacing of Reinforcement		S	=	**150**	mm

DESIGN FOR THICKNESS AND REINFORCEMENT

Strength reduction factor (ϕ)		Flexure		=	**0.9**	(Table 21.2.1 , ACI 318-14)
		Shear		=	**0.75**	(Table 21.2.1 , ACI 318-14)
Factor	Use	β1		=	**0.8500**	
where:		β1	(if fc'≤ 28MPa)	=	0.85	
		β1	(if fc'> 28MPa)	=	0.85	- 0.05/7(fc'-28)
		β1		>	0.65	

Design Moment		Muz/ϕ	=	12.67	kNm
Width considered		b	=	**1000**	mm
Effective Depth		(h-cc-0.5dia) = d	=	69	mm
z assumed			=	least of 0.9*d or d - 0.5*a	
		0.9*d	=	62.1	mm
		a	=	As_{prov}*fy / (0.85*fc'*b)	
			=	12.672	mm
		d - 0.5*a =		62.664	mm
therefore, z assumed			=	62	mm
As reqd = M/fy*z			=	510	mm^2/m
Provided steel reinf.	**DB 12-150**	$As_{prov.}$	=	**754**	mm^2 /m
			>	510	**Hence OK**
Minimum area of reinforcement in ver dir req.			=	0.0015 * b*D/2	(Table 11.6.1,ACI -318-14)
			=	113	mm^2/m
			<	754	mm^2/m
				Hence OK	
Minimum area of reinforcement in Hor dir req.			=	0.0025 * b*D/2	(Table 11.6.1,ACI -318-14)
			=	188	mm^2/m
			<	754	mm^2/m
				Hence OK	
Maximum area of reinforcement req.		As_{max}	=	0.75 * ρ_b * b * d	
		ρ_b	=	0.85 * β1 * fc' * 600 / [fy * (600+fy)]	
			=	0.0303	
		As_{max}	=	1570	mm^2/m

As_{min} < $As_{prov.}$ < As_{max} **Hence OK**

CHECK FOR ONE-WAY SHEAR

Actual shear stress	Vu	=	0.192	N/mm^2
Strength reduction factor for Shear	ϕ_v	=	**0.75**	
	d	=	69	mm
Shear strength	ϕV_c	=	ϕ_v 0.17√ f'c	
	ϕV_c	=	0.67	N/mm^2

Shear force is less than Shear strength, O.K.

DESIGN OF MANHOLE _TYPE -1

7.1 DESIGN LOADS FOR MANHOLE-TYPE-1 (Upto 1.0m Depth)

7.1.1 DEAD LOAD

Self wt of structure will be generated by STAAD itself

Checkered Plate Cover (6mm thk)	=	0.50	kN/m^2

7.1.2 LIVE LOAD

Live load on Cover	=	5.00	kN/m^2

7.1.3 HYDRO LOAD

FULL CONDITION:

Height of wall	=	1.15	m
Max. water level inside, h_w max	=	1.00	m
Unit weight of water, γ_w	=	10.00	kN/m^3
Vertical Pressure on base slab	=	$\gamma_w \times h_{w1}$	
	=	10.000	kN/m^2

Lateral pressure due to water inside is applied on all the sides of the wall

Lateral pressure due to water on top of wall	=	$\gamma_w \times h_{w1}$	
where: h_{w1} = 0 m	=	0.000	kN/m^2
Lateral pressure due to water on bottom side wall	=	$\gamma_w \times h_{w2}$	
where: h_{w2} = 1 m	=	10.000	kN/m^2

The load is applied in STAAD as lateral load ranging from 0 kN/m^2 to 10.000 kN/m^2

UPLIFT CONDITION:

(ground water table at 1.50m)

Height of wall, h	=	1.15	m
Unit weight of water, γ_w	=	10.00	kN/m^3
Vertical Uplift Pressure on base slab	=	$\gamma_w \times h$	
	=	11.5	kN/m^2

7.1.4 EARTH PRESSURE LOAD

For calculating the earth pressure load on the side walls , it is assumed that the ground water table is at FGL conservatively.

Unit weight of soil	γ	=	18	kN/m^3
Angle of repose		=	30	ϕ
Unit weight of water	$\gamma\omega$	=	10	kN/m^3
Soil submerged density,	$\gamma's$	=	8	kN/m^3
coefficient for surcharge pressure	k_s	=	0.50	
Soil active pressure coefficient,	ka	=	0.33	

ka = $\tan^2(45 - \text{ø}/2)$ for ø =30deg

Ground water table	*hw*	=	1.50	m	from FGL
The height of wall below GL	h	=	1.00	m	
Depth of the base slab	D_{bs}	=	0.15	m	
Surcharge load,	q	=	10.00	kN/m^2	
Total Height of wall	H	=	1.00	m	

a. Load due to surcharge = k_s*q

= 5.0 kN/m^2

b. Active pressure due to dry soil , *qa =ka•g •(hw)* = 6.00 kN/m^2

7.1.5 <u>SEISMIC EARTH PRESSURE LOAD</u>

Mononobe-Okabe Method :

Dynamic active earth thrust Pdae = Kae x γ x H

<u>Where</u> Kae = seismic active earth pressure coefficient

$$Kae = \frac{\cos^2(\Phi-\Psi-\theta)}{\cos(\Psi)\cos^2(\theta)\cos(\delta+\theta+\Psi) \times \left[1+\left[\frac{\sin(\Phi+\delta)\sin(\Phi-\Psi-\beta)}{\cos(\beta-\theta)\cos(\delta+\Psi+\theta)}\right]^{0.5}\right]^2}$$

Where

ϕ =	Angle of internal friction	=	30	deg
δ =	Angle of friction between soil and wall	=	0	(Ref. Bowles book)
Ψ =	$\tan^{-1}[k_h/(1-k_v)]$			
k_h =	horizontal acceleration coefficient = 0.025g			
	g = gravitational accelaration =		9.810	m/s^2
k_h =	0.24525			
k_v =	vertical acceleration coefficient	=	0.164	
Ψ =	$\tan^{-1}[k_h/(1-k_v)]$	=	3.918	
β =	backfill slope angle	=	20	deg
θ =	angle of backface to the wall with the vertical	=	0	(Uniform earth fill)

$$Kae = \frac{\cos^2(30-3.918-0)}{\cos(3.918\ \cos^2(0)\cos(0+0+3.918) \times \left[1+\left[\frac{\sin(30+0)\sin(30-3.918-0)}{\cos(0-0)\cos(0+3.918+0)}\right]\right]}$$

$$Kae = \frac{0.807}{0.995 \times 1.545}$$

Kae = 0.52461

Dynamic active earth thrust Pdae = Kae x γ x H
= 0.525 x 18 x 1
= 9.443 kN/m^2

Active Earth pressure Pae = Ka x γ x H
= 0.333 x 18 x 1
= 6.000 kN/m^2

Coefficient of active earth pressure is Ka = 0.33

Therefore, the dynamic increment,
= Pdae - Pae
= 9.443 - 6
= 3.443 kN/m^2

Additional 3.443 kN/m^2 is applied on the trench walls as a dynamic increment due to earth pressure.

Vertical Seismic Effect (Section 12.4.2.2 of ASCE 7-10)

$Ev = 0.2^*S_{DS}{}^*DL$

SDS = 0.094

Ev = 0.0188 D

7.1.7 PRIMARY LOADS

LOAD 1	Earthquake Load (X)	SL+X
LOAD 2	Earthquake Load (Z)	SL+Z
LOAD 3	Vertical Seismic Effect	SL Y
LOAD 4	Soil Pressure	SP
LOAD 5	Fluid Load	FL
LOAD 6	Dead Load	DL
LOAD 7	Live Load	LL

ii) **Service Loads**

LOAD COMB 11 DL+FL

LOAD COMB 12 DL+SP+FL+LL

LOAD COMB 13 DL+SP+0.75FL+0.75LL

LOAD COMB 14 DL+SP +0.70SL(+X)+0.70SL(-Y)

LOAD COMB 15 DL+SP -0.70SL(+X)+0.70SL(-Y)

LOAD COMB 16 DL+SP +0.70SL(+Z)+0.70SL(-Y)

LOAD COMB 17 DL+SP -0.70SL(-Z)+0.70SL(-Y)

LOAD COMB 18 DL+SP+FL+LL+0.70SL(+X)+0.70SL(-Y)

LOAD COMB 19 DL+SP+FL+LL-0.70SL(+X)+0.70SL(-Y)

LOAD COMB 20 DL+SP+FL+LL+0.70SL(+Z)+0.70SL(-Y)

LOAD COMB 21 DL+SP+FL+LL-0.70SL(+Z)+0.70SL(-Y)

LOAD COMB 21 0.60 DL+0.70SL+X-0.70SL(-Y)

LOAD COMB 22 0.60 DL-0.70SL+X-0.70SL(-Y)

LOAD COMB 23 0.60 DL+0.70SL+Z-0.70SL(-Y)

LOAD COMB 24 0.60 DL-0.70SL+Z-0.70SL(-Y)

LOAD COMB 25 DL+SP+FL+0.75LL+0.525SL(+X)+0.70SL(-Y)

LOAD COMB 26 DL+SP+FL+0.75LL-0.525SL(+X)+0.70SL(-Y)

LOAD COMB 27 DL+SP+FL+0.75LL+0.525SL(+Z)+0.70SL(-Y)

LOAD COMB 28 DL+SP+FL+0.75LL-0.525SL(+Z)+0.70SL(-Y)

iii) **Ultimate Loads**

LOAD COMB 101 1.4DL+1.4 FL

LOAD COMB 102 1.2DL+1.6DASP+1.6SP+1.2FL+1.6LL

LOAD COMB 103 1.2DL+1.6DASP+1.6SP+1.0LL

LOAD COMB 104 1.2DL+DASP+SP+LL+1.0SL+X +1.0SL(-Y)

LOAD COMB 105 1.2DL+DASP+SP+LL-1.0SL+X +1.0SL(-Y)

LOAD COMB 106 1.2DL+DASP+SP+LL+1.0SL+Z +1.0SL(-Y)

LOAD COMB 107 1.2DL+DASP+SP+LL-1.0SL+Z +1.0SL(-Y)

LOAD COMB 108 0.9DL+1.6DASP+1.6SP+1.0SL+X+1.0SL(-Y)

LOAD COMB 109 0.9DL+1.6DASP+1.6SP-1.0SL+X+1.0SL(-Y)

LOAD COMB 110 0.9DL+1.6DASP+1.6SP+1.0SL+Z+1.0SL(-Y)

LOAD COMB 111 0.9DL+1.6DASP+1.6SP-1.0SL+Z+1.0SL(-Y)

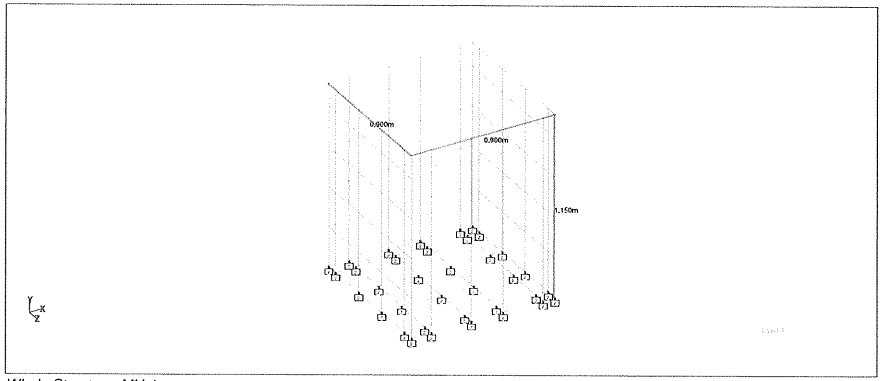
LOAD COMB 112 1.2DL+DASP+SP+1.2FL+1.6LL+1.0SL+X +1.0SL(-Y)

LOAD COMB 113 1.2DL+DASP+SP+1.2FL+1.6LL-1.0SL+X +1.0SL(-Y)

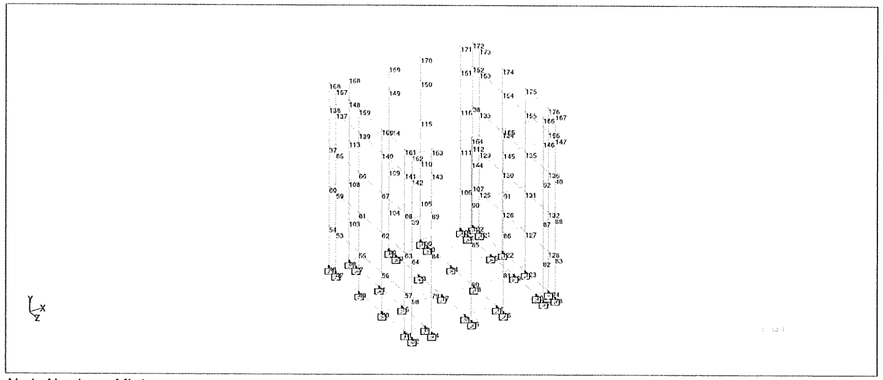
LOAD COMB 114 1.2DL+DASP+SP+1.2FL+1.6LL+1.0SL+Z +1.0SL(-Y)

LOAD COMB 115 1.2DL+DASP+SP+1.2FL+1.6LL-1.0SL+Z +1.0SL(-Y)

Software licensed to Jurong Engineering Limited CONNECTED User: kalyani rajmohan	Job No 20054	Sheet No 1	Rev A
	Part Manhole -Type-1		
Job Title BCC2 PROJECT	Ref		
	By Mohan	Date 5/10/2021	Chd Diana
Client BCC 2	File BCC2-Manhole-1 design	Date/Time 12-May-2021 17:24	



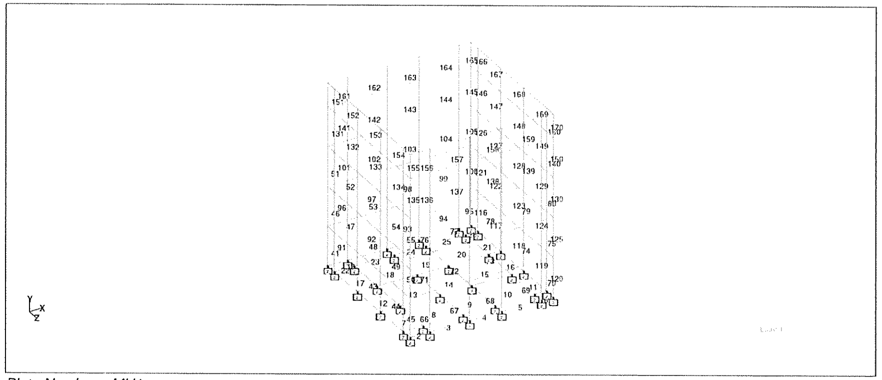
Whole Structure_MH-1



Node Numbers_MH1

Print Time/Date: 25/05/2021 14:46 STAAD.Pro CONNECT Edition 22.04.00.40 Print Run 1 of 6

Software licensed to Jurong Engineering Limited CONNECTED User: kalyani rajmohan	Job No 20054	Sheet No 2	Rev A
	Part Manhole -Type-1		
Job Title BCC2 PROJECT	Ref		
	By Mohan	Date 5/10/2021	Chd Diana
Client BCC 2	File BCC2-Manhole-1 design	Date/Time 12-May-2021 17:24	



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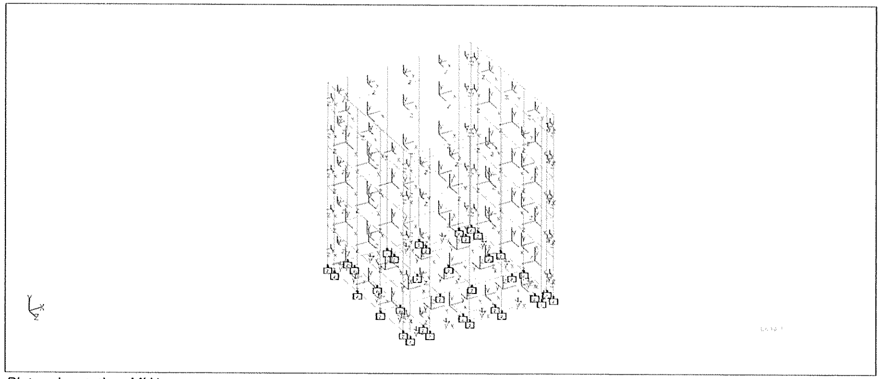
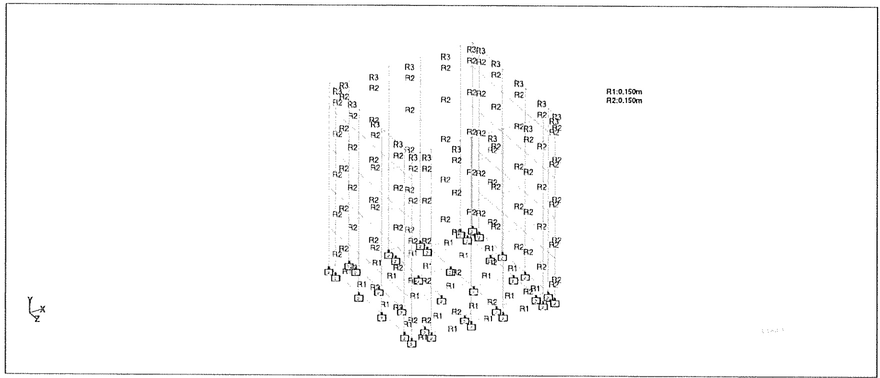


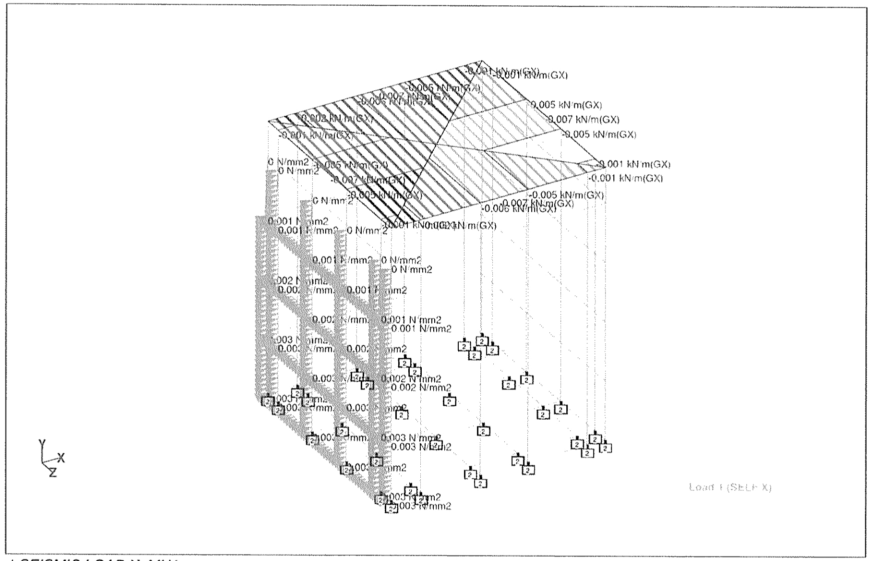
Plate orienatation_MH1

Print Time/Date: 25/05/2021 14:46 STAAD.Pro CONNECT Edition 22.04.00.40 Print Run 2 of 6

Software licensed to Jurong Engineering Limited CONNECTED User: kalyani rajmohan	Job No 20054	Sheet No 3	Rev A
Job Title BCC2 PROJECT	Part Manhole -Type-1		
	Ref		
	By Mohan	Date 5/10/2021	Chd Diana
Client BCC 2	File BCC2-Manhole-1 design	Date/Time 12-May-2021 17:24	



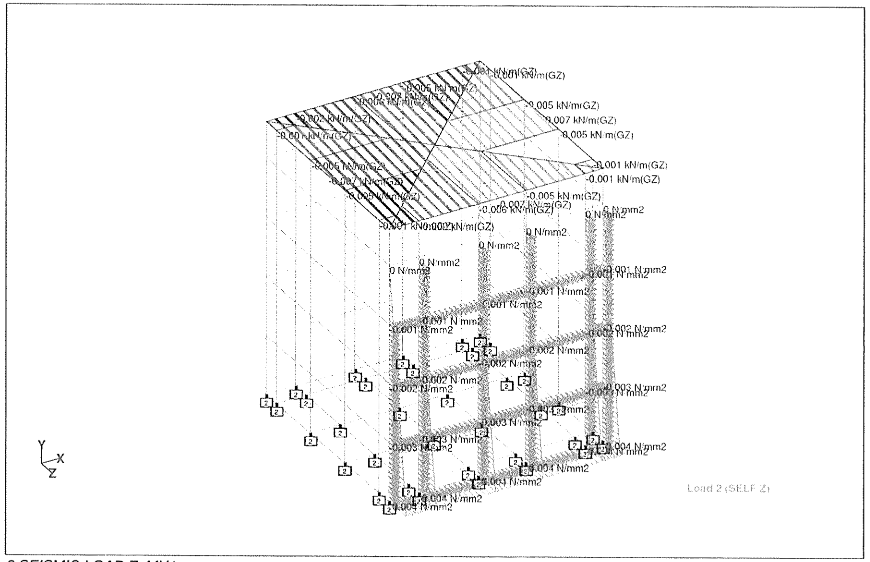
Member property_MH1



1 SEISMIC LOAD X_MH1

Print Time/Date: 25/05/2021 14:46 STAAD.Pro CONNECT Edition 22.04.00.40 Print Run 3 of 6

Software licensed to Jurong Engineering Limited CONNECTED User: kalyani rajmohan	Job No 20054	Sheet No 4	Rev A
Job Title BCC2 PROJECT	Part Manhole -Type-1		
	Ref		
	By Mohan	Date 5/10/2021	Chd Diana
Client BCC 2	File BCC2-Manhole-1 design	Date/Time 12-May-2021 17:24	



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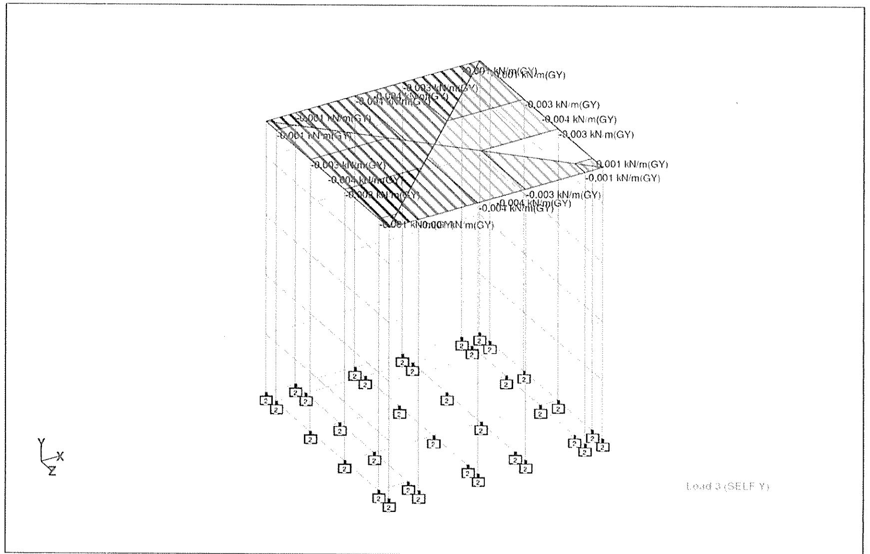
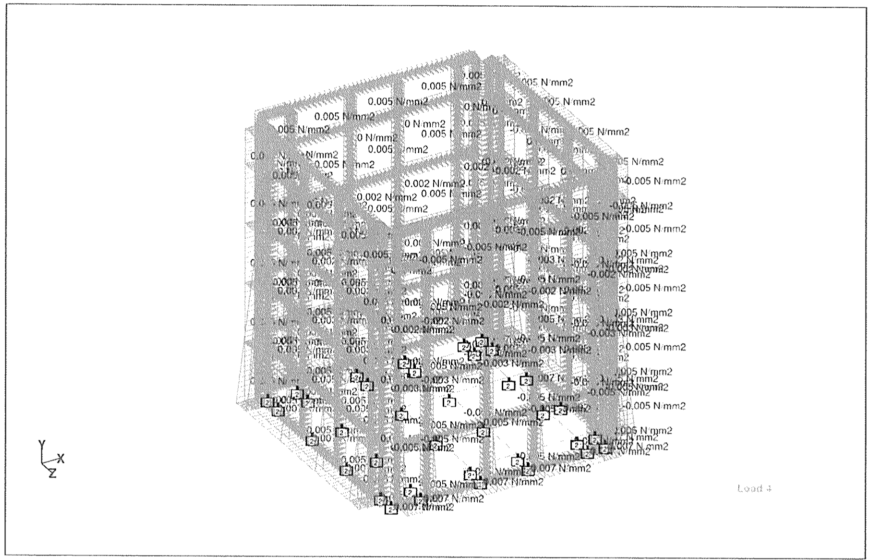


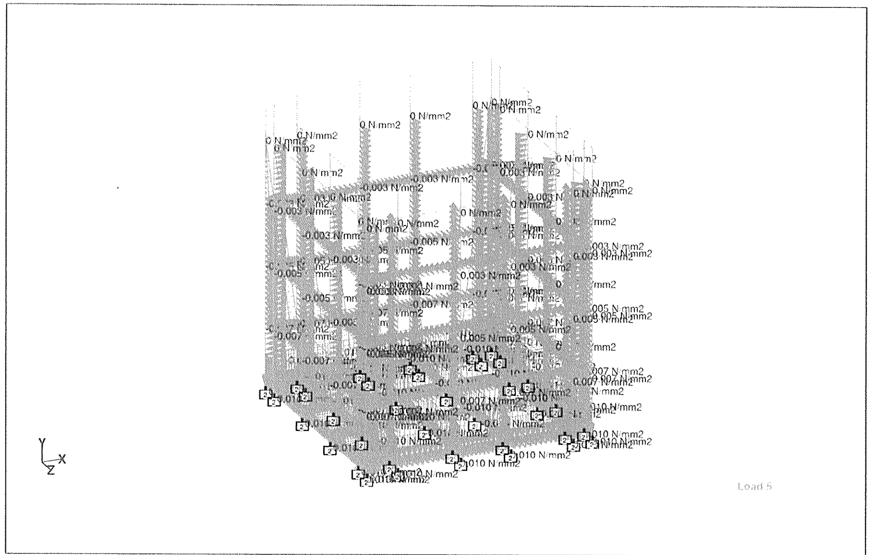
3 SEISMIC LOAD -Y_MH1

Print Time/Date: 25/05/2021 14:46 STAAD.Pro CONNECT Edition 22.04.00.40 Print Run 4 of 6

Software licensed to Jurong Engineering Limited CONNECTED User: kalyani rajmohan	Job No 20054	Sheet No 5	Rev A
	Part Manhole -Type-1		
Job Title BCC2 PROJECT	Ref		
	By Mohan	Date 5/10/2021	Chd Diana
Client BCC 2	File BCC2-Manhole-1 design	Date/Time 12-May-2021 17:24	

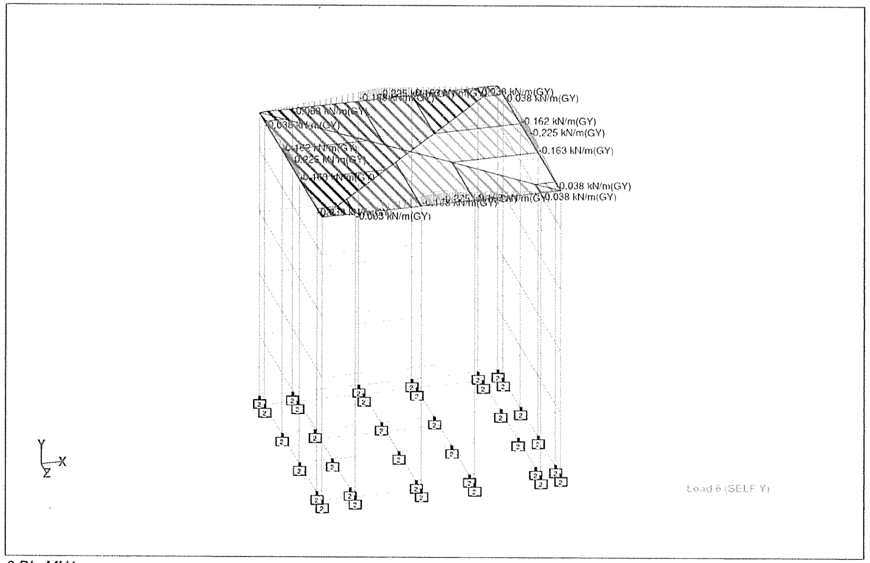


4 EARTH PRESSURE LOAD_MH1

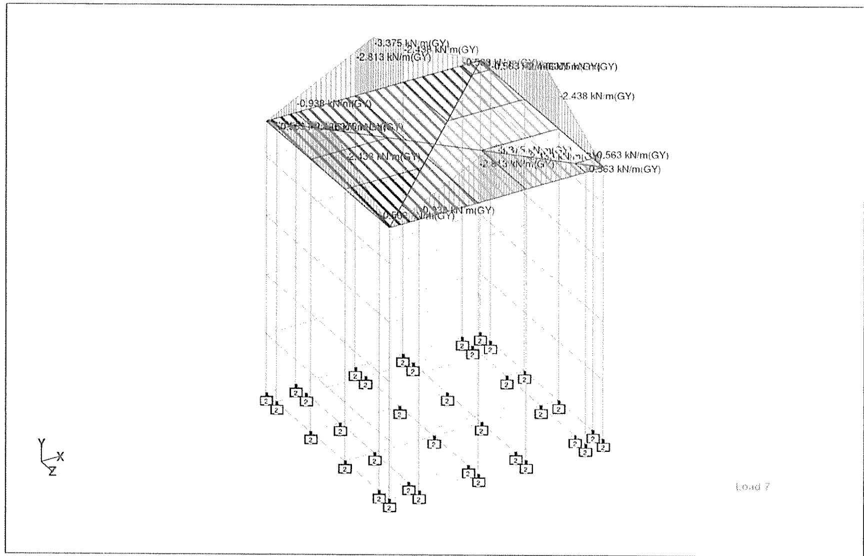


5 WATER PRESSURE LOAD_MH1

Software licensed to Jurong Engineering Limited CONNECTED User: kalyani rajmohan	Job No 20054	Sheet No 6	Rev A
	Part Manhole -Type-1		
Job Title BCC2 PROJECT	Ref		
	By Mohan	Date 5/10/2021	Chd Diana
Client BCC 2	File BCC2-Manhole-1 design	Date/Time 12-May-2021 17:24	



6 DL_MH1



7 LL_MH1

7.1.2 CHECK FOR BASE PRESSURE MANHOLE-TYPE-1

Software licensed to Jurong Engineering Limited CONNECTED User: kalyani rajmohan	Job No 20054	Sheet No 1	Rev A
	Part Manhole -Type-1		
Job Title BCC2 PROJECT	Ref		
	By Mohan	Date 5/10/2021	Chd Diana
Client BCC 2	File BCC2-Manhole-1 design	Date/Time 10-May-2021 15:45	

Base Pressure Summary

	Node	L/C	FX (N/mm^2)	FY (N/mm^2)	FZ (N/mm^2)
Max FX	6	101:1DL+1FL1	**0**	0.032	0
Min FX	6	101:1DL+1FL1	**0**	0.032	0
Max FY	52	109:DL+SP+IW	0	**0.044**	0
Min FY	48	112:0.60 DL+S	0	**0.010**	0
Max FZ	6	101:1DL+1FL1	0	0.032	**0**
Min FZ	6	101:1DL+1FL1	0	0.032	**0**

From the above Base Pressure Summary Table

Maximum Base pressure on foundation = 44.000 kN/m^2

< 75 kN/m^2

Minimum Base pressure on foundation = 10.000 kN/m^2

> 0 kN/m^2

Hence the base pressure on the foundation is with in the allowable bearing capacity of soil and there is no tension exist. Hence safe

7.1.3 DESIGN OF BASE SLAB_MANHOLE-TYPE-1

Software licensed to Jurong Engineering Limited CONNECTED User: kalyani rajmohan	Job No 20054	Sheet No 1	Rev A
	Part Manhole -Type-1		
Job Title BCC2 PROJECT	Ref		
	By Mohan	Date 5/10/2021	Chd Diana
Client BCC 2	File BCC2-Manhole-1 design	Date/Time 10-May-2021 15:45	

Plate Center Stress Summary

	Plate	L/C	Shear		Membrane			Bending		
			Qx (N/mm^2)	Qy (N/mm^2)	Sx (N/mm^2)	Sy (N/mm^2)	Sxy (N/mm^2)	Mx (kN·m/m)	My (kN·m/m)	Mxy (kN·m/m)
Max Qx	12	213:1.2DL+SP·	**0.064**	-0.000	0	0	0	-0.209	0.221	0.001
Min Qx	16	212:1.2DL+SP·	**-0.072**	-0.000	0	0	0	-0.412	0.147	-0.000
Max Qy	4	202:1.2DL+1.6:	0.002	**0.069695**	0	0	0	0.135	-0.519	0.022
Min Qy	24	214:1.2DL+SP·	0.002	**-0.070**	0	0	0	0.168	-0.443	-0.023
Max Sx	26	201:1.4DL+1.4	0.001	0.001	**0**	0	0	-0.090	-0.085	-0.089
Min Sx	26	201:1.4DL+1.4	0.001	0.001	**0**	0	0	-0.090	-0.085	-0.089
Max Sy	26	201:1.4DL+1.4	0.001	0.001	0	**0**	0	-0.090	-0.085	-0.089
Min Sy	26	201:1.4DL+1.4	0.001	0.001	0	**0**	0	-0.090	-0.085	-0.089
Max Sxy	26	201:1.4DL+1.4	0.001	0.001	0	0	**0**	-0.090	-0.085	-0.089
Min Sxy	26	201:1.4DL+1.4	0.001	0.001	0	0	**0**	-0.090	-0.085	-0.089
Max Mx	14	215:1.2DL+SP·	-0.003	-0.002	0	0	0	**0.754**	0.733	-0.001
Min Mx	16	203:1.2DL+1.6:	-0.059	-0.000	0	0	0	**-0.536**	0.048	0.000
Max My	14	215:1.2DL+SP·	-0.003	-0.002	0	0	0	0.754	**0.733**	-0.001
Min My	24	203:1.2DL+1.6:	0.002	-0.061	0	0	0	0.070	**-0.559**	-0.014
Max Mxy	10	213:1.2DL+SP·	-0.019	0.018	0	0	0	0.146	0.174	**0.213**
Min Mxy	20	213:1.2DL+SP·	-0.018	-0.018	0	0	0	0.146	0.171	**-0.212**

DESIGN FOR BENDING MOMENT

Maximum Moment in X-Dir		Mxx	=	**0.755**	kNm/m
Mxx = |Max Mx| + |Mxy| =	0.754 + 0.001				
Maximum Moment in Y-Dir		Myy	=	**0.734**	kNm/m
Myy = |Max My| + |Mxy| =	0.733 + 0.001				
Maximum Moment in XY-Dir		Mxy	=	**0.387**	kNm/m
Mxy = |Max Mxy| + |Mx or My| =	0.213 + 0.174				
Maximum Shear Stress in X-Dir		S_{QX}	=	**0.064**	N/mm^2
Maximum Shear Stress in Y-Dir		S_{Qy}	=	**0.069**	N/mm^2
Max. Ultimate Shear Stress		Vu = max (S_{QX}, S_{QY})	=	0.069	N/mm^2
Max. Ultimate Bending Moment		Mu = max(Mxx, Myy, Mxy)	=	0.755	kNm/m
Depth of section		h	=	**150**	mm
Width of Section		b	=	**1000**	mm
Concrete Cover		cc	=	**75**	mm
Concrete Grade		f'_c	=	**28**	N/mm^2
Steel Reinforcement Grade		f_y	=	**400**	N/mm^2
Diameter of Reinforcement		dia	=	**12**	mm
Spacing of Reinforcement		S	=	**200**	mm

DESIGN FOR THICKNESS AND REINFORCEMENT

Strength reduction factor (ϕ)	Flexure		=	**0.9**	(Table 21.2.1 , ACI 318-14)
	Shear		=	**0.75**	(Table 21.2.1 , ACI 318-14)
Factor	Use β1		=	**0.8500**	
where:	β1	(if fc'≤ 28MPa)	=	0.85	
	β1	(if fc'> 28MPa)	=	0.85 - 0.05/7(fc'-28)	
	β1		>	0.65	

Design Moment		Muz/ϕ	=	0.84	kNm
Width considered		b	=	**1000**	mm
Effective Depth		(h-cc-0.5dia) = d	=	69	mm
z assumed			=	least of 0.9*d or d - 0.5*a	
		0.9*d	=	62.1	mm
		a	=	As_{prov}*fy / (0.85*fc'*b)	
			=	9.504	mm
		d - 0.5*a =		64.248	mm
therefore, z assumed			=	62	mm
As reqd = M/fy*z			=	34	mm^2/m
Provided steel reinf.	**DB 12-200**	$As_{prov.}$	=	**565**	mm^2/m
			>	34	**Hence OK**
Minimum area of reinforcement req.		As_{min}	=	0.002 * b * d	(7.6.1.1,ACI 318-14)
			=	300	mm^2/m
Maximum area of reinforcement req.		As_{max}	=	0.75 * ρ_b * b * d	
		ρ_b	=	0.85 * β1 * fc' * 600 / [fy * (600+fy)]	
			=	0.0303	
		As_{max}	=	1570	mm^2/m

As_{min} < $As_{prov.}$ < As_{max} **Hence OK**

CHECK FOR ONE-WAY SHEAR

Actual shear stress	Vu	=	0.069	N/mm^2
Strength reduction factor for Shear	ϕ_v	=	**0.75**	
	d	=	69	mm
Shear strength	ϕV_c	=	$\phi_v\ 0.17\sqrt{f'c}$	
	ϕV_c	=	0.67	N/mm^2

Shear force is less than Shear strength, O.K.

7.1.4 DESIGN OF WALL_ MANHOLE-TYPE-1

Software licensed to Jurong Engineering Limited CONNECTED User: kalyani rajmohan	Job No 20054	Sheet No 1	Rev A
	Part Manhole -Type-1		
Job Title BCC2 PROJECT	Ref		
	By Mohan	Date 5/10/2021	Chd Diana
Client BCC 2	File BCC2-Manhole-1 design	Date/Time 10-May-2021 15:45	

Plate Center Stress Summary

	Plate	L/C	Shear		Membrane			Bending		
			Qx (N/mm^2)	Qy (N/mm^2)	Sx (N/mm^2)	Sy (N/mm^2)	Sxy (N/mm^2)	Mx (kN m/m)	My (kN m/m)	Mxy (kN m/m)
Max Qx	55	208:0.9DL+1.6	**0.035**	0.000	-0.037	-0.019	0.002	0.506	0.036	0.002
Min Qx	51	208:0.9DL+1.6	**-0.035**	0.000	-0.037	-0.019	-0.002	0.506	0.036	-0.002
Max Qy	93	203:1.2DL+1.6	0.000	**0.031**	-0.008	-0.059	-0.002	0.009	-0.348	0.007
Min Qy	68	203:1.2DL+1.6	-0.000	**-0.031**	-0.008	-0.059	-0.002	-0.009	0.348	-0.007
Max Sx	72	201:1.4DL+1.4	0.010643	-0.004	**0.030**	-0.031	0.006	0.097	0.151	-0.007
Min Sx	55	210:0.9DL+1.6	0.033	0.000	**-0.040**	-0.020	0.000	0.520	0.051	-0.001
Max Sy	95	201:1.4DL+1.4	0.016	0.008	0.019	**-0.000**	-0.002	0.148	-0.110	-0.050
Min Sy	118	212:1.2DL+SP	-0.000	0.014	0.006	**-0.075**	0.000	-0.108	-0.436	-0.000
Max Sxy	92	204:1.2DL+SP	-0.003	0.015	-0.005	-0.044	**0.014**	-0.046	-0.269	0.006
Min Sxy	94	205:1.2DL+SP	0.003	0.013	-0.004	-0.038	**-0.014**	-0.045	-0.242	-0.002
Max Mx	55	210:0.9DL+1.6	0.033	0.000	-0.040	-0.020	0.000	**0.520**	0.051	-0.001
Min Mx	130	210:0.9DL+1.6	-0.033	-0.001	-0.040	-0.020	0.000	**-0.519**	-0.051	-0.001
Max My	68	213:1.2DL+SP	-0.001	-0.015	0.007	-0.072	-0.007	0.110	**0.452**	0.011
Min My	93	213:1.2DL+SP	0.001	0.015	0.007	-0.071	-0.007	-0.110	**-0.451**	-0.009
Max Mxy	69	201:1.4DL+1.4	-0.010	-0.002	0.015	-0.035	-0.004	0.044	0.250	**0.108**
Min Mxy	42	201:1.4DL+1.4	0.010	-0.002	0.014	-0.034	0.004	0.046	0.251	**-0.107**

3.6.1 DESIGN FOR BENDING MOMENT

Maximum Moment in X-Dir		Mxx	=	**0.521**	kNm/m
Mxx = |Max Mx| + |Mxy| =	0.520 + 0.001				
Maximum Moment in Y-Dir		Myy	=	**0.476**	kNm/m
Myy = |Max My| + |Mxy| =	0.452 + 0.024				
Maximum Moment in XY-Dir		Mxy	=	**0.358**	kNm/m
Mxy = |Max Mxy| + |Mx or My| =	0.108 + 0.250				
Maximum Shear Stress in X-Dir		S_{QX}	=	**0.035**	N/mm^2
Maximum Shear Stress in Y-Dir		S_{Qy}	=	**0.031**	N/mm^2
Max. Ultimate Shear Stress		Vu = max (S_{QX}, S_{QY})	=	0.035	N/mm^2
Max. Ultimate Bending Moment		Mu = max(Mxx, Myy, Mxy)	=	0.521	kNm/m
Depth of section		h	=	**150**	mm
Width of Section		b	=	**1000**	mm
Concrete Cover		cc	=	**75**	mm
Concrete Grade		f'_c	=	**28**	N/mm^2
Steel Reinforcement Grade		f_y	=	**400**	N/mm^2
Diameter of Reinforcement		dia	=	**12**	mm
Spacing of Reinforcement		S	=	**200**	mm

DESIGN FOR THICKNESS AND REINFORCEMENT

Strength reduction factor (ϕ)		Flexure		=	**0.9**	(Table 21.2.1 , ACI 318-14)
		Shear		=	**0.75**	(Table 21.2.1 , ACI 318-14)
Factor	Use	$\beta 1$		=	**0.8500**	
where:		$\beta 1$	(if fc'≤ 28MPa)	=	0.85	
		$\beta 1$	(if fc'> 28MPa)	=	0.85	- 0.05/7(fc'-28)
		$\beta 1$		>	0.65	

Design Moment		Muz/ϕ	=	0.58	kNm
Width considered		b	=	**1000**	mm
Effective Depth		(h-cc-0.5dia) = d	=	69	mm
z assumed			=	least of 0.9*d or d - 0.5*a	
		0.9*d	=	62.1	mm
		a	=	As_{prov}*fy / (0.85*fc'*b)	
			=	9.504	mm
		d - 0.5*a =		64.248	mm
therefore, z assumed			=	62	mm
As reqd = M/fy*z			=	23	mm^2/m
Provided steel reinf.	**DB 12-200**	$As_{prov.}$	=	**565**	mm^2/m
			>	23	**Hence OK**

Minimum area of reinforcement in ver dir req.	=	0.0015 * b*D/2	(Table 11.6.1,ACI -318-14)
	=	113	mm^2/m
	<	565	mm^2/m
		Hence OK	
Minimum area of reinforcement in Hor dir req.	=	0.0025 * b*D/2	(Table 11.6.1,ACI -318-14)
	=	188	mm^2/m
	<	565	mm^2/m
		Hence OK	

Maximum area of reinforcement req.	As_{max}	=	0.75 * ρ_b * b * d	
	ρ_b	=	0.85 * $\beta 1$ * fc' * 600 / [fy * (600+fy)]	
		=	0.0303	
	As_{max}	=	1570	mm^2/m

As_{min} < $As_{prov.}$ < As_{max} **Hence OK**

CHECK FOR ONE-WAY SHEAR

Actual shear stress	Vu	=	0.035	N/mm^2
Strength reduction factor for Shear	ϕ_v	=	**0.75**	
	d	=	69	mm
Shear strength	ϕV_c	=	$\phi_v\ 0.17\sqrt{f'c}$	
	ϕV_c	=	0.67	N/mm^2

Shear force is less than Shear strength, O.K.

DESIGN OF MANHOLE _TYPE -2

7.2 DESIGN LOADS FOR MANHOLE-TYPE-2 (Upto 1.0m to 1.60m Depth)

7.2.1 DEAD LOAD

Self wt of structure will be generated by STAAD itself

Checkered Plate Cover (6mm thk)	=	0.50	kN/m^2

7.2.2 LIVE LOAD

Live load on Cover	=	5.00	kN/m^2

7.2.3 HYDRO LOAD

FULL CONDITION:

Height of wall	=	1.50	m
Max. water level inside, h_w max	=	1.50	m
Unit weight of water, γ_w	=	10.00	kN/m^3
Vertical Pressure on base slab	=	$\gamma_w \times h_{w1}$	
	=	15.000	kN/m^2

Lateral pressure due to water inside is applied on all the sides of the wall

Lateral pressure due to water on top of wall	=	$\gamma_w \times h_{w1}$	
where: h_{w1} = 0 m	=	0.000	kN/m^2
Lateral pressure due to water on bottom side wall	=	$\gamma_w \times h_{w2}$	
where: h_{w2} = 1.5 m	=	15.000	kN/m^2

The load is applied in STAAD as lateral load ranging from 0 kN/m^2 to 15.000 kN/m^2

UPLIFT CONDITION:

(ground water table at 1.50m)

Height of wall inside the Ground water table, h	=	0.15	m
Unit weight of water, γ_w	=	10.00	kN/m^3
Vertical Uplift Pressure on base slab	=	$\gamma_w \times h$	
	=	1.5	kN/m^2

7.2.4 EARTH PRESSURE LOAD

For calculating the earth pressure load on the side walls , it is assumed that the ground water table is at FGL conservatively.

Unit weight of soil	γ	=	18	kN/m^3
Angle of repose		=	30	ϕ
Unit weight of water	$\gamma\omega$	=	10	kN/m^3
Soil submerged density,	$\gamma's$	=	8	kN/m^3
coefficient for surcharge pressure	k_s	=	0.50	
Soil active pressure coefficient,	ka	=	0.33	

ka = $\tan^2(45 - ø/2)$ for ø =30deg

Ground water table	*hw*	=	1.50	m	from FGL
The height of wall below GL	h	=	1.50	m	
Depth of the base slab	D_{bs}	=	0.15	m	
Surcharge load,	q	=	10.00	kN/m^2	
Total Height of wall	H	=	1.50	m	

a. Active pressure due to ground water, qw = $\gamma\omega$ *(H)

= 1.50 kN/m^2

b. Active pressure due to submerged soil , *q's* = ka* γ 's * (H)

= 0.4 kN/m^2

Total Lateral pressure due to submerged earth pressure = 1.9 kN/m^2

a. Load due to surcharge = k_s*q

= 5.0 kN/m^2

b. Active pressure due to dry soil , *qa =ka•g •(hw)* = 9.00 kN/m^2

7.2.5 SEISMIC EARTH PRESSURE LOAD

Mononobe-Okabe Method :

Dynamic active earth thrust Pdae = Kae x γ x H

Where Kae = seismic active earth pressure coefficient

$$Kae = \frac{\cos^2(\Phi-\Psi-\theta)}{\cos(\Psi)\cos^2(\theta)\cos(\delta+\theta+\Psi) \times \left[1 + \left[\frac{\sin(\Phi+\delta)\sin(\Phi-\Psi-\beta)}{\cos(\beta-\theta)\cos(\delta+\Psi+\theta)}\right]^{0.5}\right]^2}$$

Where

ϕ =	Angle of internal friction =	30	deg	
δ =	Angle of friction between soil and wall =	0		(Ref. Bowles book)
Ψ =	$\tan^{-1}[k_h / (1-k_v)]$			
k_h =	horizontal acceleration coefficient = 0.025g			
	g = gravitational accelaration =	9.810	m/s^2	
k_h =	0.24525			
k_v =	vertical acceleration coefficient =	0.164		
Ψ =	$\tan^{-1}[k_h / (1-k_v)]$ =	3.918		
β =	backfill slope angle =	20	deg	

θ = angle of backface to the wall with the vertical = 0 (Uniform earth fill)

$$Kae = \frac{\cos^2(30-3.918-0)}{\cos(3.918)\cos^2(0)\cos(0+0+3.918) \times \left[1+\left\{\frac{\sin(30+0)\sin(30-3.918-0)}{\cos(0-0)\cos(0+3.918+0)}\right\}\right]}$$

$$Kae = \frac{0.807}{0.995 \times 1.545}$$

Kae = 0.52461

Dynamic active earth thrust	Pdae	=	Kae x γ x H
		=	0.525 x 18 x 1.5
		=	14.165 kN/m^2
Active Earth pressure	Pae	=	Ka x γ x H
		=	0.333 x 18 x 1.5
		=	9.000 kN/m^2

Coefficient of active earth pressure is Ka = 0.33

Therefore, the dynamic increment,	=	Pdae - Pae
	=	14.165 - 9
	=	5.165 kN/m^2

Additional 5.165 kN/m^2 is applied on the trench walls as a dynamic increment due to earth pressure.

Vertical Seismic Effect (Section 12.4.2.2 of ASCE 7-10)

$Ev = 0.2 * S_{DS} * DL$

SDS = 0.094

Ev = 0.0188 D

7.2.7 PRIMARY LOADS MANHOLE-TYPE-2

LOAD 1	Earthquake Load (X)	SL+X
LOAD 2	Earthquake Load (Z)	SL+Z
LOAD 3	Vertical Seismic Effect	SL Y
LOAD 4	Soil Pressure	SP
LOAD 5	Fluid Load	FL
LOAD 6	Dead Load	DL
LOAD 7	Live Load	LL
LOAD 8	Uplift Load	UL

ii) **Service Loads**

LOAD COMB 11 DL+FL

LOAD COMB 12 DL+SP+FL+LL

LOAD COMB 13 DL+SP+0.75FL+0.75LL

LOAD COMB 14 DL+SP +0.70SL(+X)+0.70SL(-Y)

LOAD COMB 15 DL+SP -0.70SL(+X)+0.70SL(-Y)

LOAD COMB 16 DL+SP +0.70SL(+Z)+0.70SL(-Y)

LOAD COMB 17 DL+SP -0.70SL(-Z)+0.70SL(-Y)

LOAD COMB 18 DL+SP+FL+LL+0.70SL(+X)+0.70SL(-Y)

LOAD COMB 19 DL+SP+FL+LL-0.70SL(+X)+0.70SL(-Y)

LOAD COMB 20 DL+SP+FL+LL+0.70SL(+Z)+0.70SL(-Y)

LOAD COMB 21 DL+SP+FL+LL-0.70SL(+Z)+0.70SL(-Y)

LOAD COMB 21 0.60 DL+0.70SL+X-0.70SL(-Y)

LOAD COMB 22 0.60 DL-0.70SL+X-0.70SL(-Y)

LOAD COMB 23 0.60 DL+0.70SL+Z-0.70SL(-Y)

LOAD COMB 24 0.60 DL-0.70SL+Z-0.70SL(-Y)

LOAD COMB 25 DL+SP+FL+0.75LL+0.525SL(+X)+0.70SL(-Y)

LOAD COMB 26 DL+SP+FL+0.75LL-0.525SL(+X)+0.70SL(-Y)

LOAD COMB 27 DL+SP+FL+0.75LL+0.525SL(+Z)+0.70SL(-Y)

LOAD COMB 28 DL+SP+FL+0.75LL-0.525SL(+Z)+0.70SL(-Y)

UPLIFT CHECK

LOAD COMB 29 1.0DL+1.0FL+0.66UL

6 1.0 5 1.0 8 0.66

iii) **Ultimate Loads**

LOAD COMB 101 1.4DL+1.4 FL

LOAD COMB 102 1.2DL+1.6DASP+1.6SP+1.2FL+1.6LL

LOAD COMB 103 1.2DL+1.6DASP+1.6SP+1.0LL

LOAD COMB 104 1.2DL+DASP+SP+LL+1.0SL+X +1.0SL(-Y)

LOAD COMB 105 1.2DL+DASP+SP+LL-1.0SL+X +1.0SL(-Y)

LOAD COMB 106 1.2DL+DASP+SP+LL+1.0SL+Z +1.0SL(-Y)

LOAD COMB 107 1.2DL+DASP+SP+LL-1.0SL+Z +1.0SL(-Y)

LOAD COMB 108 0.9DL+1.6DASP+1.6SP+1.0SL+X+1.0SL(-Y)

LOAD COMB 109 0.9DL+1.6DASP+1.6SP-1.0SL+X+1.0SL(-Y)

LOAD COMB 110 0.9DL+1.6DASP+1.6SP+1.0SL+Z+1.0SL(-Y)

LOAD COMB 111 0.9DL+1.6DASP+1.6SP-1.0SL+Z+1.0SL(-Y)

LOAD COMB 112 1.2DL+DASP+SP+1.2FL+1.6LL+1.0SL+X +1.0SL(-Y)

LOAD COMB 113 1.2DL+DASP+SP+1.2FL+1.6LL-1.0SL+X +1.0SL(-Y)

LOAD COMB 114 1.2DL+DASP+SP+1.2FL+1.6LL+1.0SL+Z +1.0SL(-Y)

LOAD COMB 115 1.2DL+DASP+SP+1.2FL+1.6LL-1.0SL+Z +1.0SL(-Y)

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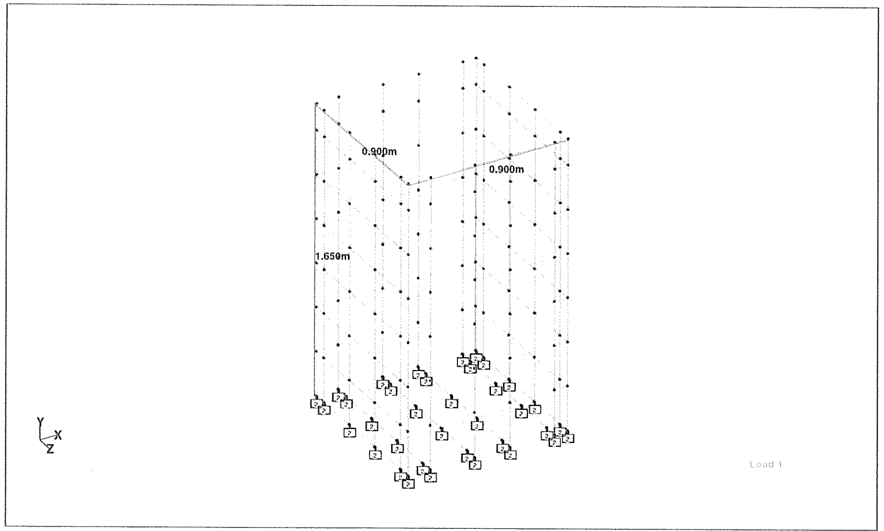
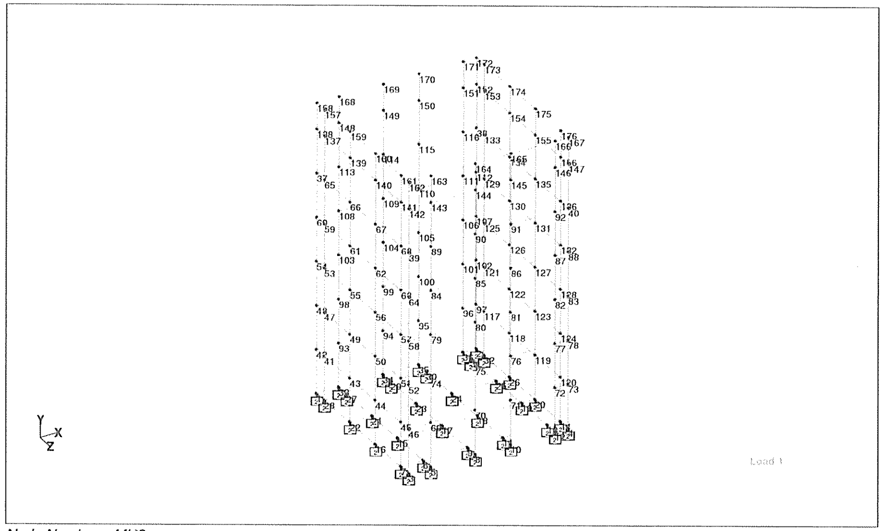
	Part Manhole Drain		
Job Title BCC-2 PROJECT	Ref		
	By Mohan	Date 5/11/2021	Chd Diana
Client BCC-2	File Manhole design-MH2 _re	Date/Time 11-May-2021 19:51	



Whole Structure_MH2



Node Numbers_MH2

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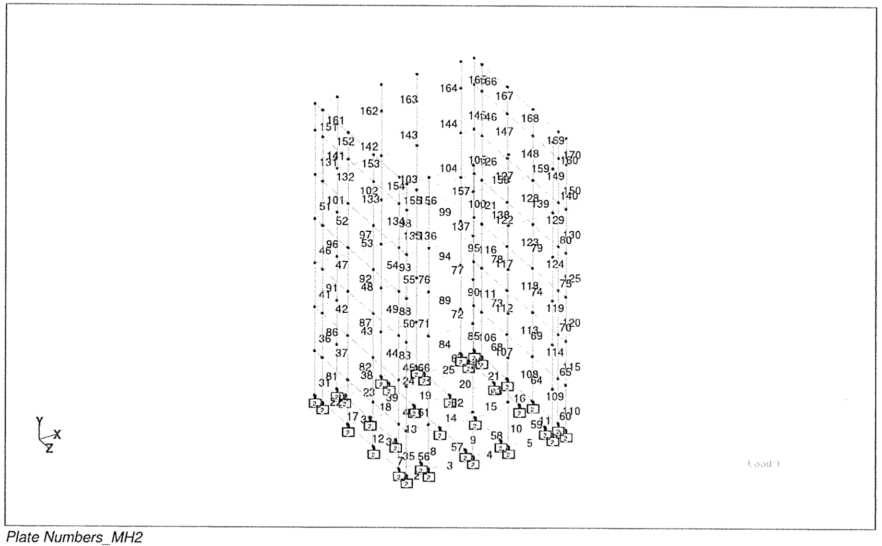
	Part Manhole Drain		
Job Title BCC-2 PROJECT	Ref		
	By Mohan	Date 5/11/2021	Chd Diana
Client BCC-2	File Manhole design-MH2 _re	Date/Time 11-May-2021 19:51	



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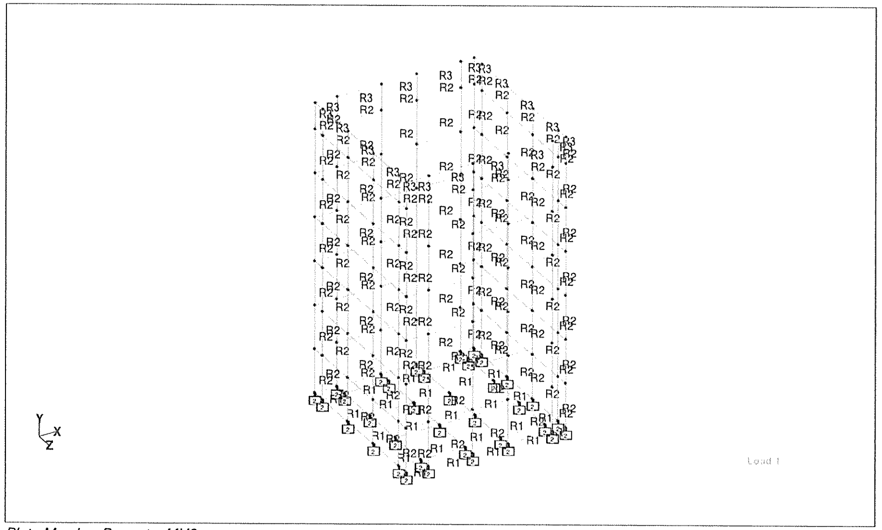

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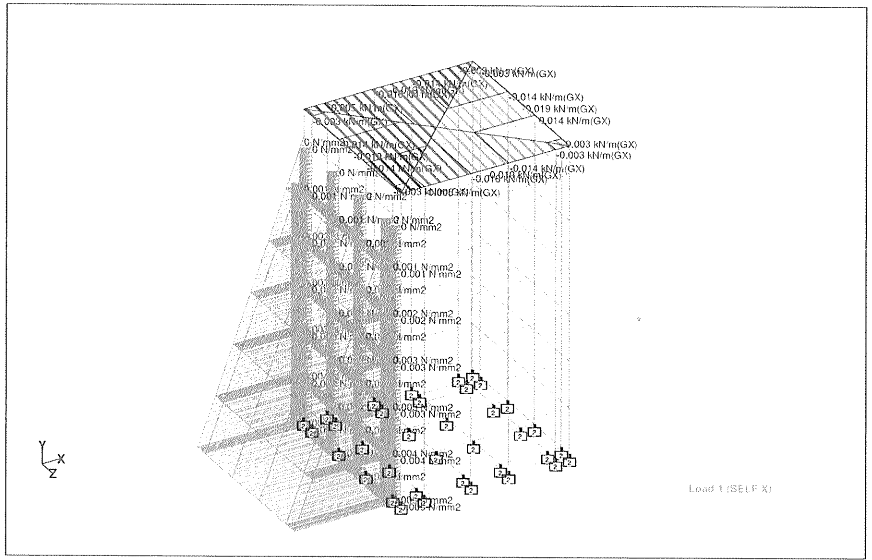
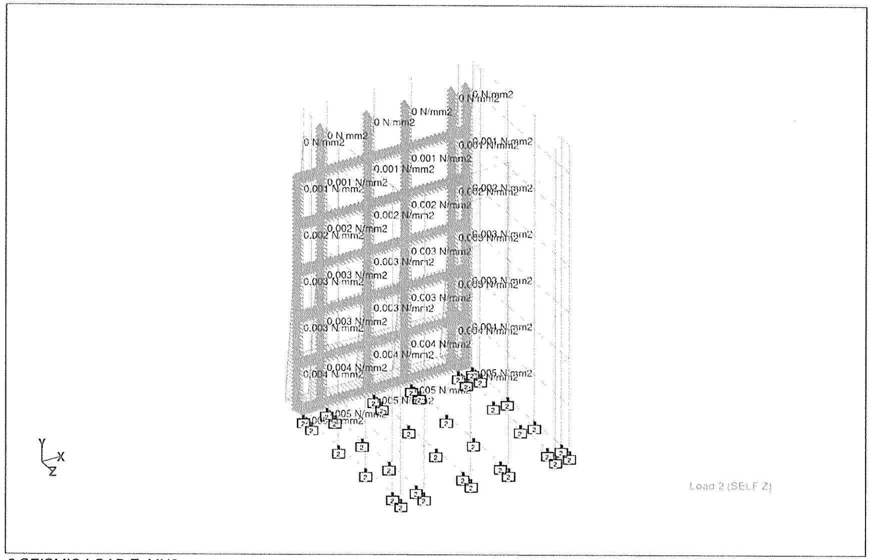
	By Mohan	Date 5/11/2021	Chd Diana
Client BCC-2	File Manhole design-MH2 _re	Date/Time 11-May-2021 19:51	



1 SEISMIC LOAD X_MH2



2 SEISMIC LOAD Z_MH2

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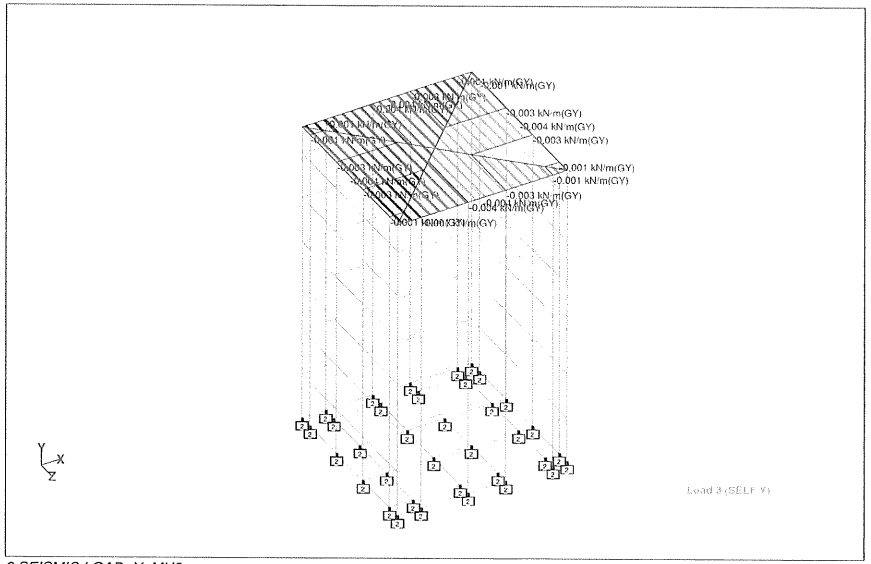
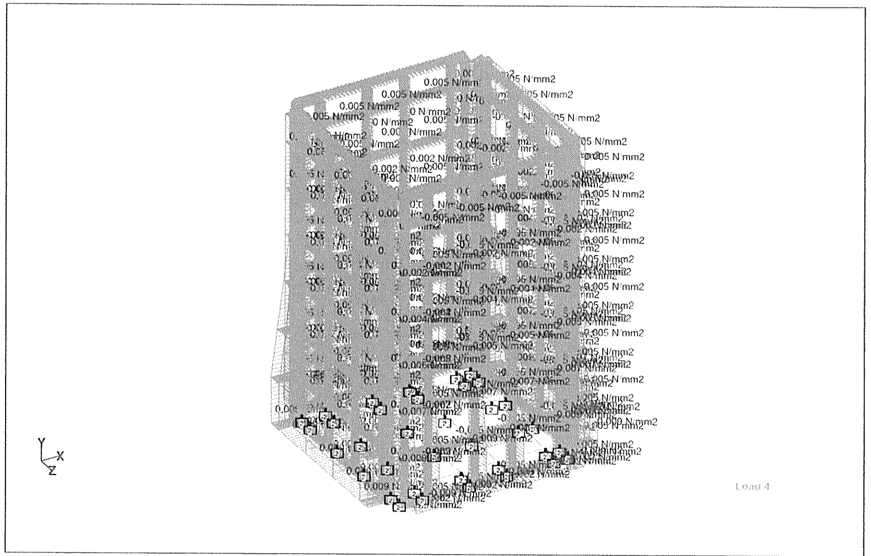
	Part Manhole Drain		
Job Title BCC-2 PROJECT	Ref		
	By Mohan	Date 5/11/2021	Chd Diana
Client BCC-2	File Manhole design-MH2 _re	Date/Time 11-May-2021 19:51	



3 SEISMIC LOAD -Y_MH2



4 EARTH PRESSURE LOAD_MH2

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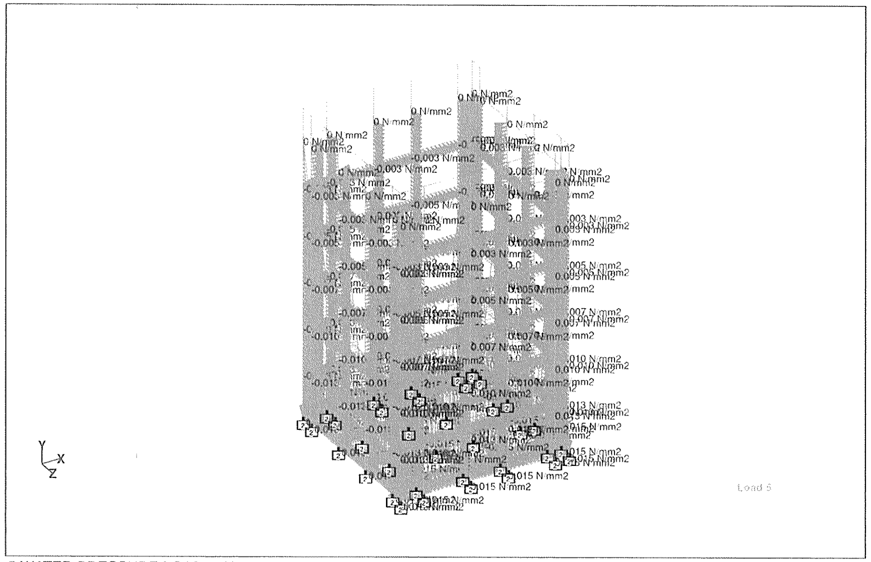
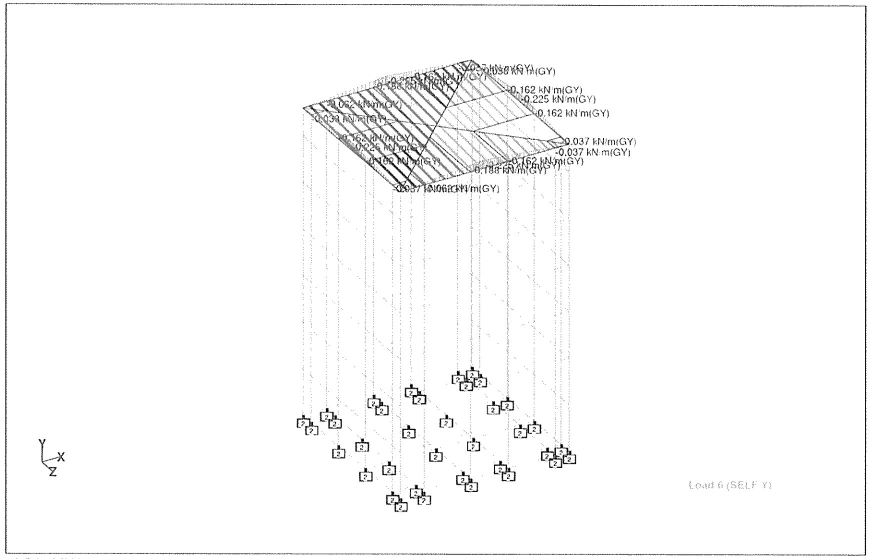
	Part Manhole Drain		
Job Title BCC-2 PROJECT	Ref		
	By Mohan	Date 5/11/2021	Chd Diana
Client BCC-2	File Manhole design-MH2 _re	Date/Time 11-May-2021 19:51	



5 WATER PRESSURE LOAD_MH2



6 DL_MH2

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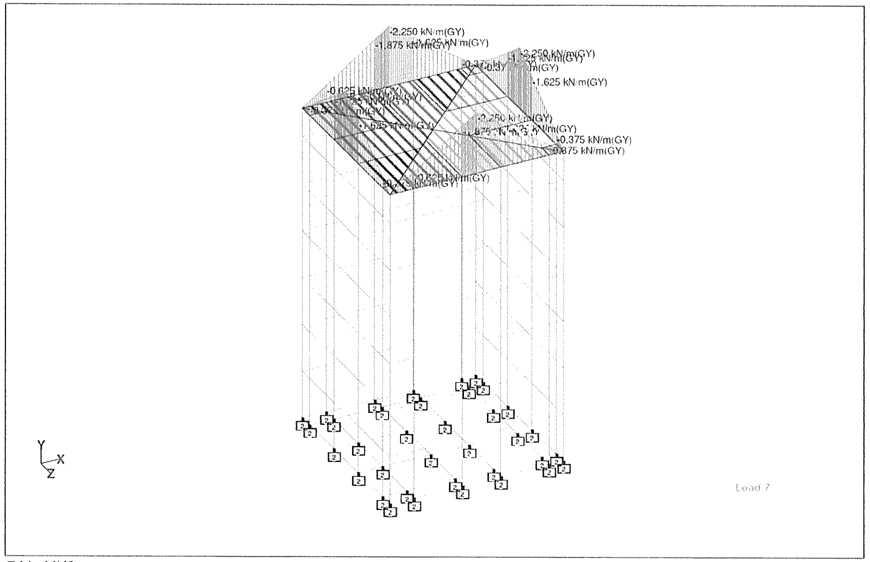
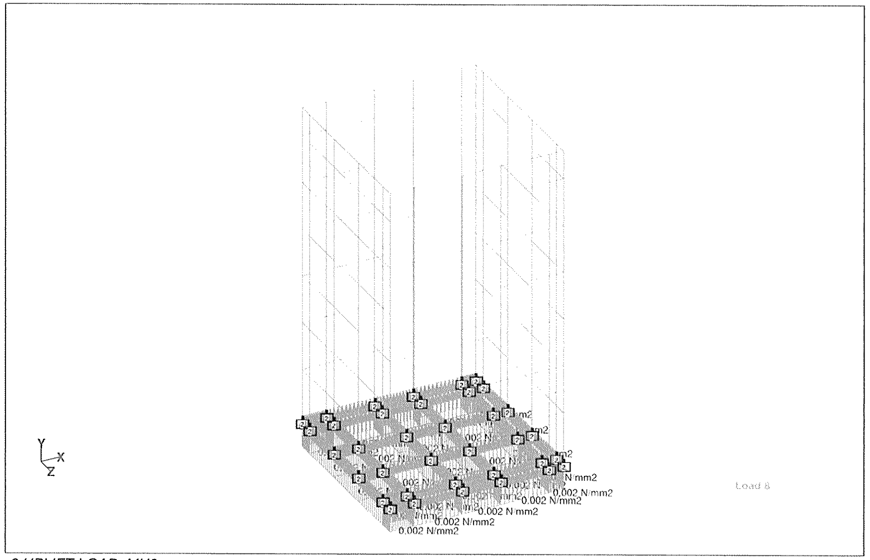
	Part Manhole Drain		
Job Title BCC-2 PROJECT	Ref		
	By Mohan	Date 5/11/2021	Chd Diana
Client BCC-2	File Manhole design-MH2 _re	Date/Time 11-May-2021 19:51	



7 LL_MH2



8 UPLIFT LOAD_MH2

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7.2.8 CHECK FOR BASE PRESSURE MANHOLE-TYPE-2

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	Part Manhole Drain		
Job Title BCC-2 PROJECT	Ref		
	By Mohan	Date 5/11/2021	Chd Diana
Client BCC-2	File Manhole design-MH2 _re	Date/Time 11-May-2021 19:51	

Base Pressure Summary

	Node	L/C	FX (N/mm²)	FY (N/mm²)	FZ (N/mm²)
Max FX	1	101:1DL+1FL1	**0**	0.045	0
Min FX	1	101:1DL+1FL1	**0**	0.045	0
Max FY	1	111:DL+SP+IW	0	**0.066**	0
Min FY	2	114:0.60 DL+S	0	**0.002**	0
Max FZ	1	101:1DL+1FL1	0	0.045	**0**
Min FZ	1	101:1DL+1FL1	0	0.045	**0**

From the above Base Pressure Summary Table

Maximum Base pressure on foundation = 66.000 kN/m^2
< 75 kN/m^2

Minimum Base pressure on foundation = 2.000 kN/m^2
> 0 kN/m^2

Hence the base pressure on the foundation is with in the allowable bearing capacity of soil and there is no tension exist. Hence safe

7.2.9 DESIGN OF BASE SLAB -MH-2

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	Part Manhole Drain		
Job Title BCC-2 PROJECT	Ref		
	By Mohan	Date 5/11/2021	Chd Diana
Client BCC-2	File Manhole design-MH2 _re	Date/Time 11-May-2021 19:51	

Plate Center Stress Summary

	Plate	L/C	Shear		Membrane			Bending		
			Qx (N/mm²)	Qy (N/mm²)	Sx (N/mm²)	Sy (N/mm²)	Sxy (N/mm²)	Mx (kN m/m)	My (kN m/m)	Mxy (kN m/m)
Max Qx	12	213:1.2DL+SP	**0.084**	0.000	0	0	0	-0.120	0.319	0.000
Min Qx	16	212:1.2DL+SP	**-0.097**	-0.000	0	0	0	-0.406	0.219	0.000
Max Qy	4	214:1.2DL+SP	0.003	**0.099**	0	0	0	0.271	-0.417	0.030
Min Qy	24	215:1.2DL+SP	0.003	**-0.097**	0	0	0	0.294	-0.324	-0.032
Max Sx	26	201:1.4DL+1.4	0.002	0.002	**0**	0	0	-0.110	-0.099	-0.139
Min Sx	26	201:1.4DL+1.4	0.002	0.002	**0**	0	0	-0.110	-0.099	-0.139
Max Sy	26	201:1.4DL+1.4	0.002	0.002	0	**0**	0	-0.110	-0.099	-0.139
Min Sy	26	201:1.4DL+1.4	0.002	0.002	0	**0**	0	-0.110	-0.099	-0.139
Max Sxy	26	201:1.4DL+1.4	0.002	0.002	0	0	**0**	-0.110	-0.099	-0.139
Min Sxy	26	201:1.4DL+1.4	0.002	0.002	0	0	**0**	-0.110	-0.099	-0.139
Max Mx	14	201:1.4DL+1.4	-0.003	0.000	0	0	0	**0.952**	0.931	0.000
Min Mx	16	203:1.2DL+1.6	-0.073	-0.000	0	0	0	**-0.693**	0.044	0.000
Max My	14	201:1.4DL+1.4	-0.003	0.000	0	0	0	0.952	**0.931**	0.000
Min My	24	206:1.2DL+SP	0.002	-0.055	0	0	0	0.022	**-0.777**	-0.016
Max Mxy	10	201:1.4DL+1.4	-0.021	0.021	0	0	0	0.313	0.326	**0.280**
Min Mxy	20	201:1.4DL+1.4	-0.021	-0.021	0	0	0	0.313	0.326	**-0.280**

DESIGN FOR BENDING MOMENT

Maximum Moment in X-Dir	Mxx	=	**0.953**	kNm/m
Mxx = |Max Mx| + |Mxy| = 0.952 + 0.001				
Maximum Moment in Y-Dir	Myy	=	**0.932**	kNm/m
Myy = |Max My| + |Mxy| = 0.931 + 0.001				
Maximum Moment in XY-Dir	Mxy	=	**0.606**	kNm/m
Mxy = |Max Mxy| + |Mx or My| = 0.280 + 0.326				
Maximum Shear Stress in X-Dir	S_{QX}	=	**0.097**	N/mm²
Maximum Shear Stress in Y-Dir	S_{Qy}	=	**0.099**	N/mm²
Max. Ultimate Shear Stress	Vu = max (S_{QX}, S_{QY})	=	0.099	N/mm²
Max. Ultimate Bending Moment	Mu = max(Mxx, Myy, Mxy)	=	0.953	kNm/m
Depth of section	h	=	**150**	mm
Width of Section	b	=	**1000**	mm
Concrete Cover	cc	=	**75**	mm
Concrete Grade	f'_c	=	**28**	N/mm²
Steel Reinforcement Grade	f_y	=	**400**	N/mm²
Diameter of Reinforcement	dia	=	**12**	mm
Spacing of Reinforcement	S	=	**200**	mm

DESIGN FOR THICKNESS AND REINFORCEMENT

Strength reduction factor (ϕ)	Flexure		=	**0.9**	(Table 21.2.1 , ACI 318-14)
	Shear		=	**0.75**	(Table 21.2.1 , ACI 318-14)
Factor	Use $\beta 1$		=	**0.8500**	
where:	$\beta 1$	(if fc'≤ 28MPa)	=	0.85	
	$\beta 1$	(if fc'> 28MPa)	=	0.85 - 0.05/7(fc'-28)	
	$\beta 1$		>	0.65	

Design Moment	Muz/ϕ	=	1.06	kNm
Width considered	b	=	**1000**	mm
Effective Depth	(h-cc-0.5dia) = d	=	69	mm
z assumed		=	least of 0.9*d or d - 0.5*a	
	0.9*d	=	62.1	mm
	a	=	As_{prov}*fy / (0.85*fc'*b)	
		=	9.504	mm
	d - 0.5*a =		64.248	mm
therefore, z assumed		=	62	mm
As reqd = M/fy*z		=	43	mm^2/m
Provided steel reinf. **DB 12-200**	$As_{prov.}$	=	**565**	mm^2 /m
		>	43	**Hence OK**
Minimum area of reinforcement req.	As_{min}	=	0.002 * b * d	(7.6.1.1,ACI 318-14)
		=	300	mm^2/m
Maximum area of reinforcement req.	As_{max}	=	0.75 * ρ_b * b * d	
	ρ_b	=	0.85 * $\beta 1$ * fc' * 600 / [fy * (600+fy)]	
		=	0.0303	
	As_{max}	=	1570	mm^2/m

As_{min} < $As_{prov.}$ < As_{max} **Hence OK**

CHECK FOR ONE-WAY SHEAR

Actual shear stress	Vu	=	0.099	N/mm^2
Strength reduction factor for Shear	ϕ_v	=	**0.75**	
	d	=	69	mm
Shear strength	ϕV_c	=	ϕ_v 0.17√ f'c	
	ϕV_c	=	0.67	N/mm^2

Shear force is less than Shear strength, O.K.

7.2.10 DESIGN OF WALL _MH-2

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Job No	20054	Sheet No	1	Rev	A
Part	Manhole Drain				
Job Title	BCC-2 PROJECT	Ref			
By	Mohan	Date	5/11/2021	Chd	Diana
Client	BCC-2	File	Manhole design-MH2 _re	Date/Time	11-May-2021 19:51

Plate Center Stress Summary

	Plate	L/C	Shear		Membrane			Bending		
			Qx (N/mm^2)	Qy (N/mm^2)	Sx (N/mm^2)	Sy (N/mm^2)	Sxy (N/mm^2)	Mx (kNm/m)	My (kNm/m)	Mxy (kNm/m)
Max Qx	45	208:0.9DL+1.6	**0.057**	0.002	-0.056	-0.027	0.007	0.812	0.068	-0.009
Min Qx	41	208:0.9DL+1.6	**-0.057**	0.002	-0.056	-0.027	-0.007	0.812	0.068	0.009
Max Qy	83	210:0.9DL+1.6	0.000	**0.042517**	-0.017	-0.023	-0.001	0.128	-0.246	0.024
Min Qy	58	203:1.2DL+1.6	-0.001	**-0.042**	-0.012	-0.073	-0.002	-0.034	0.434	-0.012
Max Sx	87	201:1.4DL+1.4	-0.019	0.005	**0.052**	-0.049	0.008	-0.167	-0.232	0.035
Min Sx	41	210:0.9DL+1.6	-0.050	0.002	**-0.064**	-0.028	0.006	0.850	0.101	0.004
Max Sy	40	216:1.4DL+1.4	-0.036	-0.006	0.041	**0.013**	-0.001	-0.459	-0.006	0.025
Min Sy	58	214:1.2DL+SP	-0.001	-0.015	0.010	**-0.106**	-0.002	0.157	0.546	0.015
Max Sxy	82	204:1.2DL+SP	-0.003	0.018	-0.010	-0.047	**0.027**	-0.051	-0.308	0.002
Min Sxy	84	205:1.2DL+SP	0.003	0.015468	-0.007	-0.040	**-0.026**	-0.052	-0.281	0.010
Max Mx	41	210:0.9DL+1.6	-0.050	0.002	-0.064	-0.028	0.006	**0.850**	0.101	0.004
Min Mx	116	210:0.9DL+1.6	0.050	-0.002	-0.064	-0.028	0.006	**-0.850**	-0.101	-0.003
Max My	58	214:1.2DL+SP	-0.001	-0.015	0.010	-0.106	-0.002	0.157	**0.546**	0.015
Min My	83	215:1.2DL+SP	0.001	0.008	0.011358	-0.105	-0.002	-0.191	**-0.534**	-0.020
Max Mxy	59	201:1.4DL+1.4	-0.016	-0.002	0.025	-0.052	-0.005	0.059	0.347	**0.178**
Min Mxy	84	201:1.4DL+1.4	0.016	0.002	0.025	-0.052	-0.005	-0.059	-0.347	**-0.178**

3.6.1 DESIGN FOR BENDING MOMENT

Maximum Moment in X-Dir		Mxx	=	**0.854**	kNm/m
Mxx = |Max Mx| + |Mxy| =	0.850 + 0.004				
Maximum Moment in Y-Dir		Myy	=	**0.561**	kNm/m
Myy = |Max My| + |Mxy| =	0.546 + 0.015				
Maximum Moment in XY-Dir		Mxy	=	**0.528**	kNm/m
Mxy = |Max Mxy| + |Mx or My| =	0.178 + 0.350				
Maximum Shear Stress in X-Dir		S_{QX}	=	**0.057**	N/mm^2
Maximum Shear Stress in Y-Dir		S_{Qy}	=	**0.043**	N/mm^2
Max. Ultimate Shear Stress	Vu = max (S_{QX}, S_{QY})		=	0.057	N/mm^2
Max. Ultimate Bending Moment	Mu = max(Mxx, Myy, Mxy)		=	0.854	kNm/m
Depth of section		h	=	**150**	mm
Width of Section		b	=	**1000**	mm
Concrete Cover		cc	=	**75**	mm
Concrete Grade		f'_c	=	**28**	N/mm^2
Steel Reinforcement Grade		f_y	=	**400**	N/mm^2
Diameter of Reinforcement		dia	=	**12**	mm
Spacing of Reinforcement		S	=	**200**	mm

DESIGN FOR THICKNESS AND REINFORCEMENT

Strength reduction factor (ϕ)	Flexure		=	**0.9**	(Table 21.2.1 , ACI 318-14)
	Shear		=	**0.75**	(Table 21.2.1 , ACI 318-14)
Factor	Use $\beta 1$		=	**0.8500**	
where:	$\beta 1$	(if fc'≤ 28MPa)	=	0.85	
	$\beta 1$	(if fc'> 28MPa)	=	0.85 - 0.05/7(fc'-28)	
	$\beta 1$		>	0.65	

Design Moment	Muz/ϕ	=	0.95	kNm
Width considered	b	=	**1000**	mm
Effective Depth	(h-cc-dia-0.5dia) = d	=	69	mm
z assumed		=	least of 0.9*d or d - 0.5*a	
	0.9*d	=	62.1	mm
	a	=	As_{prov}*fy / (0.85*fc'*b)	
		=	9.504	mm
	d - 0.5*a =		64.248	mm
therefore, z assumed		=	62	mm
As reqd = M/fy*z		=	38	mm^2/m
Provided steel reinf. **DB 12-200**	$As_{prov.}$	=	**565**	mm^2 /m
		>	38	**Hence OK**

Minimum area of reinforcement in ver dir req.	=	0.0015 * b*D/2	(Table 11.6.1,ACI -318-14)
	=	113	mm^2/m
	<	565	mm^2/m
		Hence OK	
Minimum area of reinforcement in Hor dir req.	=	0.0025 * b*D/2	(Table 11.6.1,ACI -318-14)
	=	188	mm^2/m
	<	565	mm^2/m
		Hence OK	

Maximum area of reinforcement req.	As_{max}	=	0.75 * ρ_b * b * d	
	ρ_b	=	0.85 * $\beta 1$ * fc' * 600 / [fy * (600+fy)]	
		=	0.0303	
	As_{max}	=	1570	mm^2/m

As_{min} < $As_{prov.}$ < As_{max} **Hence OK**

CHECK FOR ONE-WAY SHEAR

Actual shear stress	Vu	=	0.057	N/mm^2
Strength reduction factor for Shear	ϕ_v	=	**0.75**	
	d	=	69	mm
Shear strength	ϕV_c	=	ϕ_v 0.17√ f'c	
	ϕV_c	=	0.67	N/mm^2

Shear force is less than Shear strength, O.K.

DESIGN OF MANHOLE _TYPE -3 & 4

7.3 DESIGN LOADS FOR MANHOLE-TYPE-3 & 4 (Upto 2.0m to 2.60 Depth)

7.3.1 DEAD LOAD

Self wt of structure will be generated by STAAD itself

Checkered Plate Cover (6mm thk) = 0.50 kN/m^2

7.3.2 LIVE LOAD

Live load on Cover = 5.00 kN/m^2

7.3.3 HYDRO LOAD

FULL CONDITION:

Height of wall	=	2.50	m
Max. water level inside, h_w max	=	2.30	m
Unit weight of water, γ_w	=	10.00	kN/m^3
Vertical Pressure on base slab	=	$\gamma_w \times h_{w1}$	
	=	23.000	kN/m^2

Lateral pressure due to water inside is applied on all the sides of the wall

Lateral pressure due to water on top of wall		=	$\gamma_w \times h_{w1}$	
where: h_{w1} =	0 m	=	0.000	kN/m^2
Lateral pressure due to water on bottom side wall		=	$\gamma_w \times h_{w2}$	
where: h_{w2} =	2.3 m	=	23.000	kN/m^2

The load is applied in STAAD as lateral load ranging from 0 kN/m^2 to 23.000 kN/m^2

UPLIFT CONDITION:

(ground water table at 1.50m)

Height of wall inside the Ground water table, h	=	1.25	m
Unit weight of water, γ_w	=	10.00	kN/m^3
Vertical Uplift Pressure on base slab	=	$\gamma_w \times h$	
	=	12.5	kN/m^2

7.3.4 EARTH PRESSURE LOAD

For calculating the earth pressure load on the side walls , it is assumed that the ground water table is at FGL conservatively.

Unit weight of soil	γ	=	18	kN/m^3
Angle of repose		=	30	ϕ
Unit weight of water	$\gamma\omega$	=	10	kN/m^3
Soil submerged density,	$\gamma's$	=	8	kN/m^3
coefficient for surcharge pressure	k_s	=	0.50	
Soil active pressure coefficient,	ka	=	0.33	

$ka = \tan^2(45 - ø/2)$ for ø =30deg

Ground water table	*hw*	=	1.50	m	from FGL
The height of wall below GL	h	=	2.50	m	
Depth of the base slab	D_{bs}	=	0.25	m	
Surcharge load,	q	=	10.00	kN/m^2	
Total Height of wall	H	=	2.50	m	

a. Active pressure due to ground water, qw = $\gamma\omega$ *(H)

= 12.50 kN/m^2

b. Active pressure due to submerged soil , *q's* = ka* γ's * (H)

= 3.3 kN/m^2

Total Lateral pressure due to submerged earth pressure = 15.8 kN/m^2

a. Load due to surcharge = k_s*q

= 5.0 kN/m^2

b. Active pressure due to dry soil , *qa =ka•g •(hw)* = 9.00 kN/m^2

c. Buoyancy force on sla *qp =* *=gw •(h)* = 12.50 kN/m^2

(In Staad Applied under as seperate load case)

7.3.5 SEISMIC EARTH PRESSURE LOAD

Mononobe-Okabe Method :

Dynamic active earth thrust Pdae = Kae x γ x H

Where Kae = seismic active earth pressure coefficient

$$Kae = \frac{\cos^2(\Phi-\Psi-\theta)}{\cos(\Psi)\cos^2(\theta)\cos(\delta+\theta+\Psi) \times \left[1+\left\{\frac{\sin(\Phi+\delta)\sin(\Phi-\Psi-\beta)}{\cos(\beta-\theta)\cos(\delta+\Psi+\theta)}\right\}^{0.5}\right]^2}$$

Where

ϕ =	Angle of internal friction	=	30	deg	
δ =	Angle of friction between soil and wall	=	0		(Ref. Bowles book)
Ψ =	$\tan^{-1}$ [k_h / (1-k_v)]				
k_h =	horizontal acceleration coefficient = 0.025g				
	g = gravitational accelaration =		9.810	m/s^2	
k_h =	0.24525				
k_v =	vertical acceleration coefficient	=	0.164		

Ψ = $\tan^{-1}$ [k_h / (1-k_v)] = 3.918

β = backfill slope angle = 20 deg

θ = angle of backface to the wall with the vertical = 0

(Uniform earth fill)

$$Kae = \frac{\cos^2(30-3.918-0)}{\cos(3.918\ \cos^2(0)\ \cos(0+0+3.918) \times \left[1+\left\{\left\{\frac{\sin(30+0)\ \sin(30-3.918-0)}{\cos(0-0)\cos(0+3.918+0)}\right\}\right\}\right]}$$

$$Kae = \frac{0.807}{0.995 \times 1.545}$$

Kae = 0.52461

Dynamic active earth thrust Pdae = Kae x γ x H

= 0.525 x 18 x 2.5

= 23.608 kN/m^2

Active Earth pressure Pae = Ka x γ x H

= 0.333 x 18 x 2.5

= 15.000 kN/m^2

Coefficient of active earth pressure is Ka = 0.33

Therefore, the dynamic increment, = Pdae - Pae

= 23.608 - 15

= 8.608 kN/m^2

Additional 8.608 kN/m^2 is applied on the trench walls as a dynamic increment due to earth pressure.

Vertical Seismic Effect (Section 12.4.2.2 of ASCE 7-10)

Ev = 0.2*S_{DS}*DL

SDS = 0.094

Ev = 0.0188 D

7.3.7 PRIMARY LOADS

LOAD 1	Earthquake Load (X)	SL+X
LOAD 2	Earthquake Load (Z)	SL+Z
LOAD 3	Vertical Seismic Effect	SL Y
LOAD 4	Soil Pressure	SP
LOAD 5	Fluid Load	FL
LOAD 6	Dead Load	DL
LOAD 7	Live Load	LL
LOAD 8	Uplift Load	UL

ii) **Service Loads**

LOAD COMB 11 DL+FL
LOAD COMB 12 DL+SP+FL+LL
LOAD COMB 13 DL+SP+0.75FL+0.75LL
LOAD COMB 14 DL+SP +0.70SL(+X)+0.70SL(-Y)
LOAD COMB 15 DL+SP -0.70SL(+X)+0.70SL(-Y)
LOAD COMB 16 DL+SP +0.70SL(+Z)+0.70SL(-Y)
LOAD COMB 17 DL+SP -0.70SL(-Z)+0.70SL(-Y)
LOAD COMB 18 DL+SP+FL+LL+0.70SL(+X)+0.70SL(-Y)
LOAD COMB 19 DL+SP+FL+LL-0.70SL(+X)+0.70SL(-Y)
LOAD COMB 20 DL+SP+FL+LL+0.70SL(+Z)+0.70SL(-Y)
LOAD COMB 21 DL+SP+FL+LL-0.70SL(+Z)+0.70SL(-Y)
LOAD COMB 21 0.60 DL+0.70SL+X-0.70SL(-Y)
LOAD COMB 22 0.60 DL-0.70SL+X-0.70SL(-Y)
LOAD COMB 23 0.60 DL+0.70SL+Z-0.70SL(-Y)
LOAD COMB 24 0.60 DL-0.70SL+Z-0.70SL(-Y)
LOAD COMB 25 DL+SP+FL+0.75LL+0.525SL(+X)+0.70SL(-Y)
LOAD COMB 26 DL+SP+FL+0.75LL-0.525SL(+X)+0.70SL(-Y)
LOAD COMB 27 DL+SP+FL+0.75LL+0.525SL(+Z)+0.70SL(-Y)
LOAD COMB 28 DL+SP+FL+0.75LL-0.525SL(+Z)+0.70SL(-Y)

UPLIFT CHECK

LOAD COMB 29 1.0DL+1.0FL+0.66UL
6 1.0 5 1.0 8 0.66

iii) **Ultimate Loads**

LOAD COMB 101 1.4DL+1.4 FL

LOAD COMB 102 1.2DL+1.6DASP+1.6SP+1.2FL+1.6LL

LOAD COMB 103 1.2DL+1.6DASP+1.6SP+1.0LL

LOAD COMB 104 1.2DL+DASP+SP+LL+1.0SL+X +1.0SL(-Y)

LOAD COMB 105 1.2DL+DASP+SP+LL-1.0SL+X +1.0SL(-Y)

LOAD COMB 106 1.2DL+DASP+SP+LL+1.0SL+Z +1.0SL(-Y)

LOAD COMB 107 1.2DL+DASP+SP+LL-1.0SL+Z +1.0SL(-Y)

LOAD COMB 108 0.9DL+1.6DASP+1.6SP+1.0SL+X+1.0SL(-Y)

LOAD COMB 109 0.9DL+1.6DASP+1.6SP-1.0SL+X+1.0SL(-Y)

LOAD COMB 110 0.9DL+1.6DASP+1.6SP+1.0SL+Z+1.0SL(-Y)

LOAD COMB 111 0.9DL+1.6DASP+1.6SP-1.0SL+Z+1.0SL(-Y)

LOAD COMB 112 1.2DL+DASP+SP+1.2FL+1.6LL+1.0SL+X +1.0SL(-Y)

LOAD COMB 113 1.2DL+DASP+SP+1.2FL+1.6LL-1.0SL+X +1.0SL(-Y)

LOAD COMB 114 1.2DL+DASP+SP+1.2FL+1.6LL+1.0SL+Z +1.0SL(-Y)

LOAD COMB 115 1.2DL+DASP+SP+1.2FL+1.6LL-1.0SL+Z +1.0SL(-Y)

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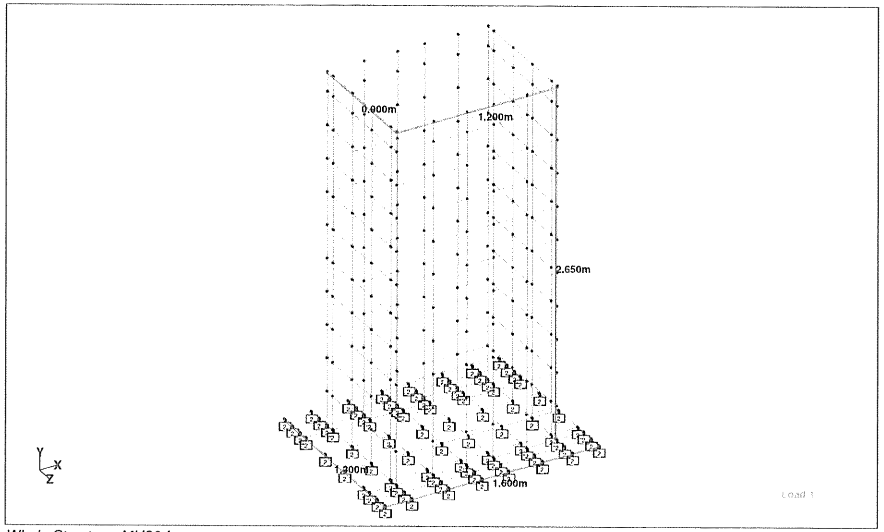
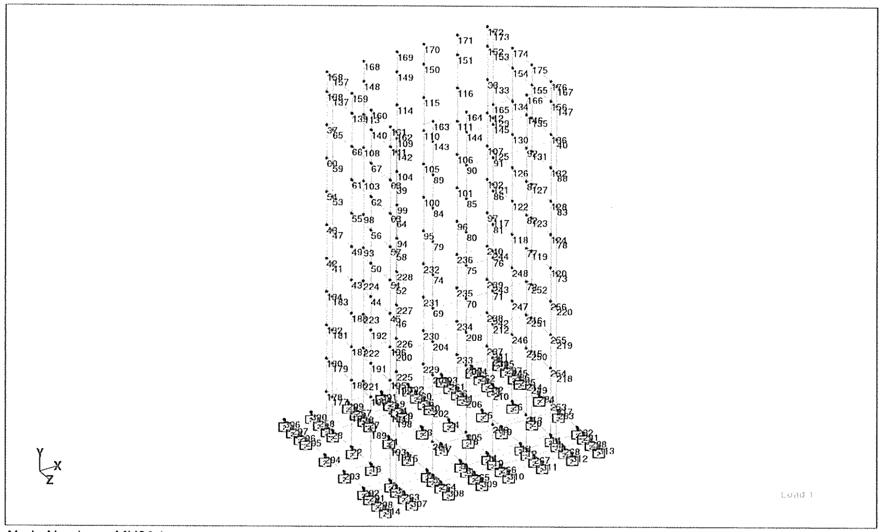
	Part Drain Manhole -3 & 4		
Job Title BCC-2 PROJECT	Ref		
	By Mohan	Date 5/11/2021	Chd Diana
Client BCC-2	File Manhole design-MH3_rev	Date/Time 19-May-2021 14:35	



Whole Structure_MH3&4



Node Numbers_MH3&4

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Client BCC-2	File Manhole design-MH3_rev	Date/Time 19-May-2021 14:35	

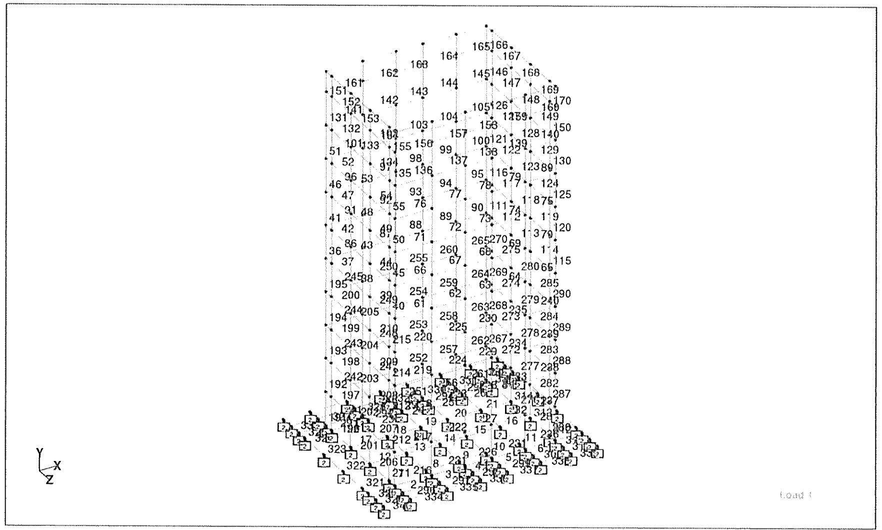

Plate Numbers_MH3&4

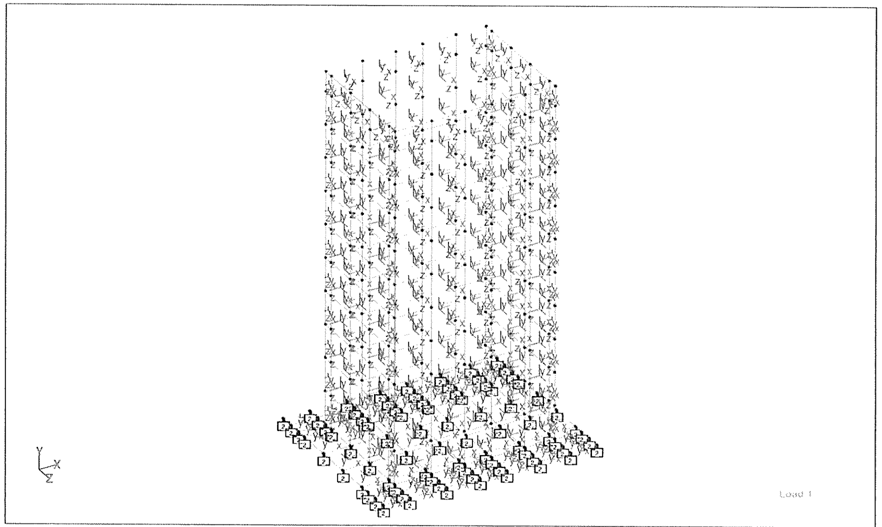

Plate Orientation_MH3&4

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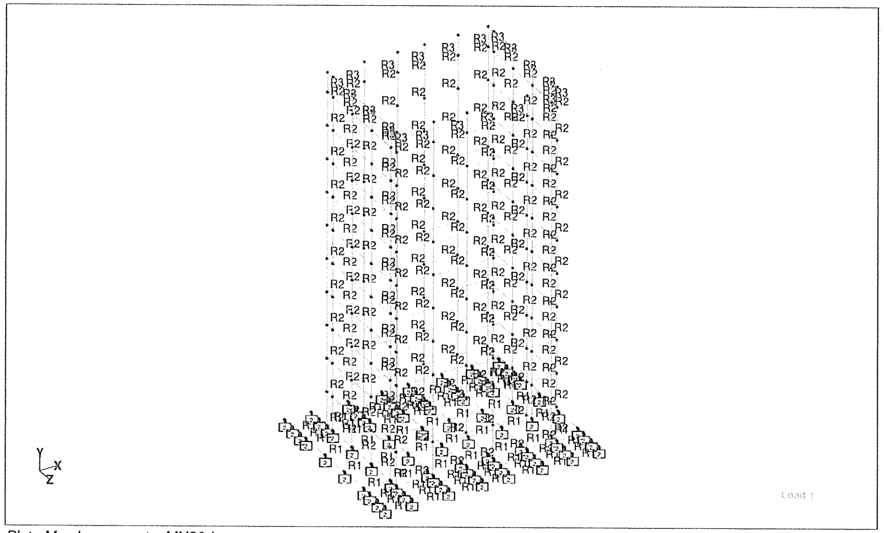
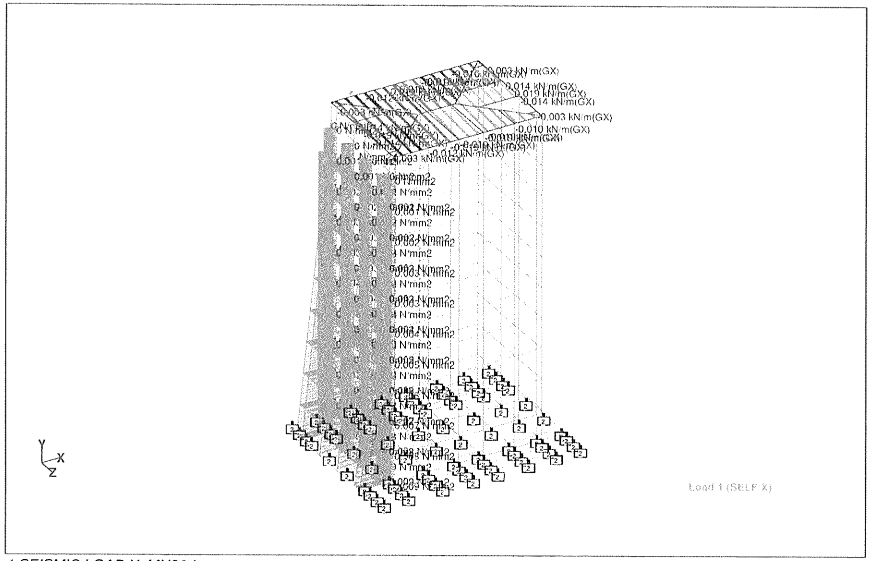


Plate Member property_MH3&4



1 SEISMIC LOAD X_MH3&4

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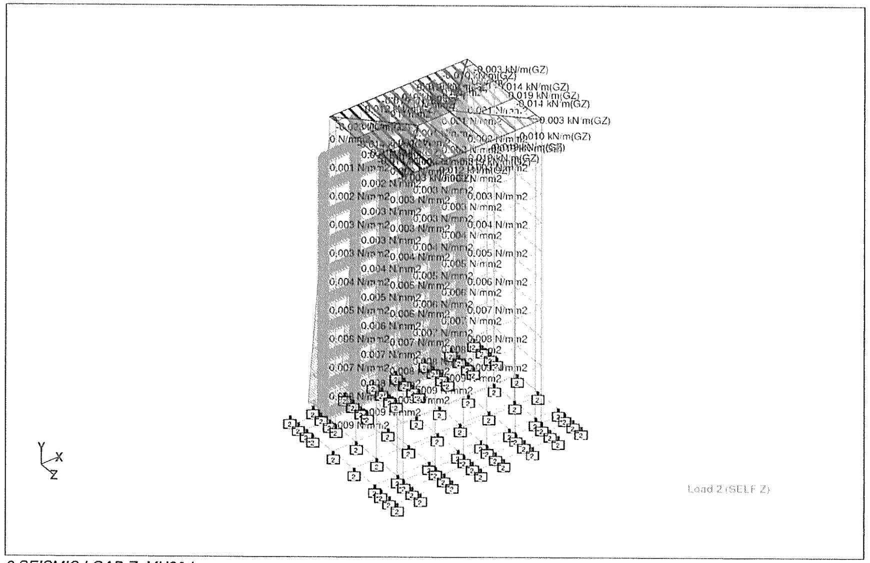
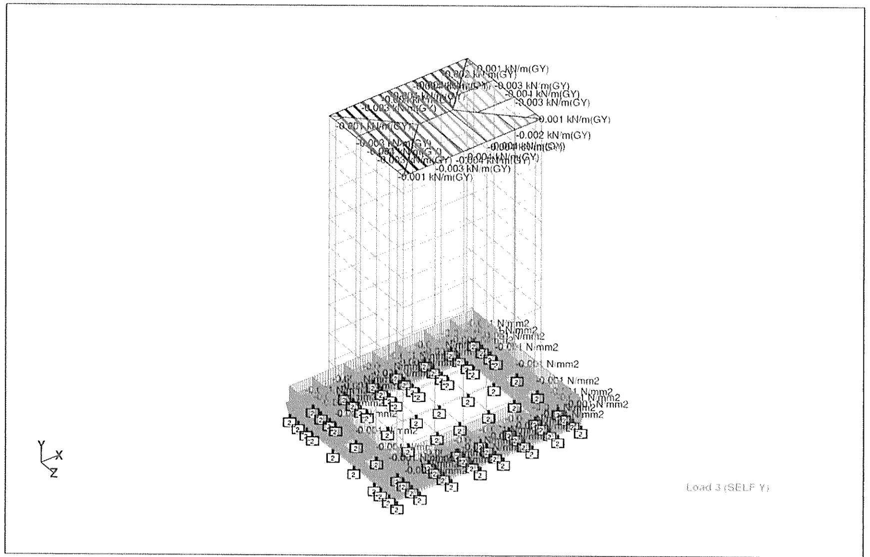


2 SEISMIC LOAD Z_MH3&4



3 SEISMIC LOAD -Y_MH3&4

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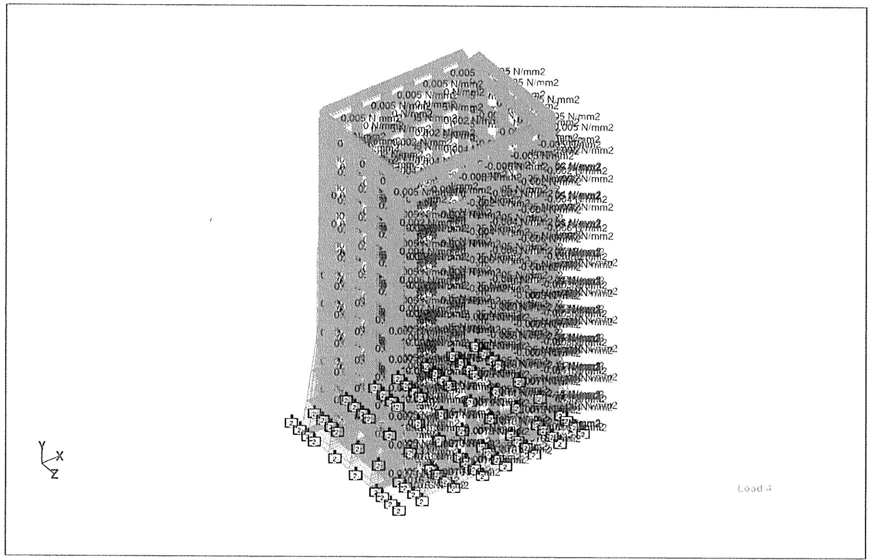
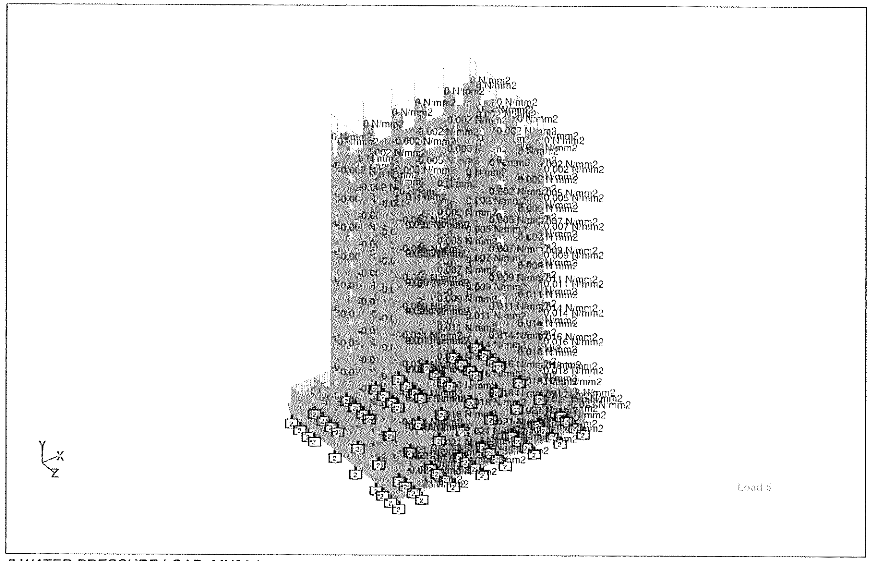
Client BCC-2	File Manhole design-MH3_rev	Date/Time 19-May-2021 14:35	



4 EARTH PRESSURE LOAD_MH3&4



5 WATER PRESSURE LOAD_MH3&4

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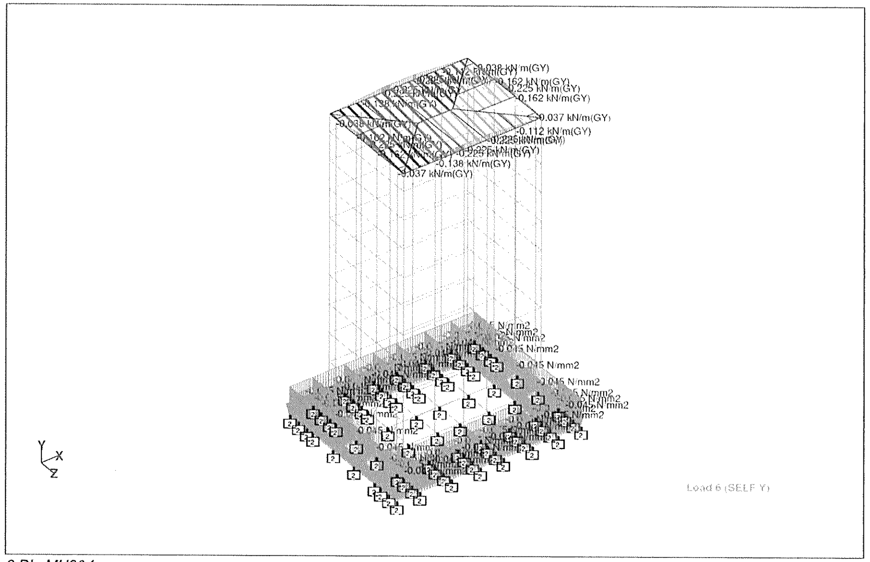
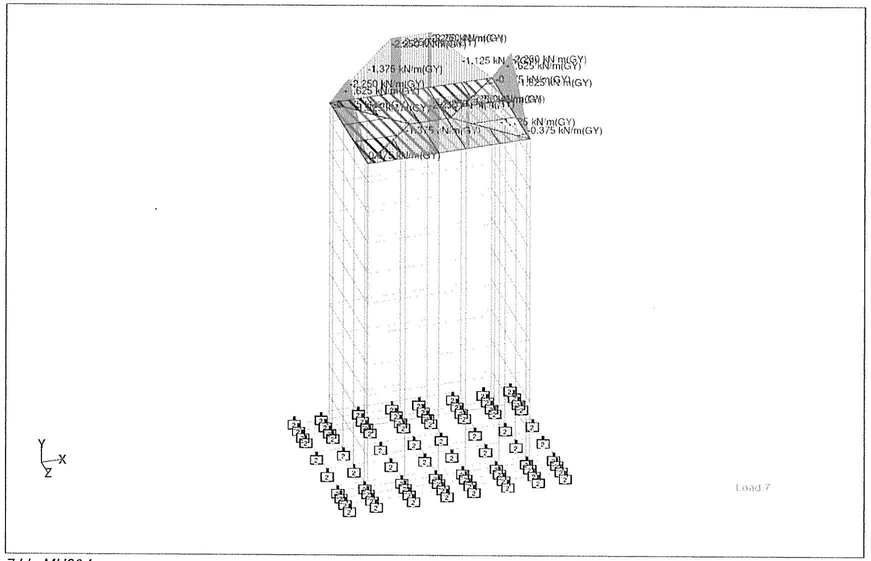


6 DL_MH3&4



7 LL_MH3&4

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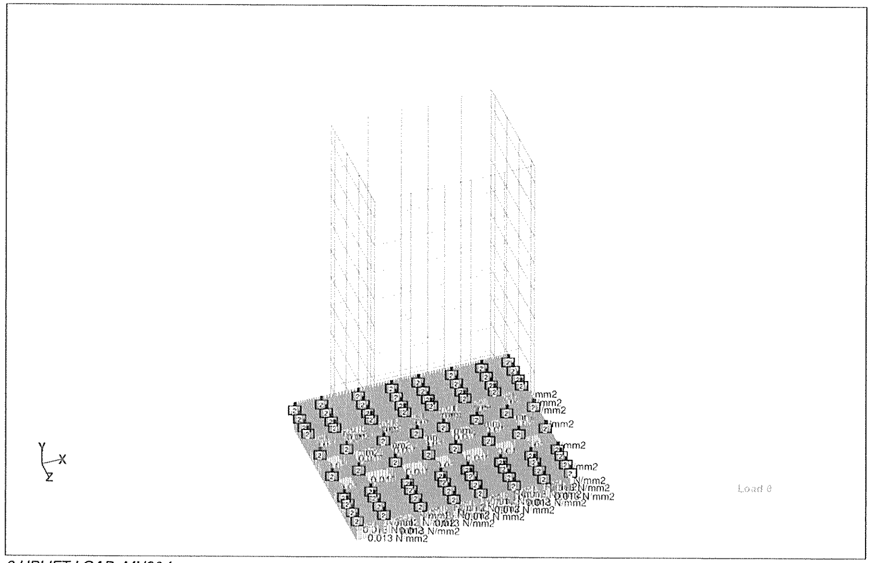

8 UPLIFT LOAD_MH3&4

7.3.8 CHECK FOR BASE PRESSURE

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	By Mohan	Date 5/11/2021	Chd Diana	
Client BCC-2	File Manhole design-MH3_rev	Date/Time 19-May-2021 13:15		

Base Pressure Summary

	Node	L/C	FX (N/mm^2)	FY (N/mm^2)	FZ (N/mm^2)
Max FX	1	101:1DL+1FL1	**0**	0.076	0
Min FX	1	101:1DL+1FL1	**0**	0.076	0
Max FY	305	111:DL+SP+IW	0	**0.097**	0
Min FY	301	114:0.60 DL+S	0	**0.007**	0
Max FZ	1	101:1DL+1FL1	0	0.076	**0**
Min FZ	1	101:1DL+1FL1	0	0.076	**0**

From the above Base Pressure Summary Table

Maximum Base pressure on foundation = 97.000 kN/m^2

< 100 kN/m^2

Minimum Base pressure on foundation = 7.000 kN/m^2

> 0 kN/m^2

Hence the base pressure on the foundation is with in the allowable bearing capacity of soil and there is no tension exist. Hence safe

7.3.9 DESIGN OF BASE SLAB -MH-3

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	Part Manhole Drain		
Job Title BCC-2 PROJECT	Ref		
	By Mohan	Date 5/11/2021	Chd Diana
Client BCC-2	File Manhole design-MH3_rev	Date/Time 12-May-2021 15:32	

Plate Center Stress Summary

			Shear		Membrane			Bending		
	Plate	L/C	Qx (N/mm^2)	Qy (N/mm^2)	Sx (N/mm^2)	Sy (N/mm^2)	Sxy (N/mm^2)	Mx (kN m/m)	My (kN m/m)	Mxy (kN m/m)
Max Qx	12	201:1.4DL+1.4	**0.053**	0.000	0	0	0	-0.030	1.099	-0.020
Min Qx	16	201:1.4DL+1.4	**-0.052**	-0.003	0	0	0	0.030	1.139	0.018
Max Qy	4	203:1.2DL+1.6	0.002	**0.082**	0	0	0	-0.022	-1.968	-0.069
Min Qy	24	203:1.2DL+1.6	0.001	**-0.087**	0	0	0	-0.100	-2.384	0.026
Max Sx	328	201:1.4DL+1.4	-0.006	0.002	**0**	0	0	0.127	0.014	-0.045
Min Sx	328	201:1.4DL+1.4	-0.006	0.002	**0**	0	0	0.127	0.014	-0.045
Max Sy	328	201:1.4DL+1.4	-0.006	0.002	0	**0**	0	0.127	0.014	-0.045
Min Sy	328	201:1.4DL+1.4	-0.006	0.002	0	**0**	0	0.127	0.014	-0.045
Max Sxy	328	201:1.4DL+1.4	-0.006	0.002	0	0	**0**	0.127	0.014	-0.045
Min Sxy	328	201:1.4DL+1.4	-0.006	0.002	0	0	**0**	0.127	0.014	-0.045
Max Mx	14	201:1.4DL+1.4	-0.001	-0.001	0	0	0	**1.655**	2.467	-0.007
Min Mx	12	208:0.9DL+1.6	0.033	-0.000	0	0	0	**-0.668**	0.064	0.034
Max My	14	201:1.4DL+1.4	-0.001	-0.001	0	0	0	1.655	**2.467**	-0.007
Min My	24	203:1.2DL+1.6	0.001	-0.087	0	0	0	-0.100	**-2.384**	0.026
Max Mxy	22	201:1.4DL+1.4	0.004	-0.024	0	0	0	0.174	0.183	**0.534**
Min Mxy	2	201:1.4DL+1.4	0.006	0.021	0	0	0	0.133	0.287	**-0.556**

DESIGN FOR BENDING MOMENT

Maximum Moment in X-Dir		Mxx	=	**1.591**	kNm/m
Mxx = |Max Mx| + |Mxy| =	1.590 + 0.001				
Maximum Moment in Y-Dir		Myy	=	**2.250**	kNm/m
Myy = |Max My| + |Mxy| =	2.250 + 0.000				
Maximum Moment in XY-Dir		Mxy	=	**0.814**	kNm/m
Mxy = |Max Mxy| + |Mx or My| =	0.557 + 0.257				
Maximum Shear Stress in X-Dir		S_{QX}	=	**0.049**	N/mm^2
Maximum Shear Stress in Y-Dir		S_{Qy}	=	**0.079**	N/mm^2
Max. Ultimate Shear Stress		Vu = max (S_{QX}, S_{QY})	=	0.079	N/mm^2
Max. Ultimate Bending Moment		Mu = max(Mxx, Myy, Mxy)	=	2.250	kNm/m
Depth of section		h	=	**250**	mm
Width of Section		b	=	**1000**	mm
Concrete Cover		cc	=	**75**	mm
Concrete Grade		f'_c	=	**28**	N/mm^2
Steel Reinforcement Grade		f_y	=	**400**	N/mm^2
Diameter of Reinforcement		dia	=	**12**	mm
Spacing of Reinforcement		S	=	**200**	mm

DESIGN FOR THICKNESS AND REINFORCEMENT

Strength reduction factor (ϕ)	Flexure		=	**0.9**	(Table 21.2.1 , ACI 318-14)
	Shear		=	**0.75**	(Table 21.2.1 , ACI 318-14)
Factor	Use $\beta1$		=	**0.8500**	
where:	$\beta1$	(if fc'≤ 28MPa)	=	0.85	
	$\beta1$	(if fc'> 28MPa)	=	0.85	- 0.05/7(fc'-28)
	$\beta1$		>	0.65	

Design Moment		Muz/ϕ	=	2.50	kNm
Width considered		b	=	**1000**	mm
Effective Depth		(h-cc-dia-0.5dia) = d	=	157	mm
z assumed			=	least of 0.9*d or d - 0.5*a	
		0.9*d	=	141.3	mm
		a	=	As_{prov}*fy / (0.85*fc'*b)	
			=	9.504	mm
		d - 0.5*a =		152.248	mm
therefore, z assumed			=	141	mm
As reqd = M/fy*z			=	44	mm^2/m
Provided steel reinf.	**DB 12-200**	$As_{prov.}$	=	**565**	mm^2 /m
			>	44	**Hence OK**
Minimum area of reinforcement req.		As_{min}	=	0.002 * b * d	(7.6.1.1,ACI 318-14)
			=	500	mm^2/m
Maximum area of reinforcement req.		As_{max}	=	0.75 * ρ_b * b * d	
		ρ_b	=	0.85 * $\beta1$ * fc' * 600 / [fy * (600+fy)]	
			=	0.0303	
		As_{max}	=	3573	mm^2/m

As_{min} < $As_{prov.}$ < As_{max} **Hence OK**

CHECK FOR ONE-WAY SHEAR

Actual shear stress	Vu	=	0.079	N/mm^2
Strength reduction factor for Shear	ϕ_v	=	**0.75**	
	d	=	157	mm
Shear strength	ϕV_c	=	ϕ_v 0.17$\sqrt{f'c}$	
	ϕV_c	=	0.67	N/mm^2

Shear force is less than Shear strength, O.K.

7.3 DESIGN OF WALL _MH-3

Software licensed to Jurong Engineering Limited CONNECTED User: kalyani rajmohan	Job No 20054	Sheet No 1		Rev A
	Part Drain Manhole -3 & 4			
Job Title BCC-2 PROJECT	Ref			
	By Mohan	Date 5/11/2021	Chd Diana	
Client BCC-2	File Manhole design-MH3_rev	Date/Time 19-May-2021 14:35		

Plate Center Stress Summary

			Shear		Membrane			Bending		
	Plate	L/C	Qx (N/mm²)	Qy (N/mm²)	Sx (N/mm²)	Sy (N/mm²)	Sxy (N/mm²)	Mx (kN·m/m)	My (kN·m/m)	Mxy (kN·m/m)
Max Qx	213	208:0.9DL+1.6	**0.081865**	-0.002	-0.094	-0.037	0.014	2.028	0.185	0.026
Min Qx	264	210:0.9DL+1.6	**-0.083**	-0.006	-0.074	-0.023	0.01393	-1.141	0.074	0.101
Max Qy	251	210:0.9DL+1.6	0.000	**0.093**	-0.017	-0.034	-0.001	0.125	-1.732	0.054
Min Qy	226	211:0.9DL+1.6:	-0.000	**-0.078**	-0.016	-0.033	-0.001	-0.074	1.544	-0.042
Max Sx	278	201:1.4DL+1.4	-0.000	0.007	**0.079**	-0.073	0.000	-0.428	-0.220	-0.000
Min Sx	268	210:0.9DL+1.6	0.073	0.004	**-0.108**	-0.033	0.017	-2.217	-0.253	0.099
Max Sy	286	215:1.2DL+SP	0.007	0.013124	0.026	**0.039**	-0.037	0.051528	-0.444	-0.003
Min Sy	226	214:1.2DL+SP	-0.000	-0.009	-0.009	**-0.164**	-0.002	0.106	0.429	0.008
Max Sxy	241	208:0.9DL+1.6	0.011	0.014	-0.016	-0.013	**0.041**	-0.349	-0.606	-0.343
Min Sxy	207	215:1.2DL+SP	-0.004	-0.005	0.019	-0.043	**-0.041**	-0.025	0.098	-0.028
Max Mx	194	210:0.9DL+1.6	-0.069	-0.005	-0.108	-0.033	0.016	**2.418**	0.385	-0.069
Min Mx	269	210:0.9DL+1.6	0.069	0.005	-0.108	-0.033	0.016	**-2.429**	-0.387	0.067
Max My	226	211:0.9DL+1.6:	-0.000	-0.078	-0.016	-0.033	-0.001	-0.074	**1.544**	-0.042
Min My	251	210:0.9DL+1.6	0.000	0.093	-0.017	-0.034	-0.001	0.125	**-1.732**	0.054
Max Mxy	257	210:0.9DL+1.6	-0.023	0.027993	-0.047	-0.013	-0.008	0.807	0.491	**0.582**
Min Mxy	242	210:0.9DL+1.6	0.053	-0.006	-0.061	-0.009	0.000	-0.622	0.057	**-0.561**

3.6.1 DESIGN FOR BENDING MOMENT

Maximum Moment in X-Dir		Mxx	=	**2.497**	kNm/m
Mxx = |Max Mx| + |Mxy| =	2.430 + 0.067				
Maximum Moment in Y-Dir		Myy	=	**1.787**	kNm/m
Myy = |Max My| + |Mxy| =	1.733 + 0.054				
Maximum Moment in XY-Dir		Mxy	=	**1.389**	kNm/m
Mxy = |Max Mxy| + |Mx or My| =	0.582 + 0.807				
Maximum Shear Stress in X-Dir		S_{QX}	=	**0.083**	N/mm^2
Maximum Shear Stress in Y-Dir		S_{Qy}	=	**0.093**	N/mm^2
Max. Ultimate Shear Stress	Vu = max (S_{QX}, S_{QY})		=	0.093	N/mm^2
Max. Ultimate Bending Moment	Mu = max(Mxx, Myy, Mxy)		=	2.497	kNm/m
Depth of section		h	=	**200**	mm
Width of Section		b	=	**1000**	mm
Concrete Cover		cc	=	**75**	mm
Concrete Grade		f'_c	=	**28**	N/mm^2
Steel Reinforcement Grade		f_y	=	**400**	N/mm^2
Diameter of Reinforcement		dia	=	**12**	mm
Spacing of Reinforcement		S	=	**200**	mm

DESIGN FOR THICKNESS AND REINFORCEMENT

Strength reduction factor (ϕ)	Flexure		=	**0.9**	(Table 21.2.1 , ACI 318-14)
	Shear		=	**0.75**	(Table 21.2.1 , ACI 318-14)
Factor	Use β_1		=	**0.8500**	
where:	β_1	(if fc'≤ 28MPa)	=	0.85	
	β_1	(if fc'> 28MPa)	=	0.85 - 0.05/7(fc'-28)	
	β_1		>	0.65	

Design Moment	Muz/ϕ	=	2.77	kNm
Width considered	b	=	**1000**	mm
Effective Depth	(h-cc-0.5dia) = d	=	119	mm
z assumed		=	least of 0.9*d or d - 0.5*a	
	0.9*d	=	107.1	mm
	a	=	As_{prov}*fy / (0.85*fc'*b)	
		=	9.504	mm
	d - 0.5*a =		114.248	mm
therefore, z assumed		=	107	mm
As reqd = M/fy*z		=	65	mm^2/m
Provided steel reinf. **DB 12-200**	$As_{prov.}$	=	**565**	mm^2 /m
		>	65	**Hence OK**

Minimum area of reinforcement in ver dir req.	=	0.0015 * b*D	(Table 11.6.1,ACI -318-14)
	=	300	mm^2/m
	<	565	mm^2/m
		Hence OK	
Minimum area of reinforcement in Hor dir req.	=	0.0025 * b*D	(Table 11.6.1,ACI -318-14)
	=	500	mm^2/m
	<	565	mm^2/m
		Hence OK	

Maximum area of reinforcement req.	As_{max}	=	0.75 * ρ_b * b * d	
	ρ_b	=	0.85 * β_1 * fc' * 600 / [fy * (600+fy)]	
		=	0.0303	
	As_{max}	=	2708	mm^2/m

As_{min} < $As_{prov.}$ < As_{max} **Hence OK**

CHECK FOR ONE-WAY SHEAR

Actual shear stress	Vu	=	0.093	N/mm^2
Strength reduction factor for Shear	ϕ_v	=	**0.75**	
	d	=	119	mm
Shear strength	ϕV_c	=	$\phi_v\ 0.17\sqrt{f'c}$	
	ϕV_c	=	0.67	N/mm^2

Shear force is less than Shear strength, O.K.