Appendix B-11

Civil Structure Calculation

CONTENTS

1. General

1.1 Structure character

1) 9 structures are dealt in this structure calculation.(Refer to the contents)
2) 9 structures are basically the water container except for the blower platform and pile foundation.
3) Structure element and finish specificaton.
   Refer to each sub-section.
4) The structures are in-situ reinforced concrete.

1.2 Design principle.

1) Limit state design.
   Two types of limit state analysis were conducted.
   a. Ultimate strength analysis
   b. Serviceability limit state analysis- crack width
      Crack width of 0.2mm was set as an allowable value for the condition.

2) Dead Load, Live Load shall be taken into consideration in the calculation.
   Snow Load (Sn.L)is assumed as 100 kgf/cm2, but this note dose not use (Sn.L), because
   Roof Live Load 100 kgf/cm2 covers enough for (Sn.L).

3) Seismic force
   Seismic force is not included in the external forces because Astana city is located in the no seismic area.

4) Up-lift
   Upward thrust against the structure by ground water was examined.

2. Grit Chamber

2.1Material and Allowable stress

TABLE 2.1 Allowable Stress (N/mm2, kg /cm2)

Item		Serviceability strength			Ultimate strength		
		Compression	Tension	Shear	Compression	Tension	Shear
Concrete	B30	10		0.8	30		1.2
		100	-------	8	300	-------	12
Steel Bar Round Bar	A- I	157.0	157.0	157.0	235.4	235.4	235.4
		1600	1600	1600	2400	2400	2400
Steel Bar Deformed Bar	A- II	196.2	196.2	196.2	358.1	358.1	358.1
		2000	2000	2000	3650	3650	3650

upper: SI units N/mm2

lower: MKS units kg/cm2

TABLE 2.2 Allowable Bonding Stress of Steel Bar to Concrete (N/mm2, kg /cm2)

Item	Serviceability strength		Remarks
	Top bars	Other bars	
ϕ6,ϕ9,ϕ12	0.9	1.3	
	9	13.5	
D10,D13,D16 D19,D22,D25,D29	1.6	2.4	
	16.2	24.3	

upper: SI units N/mm2

lower: MKS units kg/cm2

2.2 Load Table

TABLE 2.3 Dead Load

Loc.	item	thickness	kg/m2	total kg/m2	Remarks
Roof	Mortar	4cm	80		
	Concrete slab	15cm	360		
	Ceiling		25	465	<-------- MKS UNIT
				4562	<-------- SI UNIT
Common slab	Leveling motar	-	-		
	Concrete slab	20cm	500		
				500	<-------- MKS UNIT
				4905	<-------- SI UNIT

TABLE 2.4 Live Load and Floor Load

kg/m2 (Girder, Sub beam : Self weight not included)

Loc.	load type	slab	beam	girder	Remarks	
Roof	Dead Load	465.0	465.0	465.0		
	Live Load	100.0	100.0	100.0	Including snow 25cm depth	
	Total Load	565.0	565.0	565.0		
	SI unit	5543	5543	5543		<-------- SI UNIT
Machin room	Dead Load	500.0	500.0	500.0		
	Live Load	500.0	400.0	400.0		** add Machine load
	Total Load	1000.0	900.0	900.0		
	SI unit	9810	8829	8829		<-------- SI UNIT
Other floor	Dead Load	500.0	500.0	500.0		
	Live Load	300.0	250.0	200.0		
	Total Load	800.0	750.0	700.0		
	SI unit	7848	7358	6867		<-------- SI UNIT

2.3 Facility weight

Table2.5 Grit Chamber Weight

Story	Load type	Unit w (kN/m2,m)	width /hight (m) or unit	Length (m)	Area or L (m2), (m)	Weight (kN)	Small Total (t)	S Wi (t)
	Roof slab	5.54	8	11.50	92.00	509.92		
	Machine rm	8.83	8	11.50	92.00	812.27		
	Other floor 1	6.87	8	4.30	34.40	236.22		
	Other floor 2	6.87	4.4	6.00	26.40	181.29		
	Other floor 3	6.87	8	6.80	54.40	373.56		
1st story	Girder 11.5m	3.92	4	11.50	46.00	180.50		
	Girder 8m	3.92	4	8.00	32.00	125.57		
	Machine	(Included in the floor load)						
	Brick wall 3.5m	8.65	3.5	39.00	136.50	1181.06		
	Wall.1 6.3m	9.81	6.3	23.00	144.90	1421.47		
	Wall 2 1.4m	9.81	1.4	18.00	25.20	247.21		
	Wall 3 3.8m	9.81	3.8	23.10	87.78	861.12		
	Circle 1 7.3m	9.81	2.5	45.87	114.68	1125.04		
	Circle 2 1.85m	9.81	2.2	11.63	25.58	250.90		
	Water 1	9.81	4.43	3.50	15.51	152.10		
	Water 2	9.81	0.72	3.40	2.45	24.01		
	Water 3	9.81	3.6		41.85	1478.11		
	Water 4	9.81	5		2.69	131.85		
	Water 5	9.81	3	6.80	20.40	200.12		
							9492.35	9492.35
	t300 Base 1	7.36	4.4	6.00	26.40	194.24		
	t300 Base 2	7.36	2	45.36	90.73	667.54		
	t500 Base 1	12.26	8.4	3.90	32.76	401.72		
	t500 Base 2	12.26	2	5.52	11.03	135.27		
Base	t500 Base 3	12.26	7	8.40	58.80	721.04		
								(kN)
				Σ	219.72	(m2)	2119.80	11612.15

Base Area **219.72** **(m2)** **Total W=** **11,612.15**

W−Base= **9,492.3**

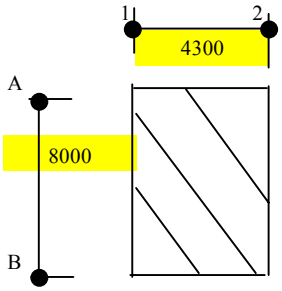
soil reaction =W/(Base area)= **52.850** (kN/m2)

Foundation's design force= **45.492** (kN/m2)

2.4 FOUNDATION

1) Inlet chamber

Load condition



		Area		unit weight	kN
Floor slab=		34.40	x	7848.0=	269.97
Wall=		144.90	x	9.8=	1.42
				Σ =	271.4
		Soil reaction load=		7.89	kN/m2
lx=	4.3 m				
ly=	8 m			t(cm)=	50
λ =	1.86			d(cm)=	39
A=	34.4 m2			cover(cm)=	11

	a	wlx2(kNm2)	M(Nm)	Additional M from wall	Total M	at= M/(σ sjd)	re-bars	
Mx1=	0.078	145.87	11,378.1	194,680	206,058	30.776 cm2	bottom 9-D20-->D20@100	31.40cm2
Mx2=	0.052	145.87	7,585.4			0.982 cm2	upper 2-D10-->D10@200	3.93cm2
								0.9%
My1=	0.042	145.87	6,126.7	194,680	200,807	29.992 cm2	bottom 9-D20-->D20@100	31.40cm2
My2=	0.028	145.87	4,084.5			0.529 cm2	upper 2-D10-->D10@200	3.93cm2
		wlx	Q(N)			ϕ=Q/(τa jd)		0.9%
Qx =	0.52	33.92	17,640.5			2.17 cm <	62.8 ok	
Qy =	0.46	33.92	15,605.1			1.92 cm <	62.8 ok	

Suffix 1: end of span

Suffix 2: middle of span

From nomogram of two-way slab

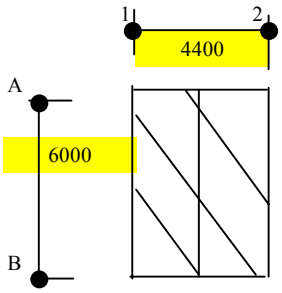
Q cap

306,072 N > Q ok

306,072 N > Q ok

2) Water channel

Load condition



		Area		unit weight	kN
Floor slab=		26.40	x	7848.0=	207.19
Wall=		25.20	x	9.8=	0.25
				Σ =	207.4
		Soil reaction load=		7.86	kN/m2
lx=	4.4 m				
ly=	6 m			t(cm)=	30
λ =	1.36			d(cm)=	19
A=	26.4 m2			cover(cm)=	11

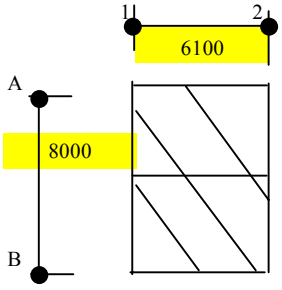
	a	wlx2(kNm2)	M(Nm)	Additional M from wall	Total M	at= M/(σ sjd)	re-bars	
Mx1=	0.07	152.12	10,648.3		10,648	3.265 cm2	bottom 2-D10-->D10@200	3.93cm2
Mx2=	0.03	152.12	4,563.6			1.399 cm2	upper 2-D10-->D10@200	3.93cm2
								0.4%
My1=	0.042	152.12	6,389.0		6,389	1.959 cm2	bottom 2-D10-->D10@200	3.93cm2
My2=	0.028	152.12	4,259.3			1.306 cm2	upper 2-D10-->D10@200	3.93cm2
		wlx	Q(N)			ϕ=Q/(τa jd)		0.4%
Qx =	0.51	34.57	17,631.9			4.45 cm <	15.7 ok	
Qy =	0.46	34.57	15,903.3			4.01 cm <	15.7 ok	

Suffix 1: end of span
Suffix 2: middle of span
From nomogram of two-way slab

Q cap
149,112 N > Q ok
149,112 N > Q ok

3) Outlet chamber

Load condition



		Area		unit weight	kN
Floor slab=		54.40	x	7848.0=	426.93
Wall=		87.78	x	9.8=	0.86
				Σ =	427.8
		Soil reaction load=		8.77	kN/m2
lx=	6.1 m				
ly=	8 m			t(cm)=	50
λ =	1.31			d(cm)=	39
A=	48.8 m2			cover(cm)=	11

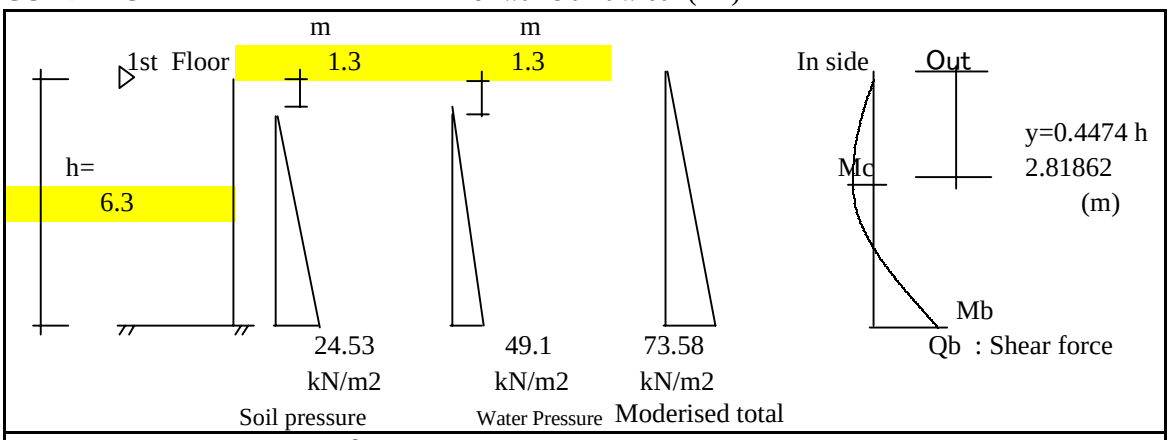
	a	wlx2(kNm2)	M(Nm)	Additional M from wall	Total M	at= M/(σ sjd)	re-bars	
Mx1=	0.068	326.19	22,181.0	62,784	84,965	12.690 cm2	bottom 5-D18-->D18@200	12.70cm2
Mx2=	0.028	326.19	9,133.4			1.364 cm2	upper 2-D10-->D10@200	3.93cm2
								0.4%
My1=	0.042	326.19	13,700.0	62,784	76,484	11.424 cm2	bottom 5-D18-->D18@200	12.70cm2
My2=	0.028	326.19	9,133.4			1.364 cm2	upper 2-D10-->D10@200	3.93cm2
		wlx	Q(N)			ϕ=Q/(τa jd)		0.4%
Qx =	0.5	53.47	26,737.0			3.29 cm <	28.26 ok	
Qy =	0.46	53.47	24,598.1			3.02 cm <	28.26 ok	

Suffix 1: end of span
Suffix 2: middle of span
From nomogram of two-way slab

Q cap
306,072 N > Q ok
306,072 N > Q ok

2.5Grit chamber wall W2-1 (1/4)

LOAD CONDITION For wall's unit width (1m)



Soil pressure	p= Ka γ h			
Ka :	0.5			
γ = :	2	Soil specific weight		
γ '= :	1	Soil specific weight in water		
Soil pressure				
ps= 0.50 x 2.0 x 0 + 0.50 x 1.0 x 5=		2.5	t/m2 --->	24.53 kN/m2
pw= 1 x 5x 9.81=		49.1	kN/m2	

BENDING MOMENT and SHEAR FORCE

For wall's unit width

Mc= 0.06 W h =	87.61	kNm	W=721.77×6.3/2	231.8 kN
Mb= - 2/15 W h =	-194.68	kNm		
Qb= 4/5 W=	185.41	kN		

Wall Profile

	external		inner				
Wall thickness t :	40	cm	re-bar inside				
d :	32	cm	35	cm			
j= 7/8 d :	0.280	m	0.306	m			
Re bar ft :	200	N/mm2	200	N/mm2			
	(196.2≒200)						
at = Mc/(ft x j) =	14.30	cm2/ (m w	5—	D20	15.71	cm2	
at = Mb/(ft x j) =	34.76	cm2/ (m w	10—	D25	49.09	cm2	
					w Mc=	0.49	%
					w Mb=	1.53	%

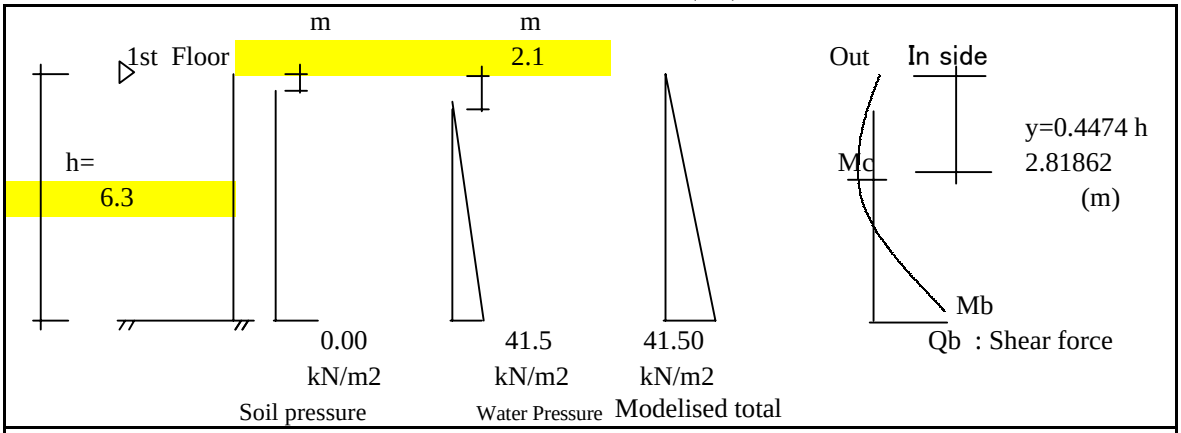
Wall Shear Stress

Wall thickness t :	40	cm		
d :	32	cm		
j= 7/8 d :	0.280	m		
Width Wa :	100	cm		
Qb :	185.41	kN		
Shear stress= Qb/(Wa j)=	0.66	N/mm2 <	0.8	N/mm2

Bottom profile

slab thickness t :	50	cm					
d :	39	cm					
j= 7/8 d :	0.341	m					
Re bar ft :	200	N/mm2					
at = Mb/(ft x j) =	28.52	cm2/ (m w	10—	D22	38.01	cm2	
					w Mc=	0.97	%

LOAD CONDITION For wall's unit width (1m)



Soil pressure	p= Ka γ h			
Ka :	0.5			
γ = :	2	Soil specific weight		
γ '= :	1	Soil specific weight in water		
Soil pressure				
ps= 0		0	t/m2 --->	0.00 kN/m2
pw= 1 x 4.23x9.81=		41.5	kN/m2	

BENDING MOMENT and SHEAR FORCE

For wall's unit width

Mc= 0.06 W h =	49.41	kNm	W= 6.3 x407.08/2	130.7 kN
Mb= - 2/15 W h =	-109.80	kNm		
Qb= 4/5 W=	104.57	kN		

Wall Profile

	external		inner				
Wall thickness t :	40	cm	re-bar inside				
d :	32	cm	35				
j= 7/8 d :	0.280	m	0.30625	m			
Re bar ft :	200	N/mm2	200	N/mm2			
at = Mc/(ft x j) =	8.07	cm2/ (m w	5—	D22	19.01	cm2	
at = Mb/(ft x j) =	19.61	cm2/ (m w	10—	D20	31.42	cm2	
				w Mc=	0.59	%	
				w Mb=	0.98	%	

Wall Shear Stress

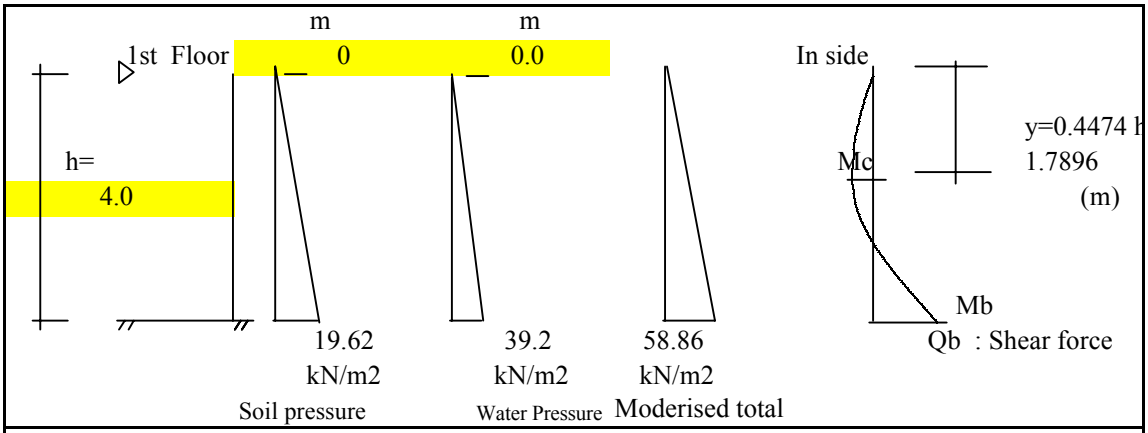
Wall thickness t :	40	cm		
d :	32	cm		
j= 7/8 d :	0.280	m		
Width Wa :	100	cm		
Qb :	104.57	kN		
Shear stress= Qb/(Wa j)=	0.37	N/mm2 <	0.8	N/mm2

Bottom profile

slab thickness t :	50	cm					
d :	39	cm					
j= 7/8 d :	0.341	m					
Re bar ft :	200	N/mm2					
at = Mb/(ft x j) =	16.09	cm2/ (m w	10—	D22	38.01	cm2	
				w Mc=	0.97	%	

W2-3 (3/4)

LOAD CONDITION For wall's unit width (1m)



Soil pressure	p= Ka γ h			
Ka :	0.5			
γ = :	2	Soil specific weight		
γ '= :	1	Soil specific weight in water		
Soil pressure				
ps= 0.50 x2.0 x 0.0 + 0.50 x 1.0 x 4=		2	t/m2 --->	19.62 kN/m2
pw= 1 x 4 x 9.81=		39.2	kN/m2	

BENDING MOMENT and SHEAR FORCE

For wall's unit width				
Mc= 0.06 W h =	28.25	kNm	W= 4.0x58.86/2=	117.7 kN
Mb= - 2/15 W h =	-62.78	kNm		
Qb= 4/5 W=	94.18	kN		

Wall Profile

	external		inner			
Wall thickness t :	40	cm	re-bar inside			
d :	32	cm	35			
j= 7/8 d :	0.280	m	0.30625	m		
Re bar ft :	200	N/mm2	200	N/mm2		
at = Mc/(ft x j) =	4.61	cm2/ (m w	5－	D14	7.70	cm2
at = Mb/(ft x j) =	11.21	cm2/ (m w	10－	D14	15.39	cm2

w Mc= 0.24 %

w Mb= 0.48 %

Wall Shear Stress

Wall thickness t :	40	cm		
d :	32	cm		
j= 7/8 d :	0.280	m		
Width Wa :	100	cm		
Qb :	94.18	kN		
Shear stress= Qb/(Wa j)=	0.34	N/mm2 <	0.8	N/mm2

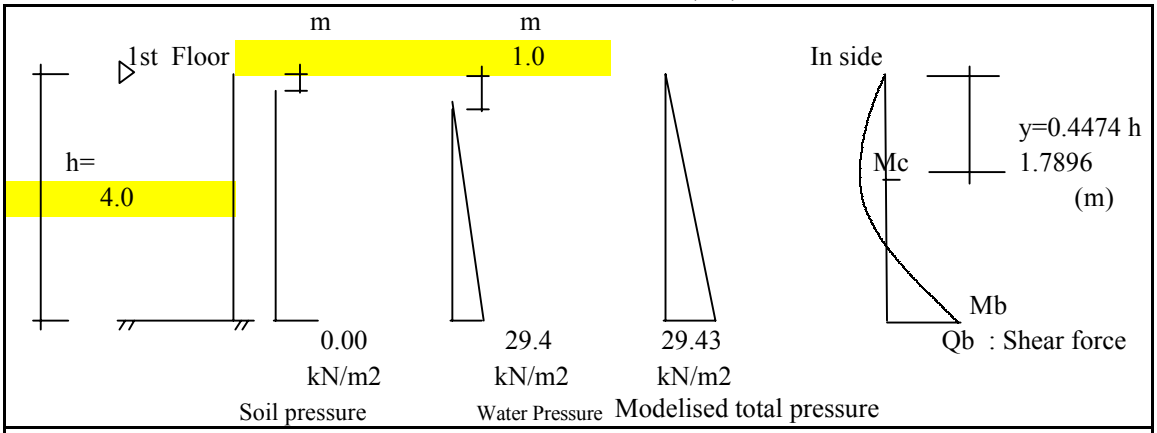
Bottom profile

slab thickness t :	50	cm				
d :	39	cm				
j= 7/8 d :	0.341	m				
Re bar ft :	200	N/mm2				
at = Mb/(ft x j) =	9.20	cm2/ (m w	10－	D22	38.01	cm2

w Mc= 0.97 %

W2-4 (4/4)

LOAD CONDITION For wall's unit width (1m)



Soil pressure	p= Ka γ h			
Ka :	0.5			
γ = :	2	Soil specific weight		
γ '= :	1	Soil specific weight in water		
Soil pressure				
ps= 0		0	t/m2 --->	0.00 kN/m2
pw= 1 x 3x 9.81=		29.4	kN/m2	

BENDING MOMENT and SHEAR FORCE

For wall's unit width

Mc= 0.06 W h =	14.13 kNm	W= 4.0x29.43/2=	58.9 kN
Mb= - 2/15 W h =	-31.39 kNm		
Qb= 4/5 W=	47.09 kN		

Wall Profile

	external	inner
Wall thickness t :	40 cm	re-bar inside
d :	32 cm	35
j= 7/8 d :	0.280 m	0.30625 m
Re bar ft :	200 N/mm2	200 N/mm2

at = Mc/(ft x j) =	2.31 cm2/ (m width	5—	D14	7.70	cm2
at = Mb/(ft x j) =	5.61 cm2/ (m width	10—	D14	15.39	cm2

w Mc 0.24 %

w Mb 0.48 %

Wall Shear Stress

Wall thickness t :	40 cm		
d :	32 cm		
j= 7/8 d :	0.280 m		
Width Wa :	100 cm		
Qb :	47.09 kN		
Shear stress= Qb/(Wa j)=	0.17 N/mm2 <	0.8 N/mm2	

Bottom profile

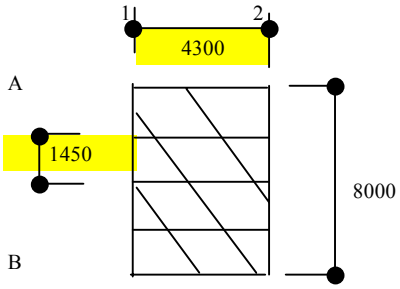
slab thickness t :	50 cm				
d :	39.0 cm				
j= 7/8 d :	0.341 m				
Re bar ft :	200.00 N/mm2				
at = Mb/(ft x j) =	4.60 cm2/ (m widt	10—	D14	15.39	cm2

w Mc 0.3947138 %

2.6 SLAB

1) Inlet chamber

Load condition



		Area		unit weight	kN
Floor slab=		6.24	x	7848.0=	48.93
Wall=		0.00	x	0.0=	0.00
				Σ =	48.9
lx=		4.3	m		
ly=		1.45	m	t(cm)=	20
λ =		2.97		d(cm)=	15
A=	6.235 m2			cover(cm)=	5

	a	wlx2(kNm2)	M(Nm)	Additional M from wall	Total M	at= M/(σ sjd)	re-bars	
Mx1=	0.083	16.50	1,369.5		1,370	0.532 cm2	upper 2-D10-->D10@200	3.93cm2
Mx2=	0.042	16.50	693.0			0.269 cm2	bottom 2-D10-->D10@200	3.93cm2
								0.5%
My1=	0.042	16.50	693.0	0	693	0.269 cm2	upper 2-D10-->D10@200	3.93cm2
My2=	0.028	16.50	462.0			0.179 cm2	bottom 2-D10-->D10@200	3.93cm2
		wlx	Q(N)			ϕ=Q/(τa jd)		0.5%
Qx =	0.52	11.38	5,917.4			1.89 cm <	15.7 ok	
Qy =	0.46	11.38	5,234.6			1.67 cm <	15.7 ok	

Suffix 1: end of span

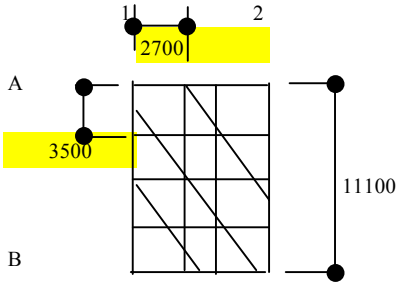
Suffix 2: middle of span

From nomogram of two-way slab

Q cap		
117,720	N > Q	ok
117,720	N > Q	ok

2) Machine room

Load condition



		Area		unit weight	kN
Floor slab=		9.45	x	9810.0=	92.70
Wall=			x		
				Σ =	92.7
lx=		2.7	m		
ly=		3.5	m	t(cm)=	25
λ =		1.30		d(cm)=	20
A=	9.45 m2			cover(cm)=	5

	a	wlx2(kNm2)	M(Nm)	Additional M from wall	Total M	at= M/(σ sjd)	re-bars	
Mx1=	0.068	71.51	4,863.0		4,863	1.416 cm2	upper 2-D10-->D10@200	3.93cm2
Mx2=	0.028	71.51	2,002.4			0.583 cm2	bottom 2-D10-->D10@200	3.93cm2
								0.4%
My1=	0.042	71.51	3,003.6	0	3,004	0.875 cm2	upper 2-D10-->D10@200	3.93cm2
My2=	0.028	71.51	2,002.4			0.583 cm2	bottom 2-D10-->D10@200	3.93cm2
		wlx	Q(N)			ϕ=Q/(τa jd)		0.4%
Qx =	0.5	26.49	13,243.5			3.17 cm <	15.7 ok	
Qy =	0.46	26.49	12,184.0			2.92 cm <	15.7 ok	

Suffix 1: end of span

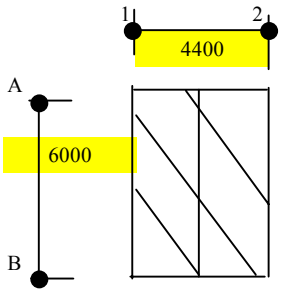
Suffix 2: middle of span

From nomogram of two-way slab

Q cap		
156,960	N > Q	ok
156,960	N > Q	ok

3) Water channel

Load condition



		Area		unit weight	kN
Floor slab=		13.20	x	7848.0=	103.59
Wall=			x		0.00
				Σ =	103.6

lx= 2.2 m
ly= 6 m
λ = 2.73
A= 26.4 m2

t(cm)= 20
d(cm)= 15
cover(cm)= 5

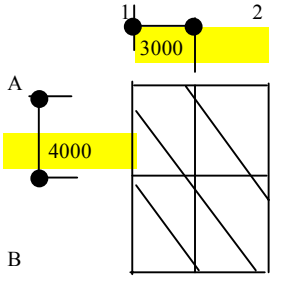
	a	wlx2(kNm2)	M(Nm)	Additional M from wall	Total M	at= M/(σ sjd)	re-bars	
Mx1=	0.083	37.98	3,152.7		3,153	1.224 cm2	bottom 2-D10-->D10@200	3.93cm2
Mx2=	0.042	37.98	1,595.3			0.620 cm2	upper 2-D10-->D10@200	3.93cm2
								0.5%
My1=	0.042	37.98	1,595.3		1,595	0.620 cm2	bottom 2-D10-->D10@200	3.93cm2
My2=	0.028	37.98	1,063.6			0.413 cm2	upper 2-D10-->D10@200	3.93cm2
		wlx	Q(N)			ϕ=Q/(τa jd)		0.5%
Qx =	0.51	17.27	8,805.5			2.81 cm <	15.7 ok	
Qy =	0.46	17.27	7,942.2			2.54 cm <	15.7 ok	

Suffix 1: end of span
Suffix 2: middle of span
From nomogram of two-way slab

Q cap
117,720 N > Q ok
117,720 N > Q ok

4) Outlet chamber

Load condition



		Area		unit weight	kN
Floor slab=		12.00	x	7848.0=	94.18
Wall=			x		0.00
				Σ =	94.2

lx= 3 m
ly= 4 m
λ = 1.33
A= 12 m2

t(cm)= 25
d(cm)= 20
cover(cm)= 5

	a	wlx2(kNm2)	M(Nm)	Additional M from wall	Total M	at= M/(σ sjd)	re-bars	
Mx1=	0.083	70.63	5,862.5		5,862	1.707 cm2	bottom 2-D10-->D10@200	3.93cm2
Mx2=	0.042	70.63	2,966.5			0.864 cm2	upper 2-D10-->D10@200	3.93cm2
								0.4%
My1=	0.042	70.63	2,966.5		2,967	0.864 cm2	bottom 2-D10-->D10@200	3.93cm2
My2=	0.028	70.63	1,977.7			0.576 cm2	upper 2-D10-->D10@200	3.93cm2
		wlx	Q(N)			ϕ=Q/(τa jd)		0.4%
Qx =	0.51	23.54	12,007.4			2.88 cm <	15.7 ok	
Qy =	0.46	23.54	10,830.2			2.59 cm <	15.7 ok	

Suffix 1: end of span
Suffix 2: middle of span
From nomogram of two-way slab

Q cap
156,960 N > Q ok
156,960 N > Q ok

2.7 BEAMS

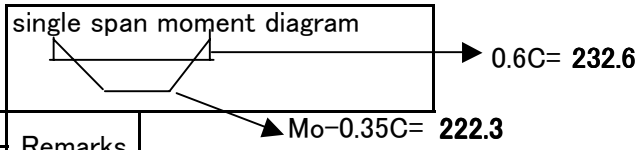
1) Grit chamber machine room **B1**

Typical example of the beam is the short side of rectangle beneath the wall.

	Load form		(slab load)		(slab load)		(girder load)+ other loads	Σ
B1		C/w	Co	Co/w	Co	w/l	Co	kNm
	Co	23.18	204.72	0.00	0.00	47.46	182.88	387.60
		M/w	Mo	Mo/w	Mo	w/l	Mo	kNm
bxD 40x60	Mo	9.48	83.68	0.00	0.00	47.46	274.32	357.99
(cm)		Q/w	Q	Q/w	Q	w/l	Q	kN
	Q	10.45	92.25	0.00	0.00	47.46	161.36	253.61
	Slab load =	8.83	(kN/m2)	ly=	3.5	m		
	Span =	6.8	(m)	lx=	2.27	m		λ= 1.54

1.Girder load 9.40 kN/m
dead load
2.Line load = 0.00 kN/m + 38.06 kN/m = 38.06 kN/m
roof wall
Total = 47.46 kN/m

single span moment diagram



2) Determination of beam B1

Beam ID	B1			Remarks
Position	B end	Mid	C end	
D.L] M(kNm) top	232.6		232.6	
+] bott.		222.3		
L.L] Q (kN)	253.61		253.61	
] b x D (cm)	50	x	80	
Size] d (cm)			75	
] j(cm)			65.625	
top	18.1		18.1	cm2
	4D25		4D25	at= M/(σsjd)
bottom		17.3		cm2
		4D25		
τ=Q/bjd	0.77		0.77	N/mm2
top	0.52		0.52	min.0.4%
Pt (%) bott.		0.52		
top	19.64		19.64	
at (cm2) bott.		19.64		
Main top	5	5	5	
Bars		D25		
bott	5	5	5	
φ (cm)	39.25		39.25	
Q /fa.j (cm)	0.98		0.98	max
judge	ok		ok	1.7
fs.bj LT(ST)	252.7		252.7	kN
(t)	D10-250	D10-250	D10-250	
judge	ok		ok	

seismic force neglected

2) Grit chamber machine room **B2**

	Load form	(slab load)		(slab load) x2		(girder load)+ other loads		Σ
B1		C/w	Co	Co/w	Co	w/1	Co	kNm
	Co	23.35		23.24	205.19	5.64	5.76	210.94
		M/w	Mo	Mo/w	Mo	w/1	Mo	kNm
bxD 40x60	Mo	9.33		23.60	208.39	5.64	8.64	217.03
(cm)		Q/w	Q	Q/w	Q	w/1	Q	kN
	Q	10.28		2.67	23.59	5.64	9.87	33.46
	Slab load =	8.83	(kN/m2)	ly=	3.5	m		
	Span =	3.5	(m)	lx=	2.25	m		λ= 1.56

1.Girder load 5.64 kN/m
dead load
2.Line load = 0.00 kN/m + 0.00 kN/m = 0.00 kN/m
roof wall
Total = 5.64 kN/m

single span moment diagram
0.6C= **126.6**
Mo−0.35C= **143.2**

2) Determination of beam B1

Beam ID	B1			Remarks
Position	B end	Mid	C end	
D.L] M(kNm) top	126.6		126.6	
+] bott.		143.2		seismic force neglected
L.L] Q (kN)	33.46		33.46	
] b x D (cm)	40	x	60	
Size] d (cm)			55	
] j(cm)			48.125	
top	13.4		13.4	cm2
	3D25		3D25	at= M/(σsjd)
bottom		15.2		cm2
		3D28		
τ=Q/bjd	0.10		0.10	N/mm2
top	0.43		0.43	min.0.4%
Pt (%) bott.		0.84		
top	9.42		9.42	
at (cm2) bott.		18.48		
top	3	3	3	
Main		D28		
Bars		D28		
bott	3	3	3	
φ (cm)	23.55		23.55	
Q /fa.j (cm)	0.30		0.30	max
judge	ok		ok	1.7
fs.bj LT(ST)	148.2		148.2	kN
(t)	D10-250	D10-250	D10-250	
judge	ok		ok	

2.8.Wall of cylindrical tanks for Grit Chamber (/)

1) Spec of Tank

Diameter	d	7.3	m	Unit Water load	Dl	1.0 t/m3=	9.81	kN/m3
Water Depth	h	1.8	m	Supporting condition of bottom :			Rigid	
Wall Thickness	t	400	mm			αe:	0	
Wall height	h1	2.7	m	f st =	120	N/mm2		
				f ct =	2.00	N/mm2	fcu=	30
Unit concrete weight		23.544	N/m3	permissible tensile stress			not used	

2) Employed Equation for analysis

*Max circumferential tension in wall due to internal pressure

N max= 0.5*K3*D1*h*d

K3: coefficient by Table 184 in "Reinforced Concrete Designer's Handbook"

Dl: 9.81 kN/m3

h: Water Depth (m)

d: Diameter (m)

Re. As= 0.5*K3*D1*h*d/f st

fst: permissible rebar tensile stress

*Vertical bending moment at the tank bottom

M max= K1*Dl*h~3

K1: coefficient by Table 184 in "Reinforced Concrete Designer's Handbook"

*Minimum thickness od Wall

T min= Dl*h*d/2*[1/fct-(αe-1)/fst]

fct: permissible concrete tensile stress

fst: permissible rebar tensile stress

αe: modular ratio

*Direct compression in wall of empty underground tank

f cc= 1/2*qep*d/(t+(αe-1)*As)

qep: external pressure/m2 at depth h1

t: wall thickness

3) Forces and Bending Moment /Reinforcement

0 h^2/d/t= 1.1096 then K1= 0.045 K2= 0.55 K3= 0.26

By table 184, pp.405

1 BM at bottom= 441.45 kN/m

2 Position height of max tension = 0.99 m above the bottom

3 Max circumference tension = 16.8 kN/m around the position of the above

4 Reqired As= 1.3965 cm2

5 Min. thickness of wall = 32.76 mm

6 Direct comp.= 290.6 kN/m2

= 0.2906 N/mm2

Reinforcement

5—	D10
5—	D10

As= 7.854 cm2

pt= 0.19635 %

4) Foundation

Effect of water pressure

Ground Level =	348.0	m
Ground Water Level =	345	m
Bottom slab level=	347.0	m
Height of Bottom slab	0.4	m
Soffit of bottom slab=	(1.6)	m

Upward thrust by water pressure

p= 9.81 kN/m3 × (1.6) = −15.70 kN/m2

A= 62.21 m2 (including wall thickness)

P= −976 kN

Bottom slab depth

*Basement including structure wall must be designed to prevent flotation

Weight				
GL slab	585.9	kN	(Slab thickness	0.4 m)
wall	615.1	kN		
Total	1201	kN		

Required weight for bottom −976 − 1201 = −2177.455426 kN

Minimum depth Fs=1.0 t= −1.49 m

*No upward thrust will affect to this structure

The depth shall be decided by the structural------> t= 0.5 m

Serviceability Check : by NJC

2.9 Limit state analysis

Rectanglar section design and limited state analysis					(1/3)
Concrete Permissible Strength		f'ck=	17 N/mm2	by use of B30	30
	Direct tensile stress	ft=	2.00 N/mm2		
	Elasticity ratio	n=	15		
	Elasticity	E=	200000 N/mm2		
Permissible strength		σsa=	250 N/mm2	round from BS	
		σsa=	140 N/mm2	deforme from BS	
Ultimate strength (characteristic strength)		σs=	365 N/mm2		

Check point				Foundation	Wall
Force	Bending Moment	Md	kN·m	206.1	194.7
	Shearing force	Sd	kN	17.6	185.4
Section Spec	Width	b	cm	100	100
	Height	h	cm	50	40
	Cover	dt	cm	5	5
	Effective Height	d	cm	45	35
Rebar Cross Section	Tension Rebar		cm^2	10− D25	10− D25
				As= 49.09	As= 49.09
	Compression Rebar		cm^2	5− D10	5− D20
				As= 3.93	As= 15.71
Stress	Concrete stress		N/mm2	5.2	6.4
	Rebar stress		N/mm2	107.6	128.0
	Shearing stress		N/mm2	0.046	0.618
B.M value for crack		Mcr	kNm	72.12	46.76
Crack width	Rebar interval	cs	mm	100	100
	Rebar diameter	φ	mm	25	25
	Cover depth	c	mm	40	40
	Rebar stress	σse	N/mm2	108.6	132.3
	Crack width	wcr	mm	0.147	0.172
Judgement: wcr<0.2 : OK				**OK**	**OK**

Examination with the Ultimate BM Strength				
Ultimate B.M Strength		Mud	kNm	729.75	558.79
γi·Md/Mud				0.282	0.348
Judgement: γi·Md/Mud<1.0 : OK				OK	OK

Crack width shall be controled as follows:

1 normal condition	crack width＜0.3mm
2 severe condition	crack width＜0.2mm
3 very severe condition	crack width＜0.1mm

Limit state analysis

Rectanglar section design and limited state analysis					(2/3)
Concrete Permissible Strength		f'ck=	17 N/mm2	by use of B30	30
	Direct tensile stress	ft=	2.00 N/mm2		
	Elasticity ratio	n=	15		
	Elasticity	E=	200000 N/mm2		
Permissible strength		σsa=	250 N/mm2	round from BS	
		σsa=	140 N/mm2	deforme from BS	
Ultimate strength (characteristic strength)		σs=	365 N/mm2		

Check point				Slab	Beam 1
Force	Bending Moment	Md	kN·m	5.9	232.6
	Shearing force	Sd	kN	12.0	253.6
Section Spec	Width	b	cm	100	50
	Height	h	cm	25	80
	Cover	dt	cm	5	5
	Effective Height	d	cm	20	75
Rebar Cross Section	Tension Rebar		cm^2	5− D10	5− D25
				As= 3.93	As= 24.54
	Compression Rebar		cm^2	5− D10	5− D25
				As= 3.93	As= 24.54
Stress	Concrete stress		N/mm2	1.2	3.7
	Rebar stress		N/mm2	78.6	135.0
	Shearing stress		N/mm2	0.064	0.749

B.M value for crack		Mcr	kNm	12.88	75.22
Crack width	Rebar interval	cs	mm	80	100
	Rebar diameter	φ	mm	10	25
	Cover depth	c	mm	40	40
	Rebar stress	σse	N/mm2	79.7	139.9
	Crack width	wcr	mm	0.115	0.181
Judgement: wcr<0.2 : OK				**OK**	**OK**

Examination with the Ultimate BM Strength				
Ultimate B.M Strength	Mud	kNm	37.52	639.39
γi·Md/Mud			0.156	0.364
Judgement: γi·Md/Mud<1.0 : OK			OK	OK

Crack width shall be controled as follows:

1 normal condition	crack width＜0.3mm
2 severe condition	crack width＜0.2mm
3 very severe condition	crack width＜0.1mm

8.7 Limit state analysis

Rectanglar section design and limited state analysis					(3/3)
Concrete Permissible Strength		f'ck=	17 N/mm2	by use of B30	30
	Direct tensile stress	ft=	2.00 N/mm2		
	Elasticity ratio	n=	15		
	Elasticity	E=	200000 N/mm2		
Permissible strength		σsa=	250 N/mm2	round from BS	
		σsa=	140 N/mm2	deforme from BS	
Ultimate strength (characteristic strength)		σs=	365 N/mm2		

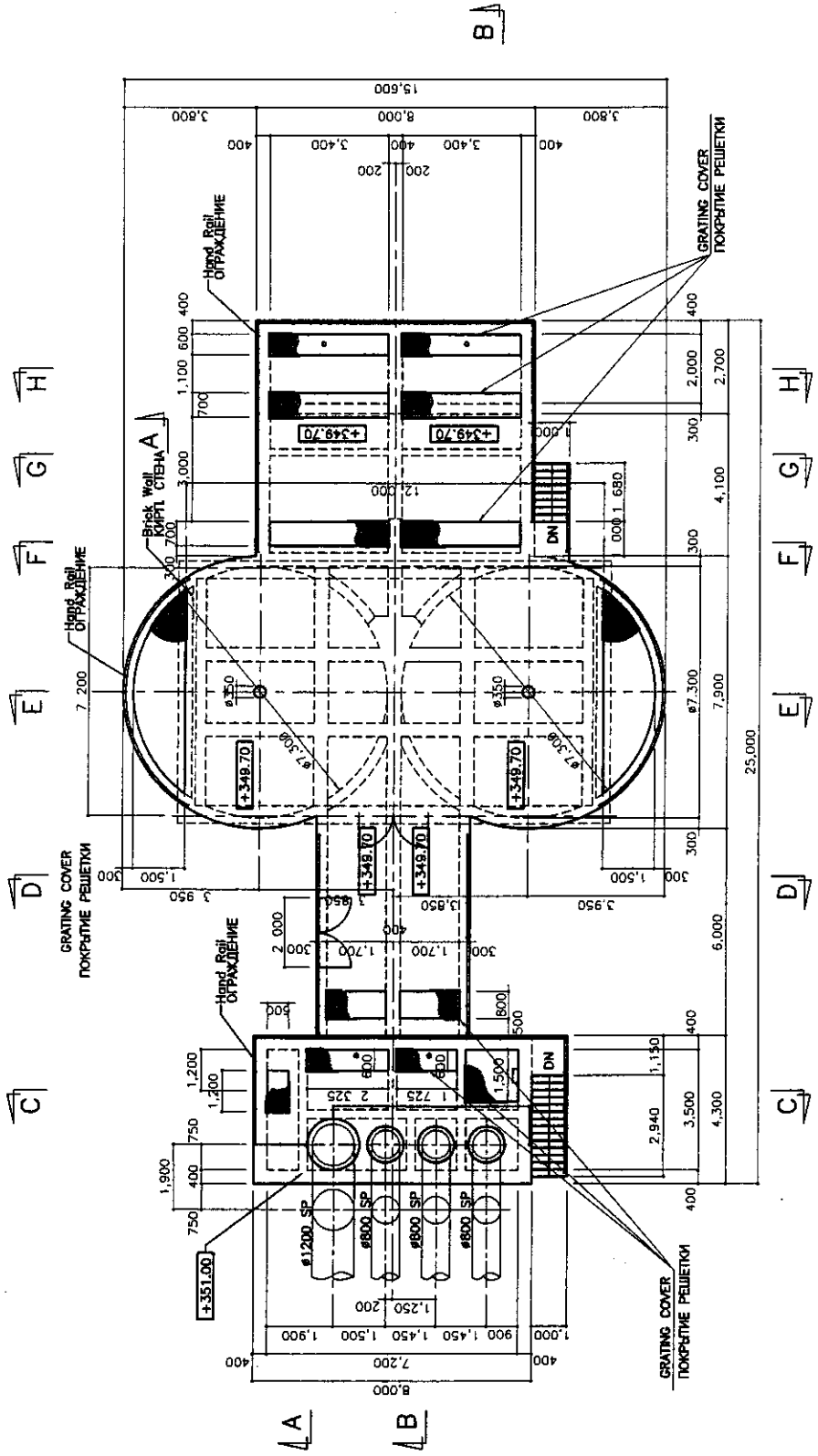
Check point				Beam 2 end	Beam 2 mid
Force	Bending Moment	Md	kN·m	126.6	143.2
	Shearing force	Sd	kN	33.5	0.0
Section Spec	Width	b	cm	40	40
	Height	h	cm	60	60
	Cover	dt	cm	5	5
	Effective Height	d	cm	55	55
Rebar Cross Section	Tension Rebar		cm^2	3－ D28	3－ D28
				As= 18.47	As= 18.47
	Compression Rebar		cm^2	3－ D28	3－ D28
				As= 18.47	As= 18.47
Stress	Concrete stress		N/mm2	4.1	4.6
	Rebar stress		N/mm2	133.5	151.0
	Shearing stress		N/mm2	0.170	0.000
B.M value for crack		Mcr	kNm	34.96	34.96
Crack width	Rebar interval	cs	mm	80	80
	Rebar diameter	φ	mm	28	28
	Cover depth	c	mm	40	40
	Rebar stress	σse	N/mm2	139.1	157.4
	Crack width	wcr	mm	0.166	0.184
Judgement: wcr<0.2 : OK				**OK**	**OK**

Examination with the Ultimate BM Strength				
Ultimate B.M Strength	Mud	kNm	346.96	346.96
γi·Md/Mud			0.365	0.413
Judgement: γi·Md/Mud<1.0 : OK			OK	OK

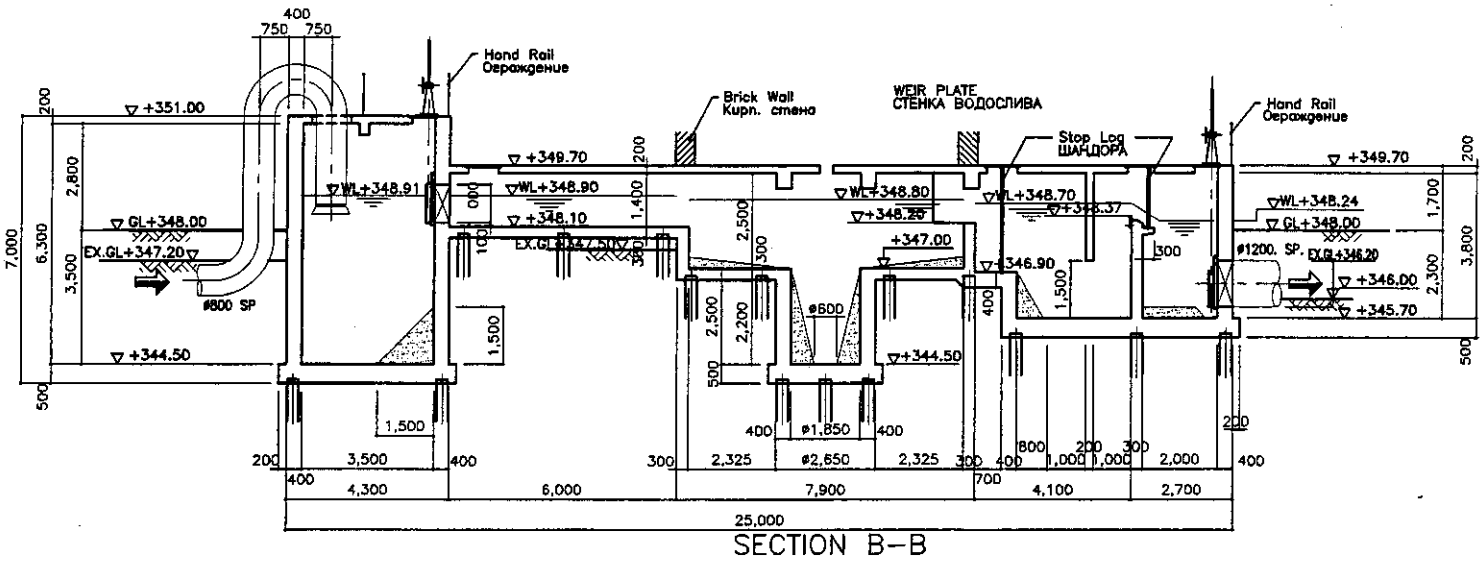
Crack width shall be controled as follows:

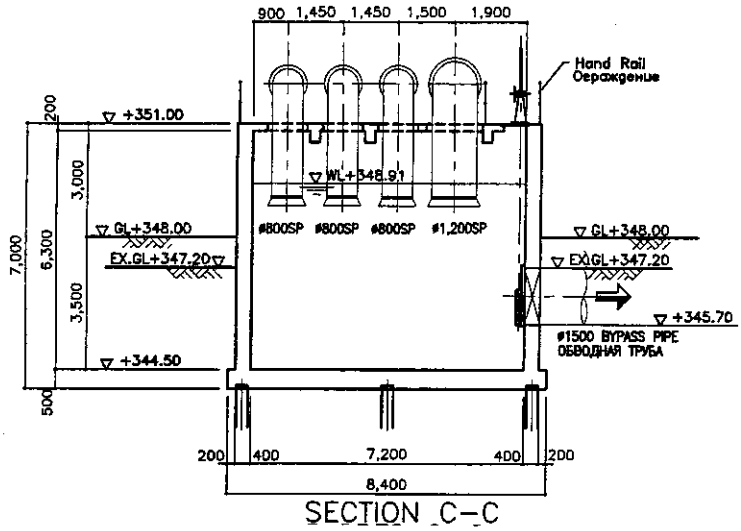
1 normal condition	crack width＜0.3mm
2 severe condition	crack width＜0.2mm
3 very severe condition	crack width＜0.1mm

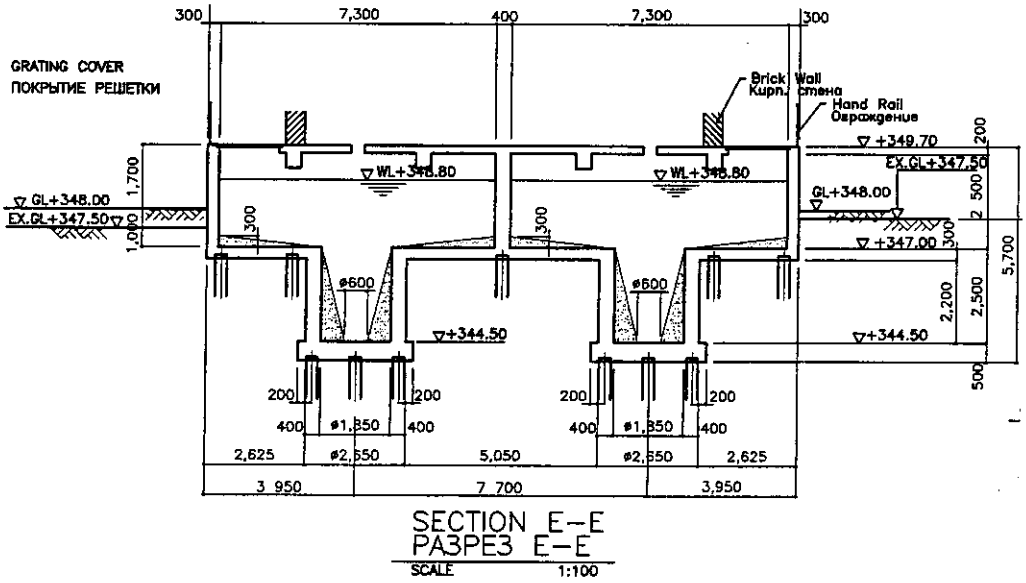
Grit chamber structure 1/2



Grit chamber structure 2/2







3. Temprary Influent Pumping Station

3.1Material and Allowable stress

TABLE 3.1 Allowable Stress (N/mm2, kg /cm2)

Item		Serviceability strength			Ultimate strength		
		Compression	Tension	Shear	Compression	Tension	Shear
Concrete	B30	10		0.8	30		1.2
		100	-------	8	300	-------	12
Steel Bar Round Bar	A- I	157.0	157.0	157.0	235.4	235.4	235.4
		1600	1600	1600	2400	2400	2400
Steel Bar Deformed Bar	A- II	196.2	196.2	196.2	358.1	358.1	358.1
		2000	2000	2000	3650	3650	3650

upper: SI units N/mm2

lower: MKS units kg/cm2

TABLE 3.2 Allowable Bonding Stress of Steel Bar to Concrete (N/mm2, kg /cm2)

Item	Serviceability strength		Remarks
	Top bars	Other bars	
ϕ6,ϕ9,ϕ12	0.9	1.3	
	9	13.5	
D10,D13,D16	1.6	2.4	
D19,D22,D25,D29	16.2	24.3	

upper: SI units N/mm2

lower: MKS units kg/cm2

3.2 Load Table

TABLE 3.3 Dead Load

Loc.	item	thickness	kg/m2	total kg/m2	Remarks
Common slab	Leveling motar	-	-		
	Concrete slab	20cm	500		
				500	<-------- MKS UNIT
				4905	<-------- SI UNIT

TABLE 3. 4 Live Load and Floor Load

kg/m2 (Girder, Sub beam : Self weight not included)

Loc.	load type	slab	beam	girder	Remarks	
Other floor	Dead Load	500.0	500.0	500.0		
	Live Load	1000.0	1000.0	1000.0		Load of heay equipment
	Total Load	1500.0	1500.0	1500.0		
	SI unit	14715	14715	14715		<-------- SI UNIT

3.3 Facility weight

Table3.4 Temp. I.P.S Weight

Story	Load type	Unit w (kN/m2,m)	width /hight (m) or unit	Length (m)	Area or L (m2), (m)	Weight (kN)	Small Total (kN)	S Wi (kN)
structure	slab	14.72	7	-	62.39	918.05		
	Beam 6m	2.94	1	6.00	6.00	17.66		
	Beam 3m*2	2.94	2	3.00	6.00	17.66		
	Machine	34.335	3	-	-	103.01		
	Wall.1 9.03m	12.263	9.03	20.42	184.40	2261.16		
	Water	9.81	9.03	28.27	255.32	2504.67		
							5822.20	5822.20
Base	t600 Base	14.72	1	28.27	28.27	416.06		
								(kN)
				Σ	28.27	(m2)	416.06	6238.25

Base Area 28.27 (m2) **Total W= 6,238.25**

W-Base= 5,822.2

soil reaction =W/(Base area **220.633** (kN/m2)

Foundation's design force= 205.918 (kN/m2)

1) Spec of Tank

Diameter	d	6	m	Unit Water load	Dl	1.0 t/m3=	9.81	kN/m3	
Water Depth	h	4.427	m	Supporting condition of bottom :			Rigid		
Wall Thickness	t	500	mm			α e:	15		
Wall height	h1	9.027	m	f st =	120	N/mm2			
				f ct =	2.00	N/mm2	fcu=	30	
Unit concrete weight		23.544	kN/m3	permissible tensile stress			not used		

2) Employed Equation for analysis

*Same with the former section

3) Forces and Bending Moment /Reinforcement

0 h^2/d/t= 6.53 then K1= 0.0175 K2= 0.42 K3= 0.54

By table 184, pp.405

1 BM at bottom= 171.68 kN/m

2 Position height of max tension = 1.859 m above the bottom

3 Max circumference tension = 70.35 kN/m around the position of the above

4 Reqired As= 5.86 cm2

Reinforcement

5 Min. thickness of wall = 49.94 mm — 4— D16 /m

6 Direct comp.= 448.8 kN/m2 — 4— D16 /m

= 0.449 N/mm2 — As= 16.085 cm2

pt= 0.3217 %>0.3%

7 Distribution Rebar 1rank lower spec. of main rebar----------> 4— D14 /m

3.2. Foundation

1) Effect of water pressure

Ground Level =	345.0 m
Ground Water Level =	343 m
Bottom slab level=	336.0 m
Height of Bottom slab=	0.6 m
Soffit of bottom slab=	7.6 m

Upward thrust by water pressure

p= 9.81 kN/m3 × 7.6 = 74.82 kN/m2

A= 50.3 m2 (including wall thickness)

P= 3760.9 kN

2) Bottom slab depth and reinfocement

*Basement including structure wall must be designed to prevent flotation

Weight			
GL slab	236.7	kN	(Slab thickness 0.2 m)
wall	2170	kN	
Total	2407	kN	

Cohesion Force 29.43 kN/m2 198.4 m2 = 5839

*no cohesion Required weight for bottom 3760.9 − 2406.7 = 1354.2 kN

Minimum depth Fs=1.0 t= 1.14 m

*cohesion included 3760.9 − 8246 = −4485.1 kN

When cohesion force between wall and soil included, additional depth for bottom slab is not necessary.

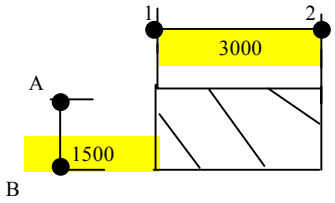
The depth shall be decided by the structural requirements. .------> t= 0.6 m

*Reinfocement

Radial reinforcement 250@ D16

3.4 Slab

Load condition



		Area		unit weight	kN
Floor slab=		4.50	x	14,715.0	66.22
Wall=			x		0.00
				Σ =	66.2
		Soil reaction load=		14.72	kN/m2
lx=	1.5 m				
ly=	3 m			t(cm)=	20
λ =	2.00			d(cm)=	15
A=	4.5 m2			cover(cm)=	5

	a	wlx2(kNm2)	M(Nm)	Additional M from wall	Total M	at= M/(σ sjd)	re-bars	
Mx1=	0.078	33.11	2,582.5	0	2,582	1.003 cm2	bottom 2-D10-->D10@100	7.85cm2
Mx2=	0.052	33.11	1,721.7			0.669 cm2	upper 2-D10-->D10@100	7.85cm2
								1.0%
My1=	0.042	33.11	1,390.6	0	1,391	0.540 cm2	bottom 2-D10-->D10@100	7.85cm2
My2=	0.028	33.11	927.0			0.360 cm2	upper 2-D10-->D10@100	7.85cm2
		wlx	Q(N)			ϕ=Q/(τa jd)		1.0%
Qx =	0.52	22.07	11,477.7			3.67 cm <	31.4 ok	
Qy =	0.46	22.07	10,153.4			3.24 cm <	31.4 ok	

Suffix 1: end of span

Suffix 2: middle of span

From nomogram of two-way slab

Q cap		
117,720	N > Q	ok
117,720	N > Q	ok

3.4 FOUNDATION

3.5 BEAMS

1) Beam **B1**

	Load form	(slab load)		(slab load) *2		(girder load)+ other loads		Σ
B1		C/w	Co	Co/w	Co	w/1	Co	kNm
	Co	0.00	0.00	7.03	103.42	4.11	3.08	106.51
		M/w	Mo	Mo/w	Mo	w/1	Mo	kNm
bxD 40x60	Mo	0.00	0.00	7.22	106.25	4.11	4.63	110.87
(cm)		Q/w	Q	Q/w	Q	w/1	Q	kN
	Q	0.00	0.00	1.69	24.83	4.11	6.17	31.00
	Slab load =	14.715	(kN/m2)	ly=	3	m		
	Span =	3	(m)	lx=	1.50	m		λ= 2.00

1.Girder load= 4.11 kN/m
dead load

2.Line load = 0.00 kN/m + 0.00 kN/m = 0.00 kN/m
roof wall

Total = 4.11 kN/m

single span moment diagram

0.6C= **63.9**

Mo−0.35C= **73.6**

2) Determination of beam B1

Beam ID	B1			Remarks
Position	B end	Mid	C end	
D.L] M(kNm	63.9		63.9	
+] bott.		73.6		seismic force neglected
L.L] Q (kN)	31.00		31.00	
] b x D (cr	35	x	50	
Size] d (cm)			45	
] j(cm)			39.375	
top	8.3		8.3	cm2
	3D22		3D22	at= M/(σsjd)
bottom		9.5		cm2
		3D22		
τ=Q/bjd	0.22		0.22	N/mm2
top	0.72		0.72	min.0.4%
Pt (%) bott.		0.72		
top	11.4		11.4	
at (cm2) bott.		11.4		
Main	3	3	3	
Bars		D22		
	3	3	3	
φ (cm)	20.724		20.724	
Q /fa.j (cm)	0.38		0.38	max
judge	ok		ok	1.7
fs.bj LT(ST)	106.1		106.1	kN
(t)	D10-250	D10-250	D10-250	
judge	ok		ok	

2) Girder **G1**

	Load form		(slab load) *2		(slab load)		P	(gider load)+	Σ
		Co/w	Co	Co/w	Co	w/l	Co	
2B2	Co	8.16	120.02	-	0.00	0.56	1.69	121.71
		Mo/w	Mo	Mo/w	Mo	w/l	Mo	
bxD 30x75	Mo	13.50	198.65	-	0.00	0.56	2.53	201.18
		Q/w	Q	Q/w	Q	w/l	Q	
	Q	6.75	99.33	-	0.00	0.56	1.69	101.01
	Slab load =	14.715	(kN/m2)	ly=	3.00	m		
	Span =	6	(m)	lx=	3.00	m		λ= 1.00

1.Girder load= 5.64 kN/m
dead load
2.Line load = 0.00 kN/m + 0.00 kN/m = 0.00 kN/m
roof wall
Total = 5.64 kN/m

single span moment diagram

0.6C= **73.0**

Mo−0.35C= **158.6**

2) Determination of beam B1

Beam ID	B1			Remarks
Position	B end	Mid	C end	
D.L] M(kNm) t	73.0		73.0	
+] bott.		158.6		
L.L] Q (kN)	101.01		101.01	
] b x D (cm)	40	x	60	
Size] d (cm)			55	
] j(cm)			48.125	
top	7.7		7.7	cm2
	3D20		3D20	at= M/(σsjd)
bottom		16.8		cm2
		4D25		
τ=Q/bjd	0.73		0.73	N/mm2
top	0.43		0.43	min.0.4%
Pt (%) bott.		0.89		
top	9.42		9.42	
at (cm2) bott.		19.64		
Main top	3	3	3	
Bars		D20		
		D25		
bot	2	4	2	
ϕ (cm)	18.84		18.84	
Q /fa.j (cm)	1.11		1.11	max
judge	ok		ok	1.7
fs.bj LT(ST)	148.2		148.2	kN
(t)	D10-250	D10-250	D10-250	
judge	ok		ok	

seismic force neglected

3.6 Limit state analysis

Rectanglar section design and limited state analysis (1/3)

Concrete Permissible Strength		f'ck=	17 N/mm2	by use of B30	30
	Direct tensile stress	ft=	2.00 N/mm2		
	Elasticity ratio	n=	15		
	Elasticity	E=	200000 N/mm2		
Permissible strength		σsa=	250 N/mm2	round	from BS
		σsa=	140 N/mm2	deformed	from BS
Ultimate strength (characteristic strength)		σs=	365 N/mm2		

Check point				Beam B1	Girder G1
Force	Bending Moment	Md	kN·m	63.9	73.0
	Shearing force	Sd	kN	31.0	101.0
Section Spec	Width	b	cm	35	40
	Height	h	cm	50	60
	Cover	dt	cm	5	5
	Effective Height	d	cm	45	55
Rebar Cross Section	Tension Rebar		cm^2	3— D20	3— D20
				As= 9.42	As= 9.42
	Compression Rebar		cm^2	2— D25	3— D20
				As= 9.82	As= 9.42
Stress	Concrete stress		N/mm2	4.2	3.4
	Rebar stress		N/mm2	160.6	149.8
	Shearing stress		N/mm2	0.217	0.502
B.M value for crack		Mcr	kNm	20.28	32.16
Crack width	Rebar interval	cs	mm	80	100
	Rebar diameter	φ	mm	20	20
	Cover depth	c	mm	40	40
	Rebar stress	σse	N/mm2	166.2	153.9
	Crack width	wcr	mm	0.198	0.199
Judgement: wcr<0.2 : OK				**OK**	**OK**

Examination with the Ultimate BM Strength					
Ultimate B.M Strength		Mud	kNm	146.02	181.55
γi·Md/Mud				0.438	0.402
Judgement: γi·Md/Mud<1.0 : OK				OK	OK

Crack width shall be controled as follows:

1 normal condition	crack width＜0.3mm
2 severe condition	crack width＜0.2mm
3 very severe condition	crack width＜0.1mm

Rectanglar section design and limited state analysis (2/3)

Concrete Permissible Strength		f'ck=	17 N/mm2	by use of B30	30
	Direct tensile stress	ft=	2.00 N/mm2		
	Elasticity ratio	n=	15		
	Elasticity	E=	200000 N/mm2		
Permissible strength		σsa=	250 N/mm2	round	from BS
		σsa=	140 N/mm2	deformed	from BS
Ultimate strength (characteristic strength)		σs=	365 N/mm2		

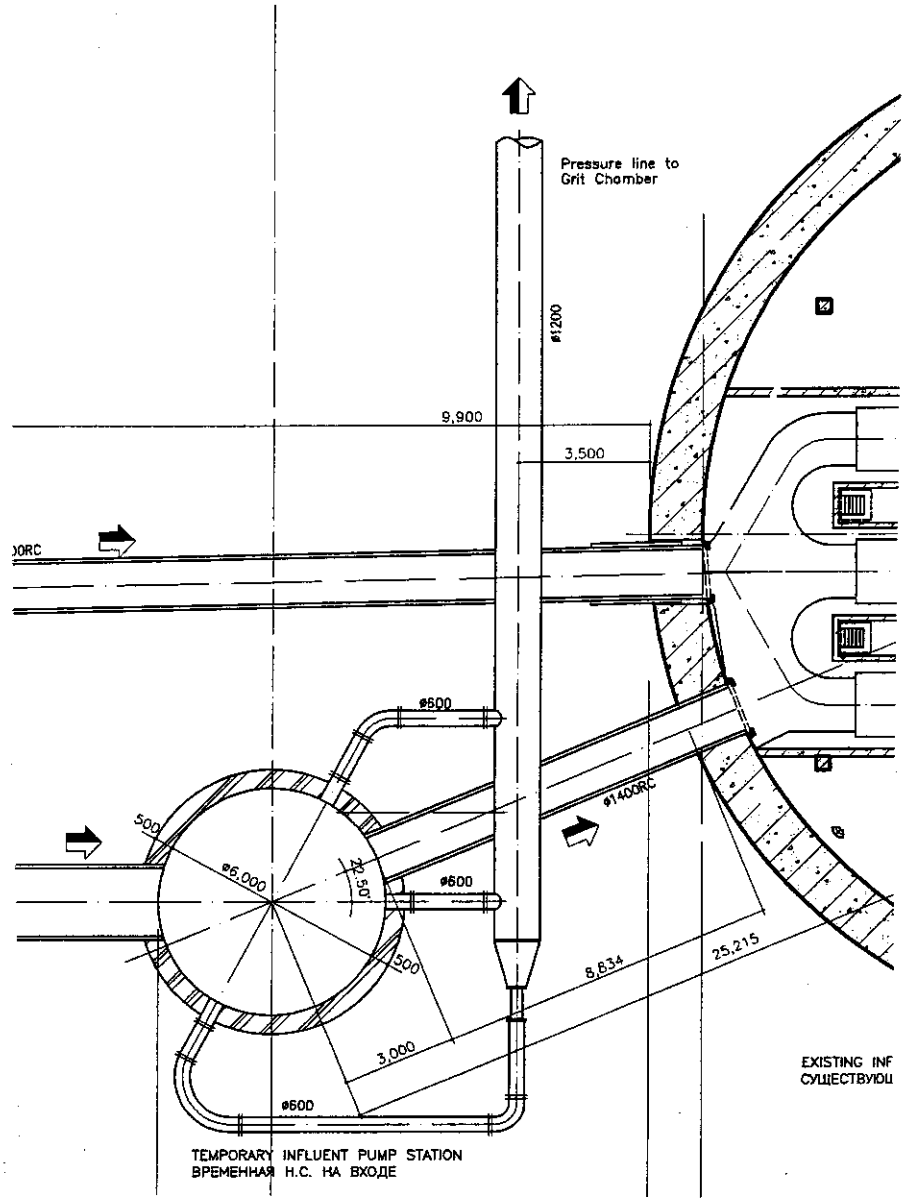
Check point				Slab	
Force	Bending Moment	Md	kN·m	2.6	
	Shearing force	Sd	kN	11.5	
Section Spec	Width	b	cm	100	
	Height	h	cm	20	#REF!
	Cover	dt	cm	5	5
	Effective Height	d	cm	15	#REF!
Rebar Cross Section	Tension Rebar		cm^2	10— D10	0— D0
				As= 7.85	
	Compression Rebar		cm^2	10— D10	0— D0
				As= 7.85	
Stress	Concrete stress		N/mm2	0.6	#VALUE!
	Rebar stress		N/mm2	23.4	#VALUE!
	Shearing stress		N/mm2	0.084	#DIV/0!
B.M value for crack		Mcr	kNm	9.15	#REF!
Crack width	Rebar interval	cs	mm	100	0
	Rebar diameter	φ	mm	10	0
	Cover depth	c	mm	40	0
	Rebar stress	σse	N/mm2	24.1	#VALUE!
	Crack width	wcr	mm	0.060	#VALUE!
Judgement: wcr<0.2:OK				**OK**	**0.00**

Examination with the Ultimate BM Strength				
Ultimate B.M Strength		Mud	kNm	48.21	#DIV/0!
γi·Md/Mud				0.054	#DIV/0!
Judgement: γi·Md/Mud<1.0:OK				OK	0

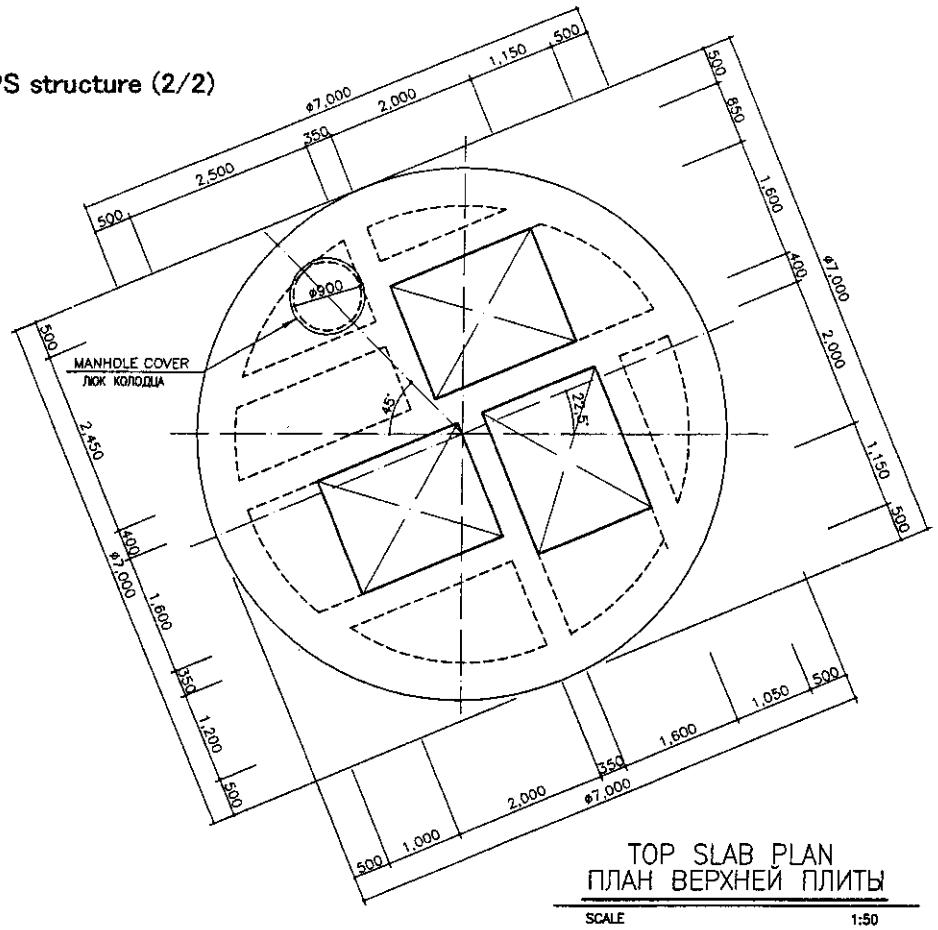
Crack width shall be controled as follows:

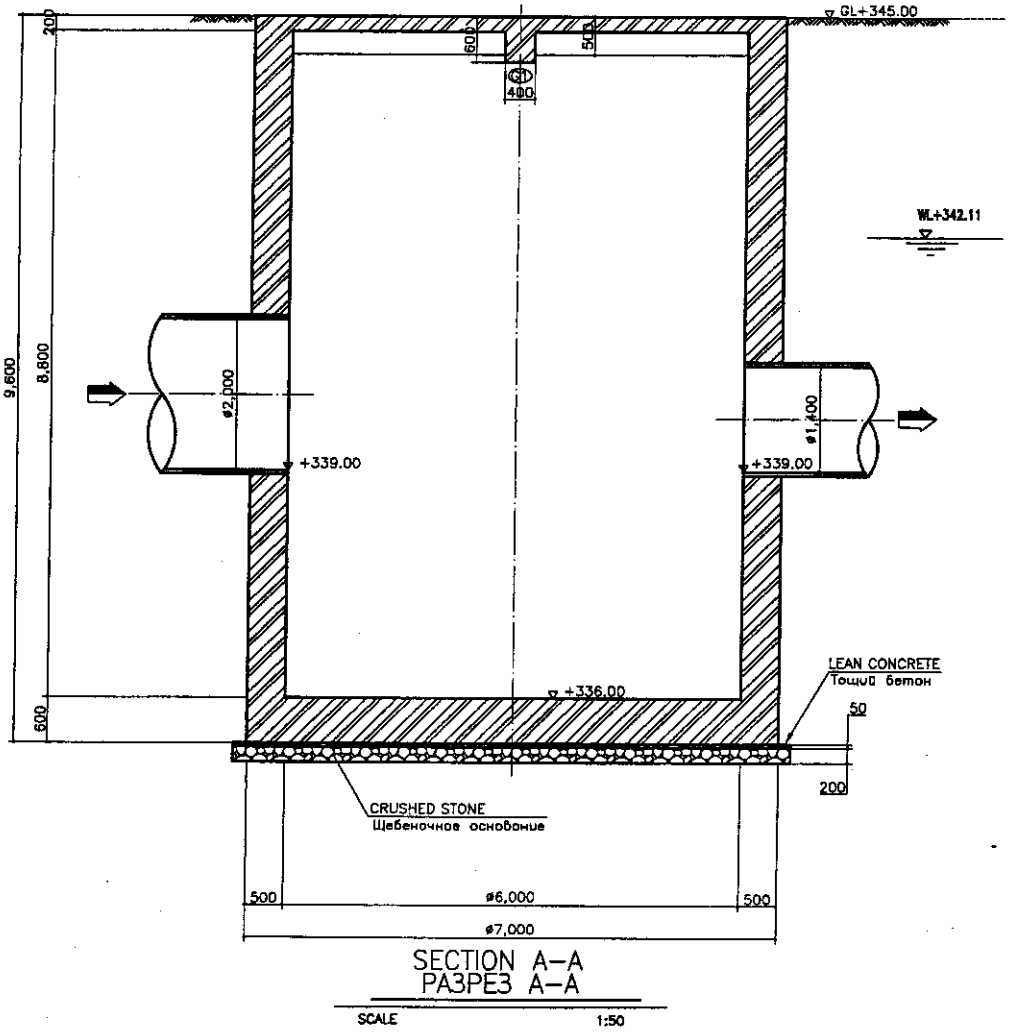
1 normal condition	crack width＜0.3mm
2 severe condition	crack width＜0.2mm
3 very severe condition	crack width＜0.1mm

Temp IPS structure (1/2)



Temp IPS structure (2/2)





4. Primary Sedimentation Tank

4.1Material and Allowable stress

TABLE 4.1 Allowable Stress (N/mm2, kg /cm2)

Item		Serviceability strength			Ultimate strength		
		Compression	Tension	Shear	Compression	Tension	Shear
Concrete	B30	10		0.8	30		1.2
		100	-------	8	300	-------	12
Steel Bar	A- I	157.0	157.0	157.0	235.4	235.4	235.4
Round Bar		1600	1600	1600	2400	2400	2400
Steel Bar	A- II	196.2	196.2	196.2	358.1	358.1	358.1
Deformed Bar		2000	2000	2000	3650	3650	3650

upper: SI units N/mm2

lower: MKS units kg/cm2

TABLE 4.2 Allowable Bonding Stress of Steel Bar to Concrete (N/mm2, kg /cm2)

Item	Serviceability strength		Remarks
	Top bars	Other bars	
	0.9	1.3	
ϕ6,ϕ9,ϕ12	9	13.5	
D10,D13,D16	1.6	2.4	
D19,D22,D25,D29	16.2	24.3	

upper: SI units N/mm2

lower: MKS units kg/cm2

4.2 Load Table

TABLE 4.3 Dead Load

Loc.	item	thickness	kg/m2	total kg/m2	Remarks
Foundation	Leveling motar	2.5	63		
	Concrete slab	60cm	1500		
				1563	<-------- MKS UNIT
				15328	<-------- SI UNIT

TABLE 4.4 Live Load and Floor Load

kg/m2 (Girder, Sub beam : Self weight not included)

Loc.	load type	Foundation	beam	girder	Remarks	
Mechanical eq.	Dead Load	-	-	-		
	Live Load	30000.0	-	-		Load of heay equipment
	Total Load	30000.0	-	-		
	SI unit	294300	-	-		<-------- SI UNIT

4.3.Wall of cylindrical tanks for Primary Sedimentation Tanks (/)

1) Spec of Tank

Diameter	d	28	m	Unit Water load	DI	1.0 t/m3=	9.81 kN/m3
Water Depth	h	3.5	m	Supporting condition of bottom :		Rigid	
Wall Thickness	t	600	mm			α e:	15
Wall height	h1	3.8	m	f st =	120 N/mm2		
				f ct =	2.00 N/mm2	fcu=	30
Unit concrete weight		23.544	kN/m3	permissible tensile stress		not used	

2) Employed Equation for analysis

*Same with the former section

3) Forces and Bending Moment /Reinforcement

0 h^2/d/t= 0.729 then K1= 0.045 K2= 0.55 K3= 0.26

By table 184, pp.405

1 BM at bottom= 18.93 kNm/m

2 Position height of max tension = 1.925 m above the bottom

3 Max circumference tension = 124.98 kN/m around the position of the above

4 Reqired As= 40.1 cm2 for tension

5 Min. thickness of wall = 184.26 mm

6 Direct comp.= 1293.87 kN/m2

= 1.294 N/mm2

Reinforcement

5— D25

5— D25

As= 49.1 cm2

pt= 0.82 %>0.3%

7 Shearing force V1=F/PI/d

= 24.50 kN

8 Distribution Rebar

5— D22

4.2. Foundation

1) Effect of water pressure

Ground Level =	347.0 m
Ground Water Level =	342 m
Bottom slab level=	343.6 m
Height of Bottom slab=	0.6 m
Soffit of bottom slab=	(1.0) m

Upward thrust by water pressure

p= 9.81 kN/m3 × (1.0) = −9.81 kN/m2

A= 824.5 m2 (including wall thickness)

P= −8088.2 kN

2) Bottom slab depth

*Basement including structure wall must be designed to prevent flotation

Weight		
GL slab	0 kN	(Slab thickness 0 m)
wall	4823.164 kN	
Total	4823.164 kN	

Required weight for bottom −8088.16 − 4823 = −12911 kN

Minimum depth Fs=1.0 t= −0.66513 m

*No upward thrust will not affect to this structure.

*Reinfocement

Radial reinforcement 200@ D25

3) Weight of PST

*Structure

	Diameter	height	thickness	unitweight	weight	
Wall	28.6	3.8	0.6	23.544	4,823	kN
Base	30.2		0.6	23.544	10,119	kN
Water	28.0	3.5		9.81	21,142	kN
Total					36,084	kN

*Equipoment

Sludge collecter	design weight 30 t	294	kN

*Grand total		36,378	kN	

Unit load strength

36378.3 kN	/	716.3 m2	=	50.8 kN/m2

3.6 Limit state analysis

Rectanglar section design and limited state analysis (1/1)

Concrete Permissible Strength		f'ck=	17 N/mm2	by use of B30	30
	Direct tensile stress	ft=	2.00 N/mm2		
	Elasticity ratio	n=	15		
	Elasticity	E=	200000 N/mm2		
Permissible strength		σsa=	250 N/mm2	round	from BS
		σsa=	140 N/mm2	deformed	from BS
Ultimate strength (characteristic strength)		σs=	365 N/mm2		

Check point				Wall	
Force	Bending Moment	Md	kN·m	18.9	
	Shearing force	Sd	kN	24.5	
Section Spec	Width	b	cm	100	
	Height	h	cm	60	
	Cover	dt	cm	5	
	Effective Height	d	cm	55	
Rebar Cross Section	Tension Rebar		cm^2	5－ D25	
				As= 24.55	
	Compression Rebar		cm^2	5－ D25	
				As= 24.55	
Stress	Concrete stress		N/mm2	0.3	
	Rebar stress		N/mm2	14.9	
	Shearing stress		N/mm2	0.049	

B.M value for crack		Mcr	kNm	80.79	
Crack width	Rebar interval	cs	mm	200	
	Rebar diameter	φ	mm	25	
	Cover depth	c	mm	70	
	Rebar stress	σse	N/mm2	15.3	
	Crack width	wcr	mm	0.091	
Judgement: wcr<0.2 : OK				**OK**	

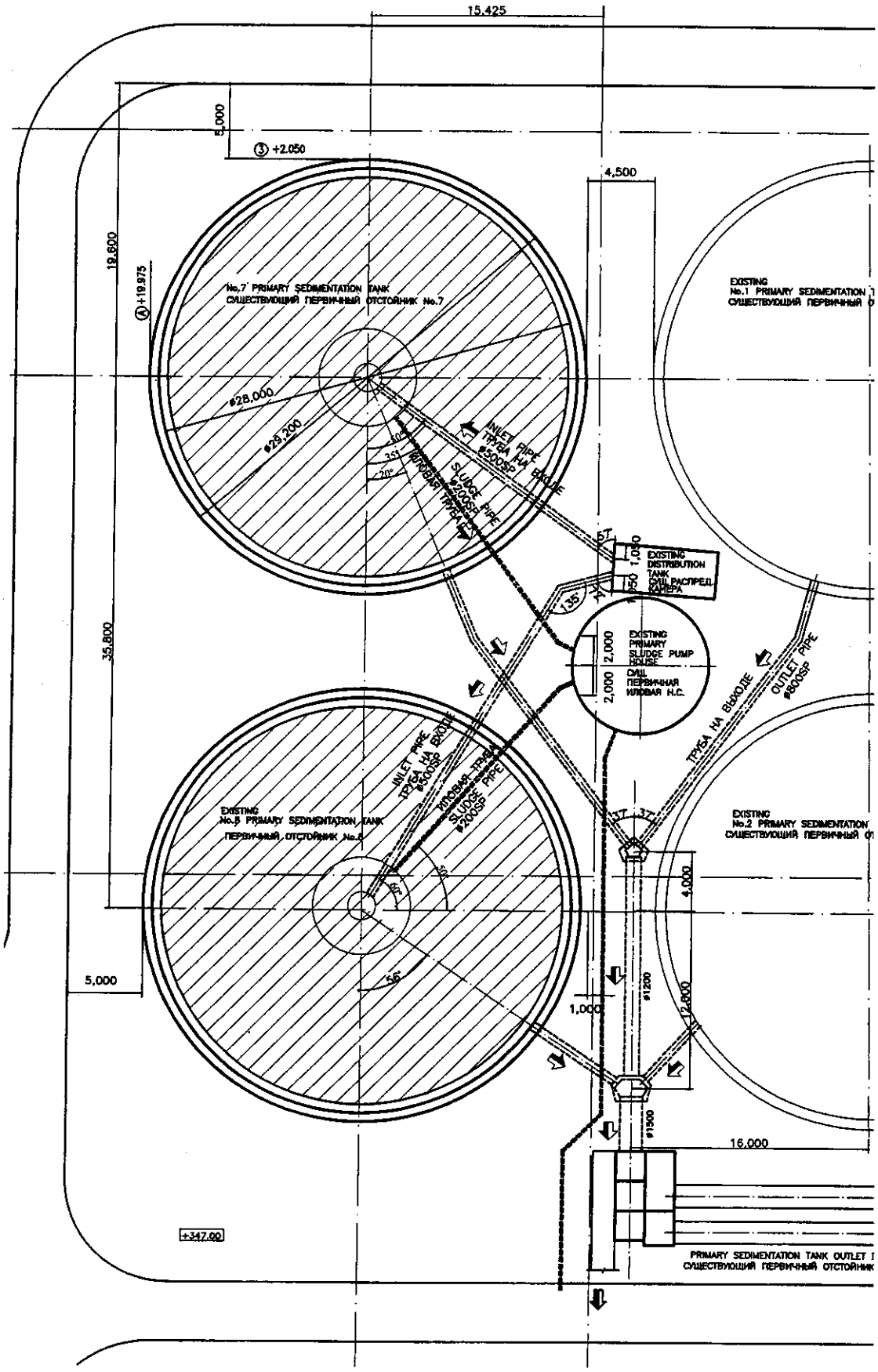
Examination with the Ultimate BM Strength

Ultimate B.M Strength	Mud	kNm	471.96	
γi·Md/Mud			0.040	
Judgement: γi·Md/Mud<1.0 : OK			OK	

Crack width shall be controled as follows:

1 normal condition	crack width＜0.3mm
2 severe condition	crack width＜0.2mm
3 very severe condition	crack width＜0.1mm

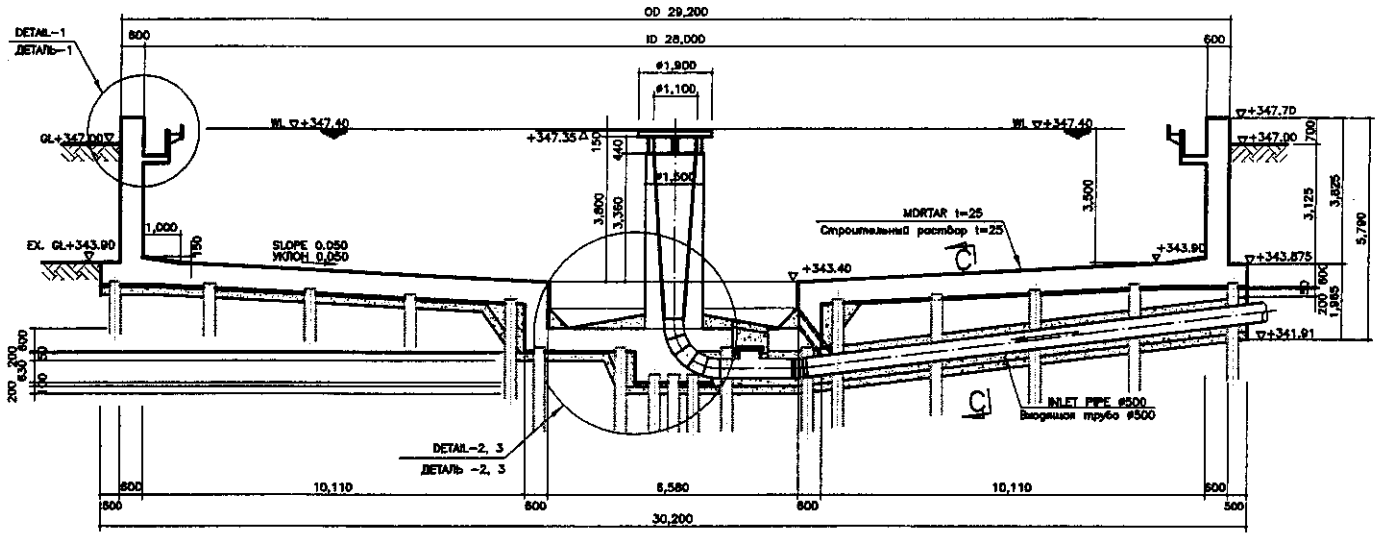
PST structure(1/2)



PRIMARY SEDIMENTATION TANK LAYOUT
РАСПОЛОЖЕНИЕ ПЕРВИЧНЫХ ОТСТОЙНИКОВ

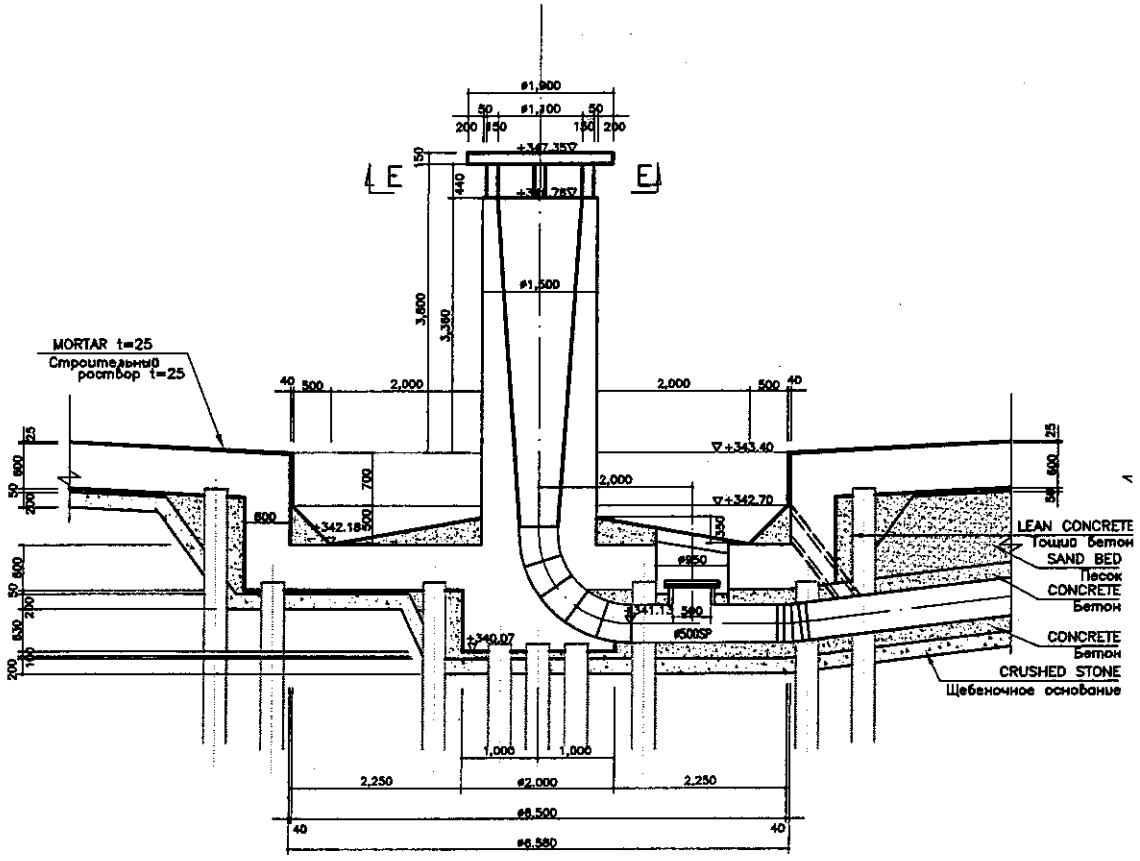
SCALE 1:200

PST structure(2/2)



SECTION A–A
РАЗРЕЗ A–A

SCALE 1:100



DETAIL-2
ДЕТАЛЬ-2

SCALE 1:50

5. Secondary Sedimentation Tank

5.1Material and Allowable stress

TABLE 5.1 Allowable Stress (N/mm2, kg /cm2)

Item		Serviceability strength			Ultimate strength		
		Compression	Tension	Shear	Compression	Tension	Shear
Concrete	B30	10		0.8	30		1.2
		100	-------	8	300	-------	12
Steel Bar Round Bar	A- I	157.0	157.0	157.0	235.4	235.4	235.4
		1600	1600	1600	2400	2400	2400
Steel Bar Deformed Bar	A- II	196.2	196.2	196.2	358.1	358.1	358.1
		2000	2000	2000	3650	3650	3650

upper: SI units N/mm2

lower: MKS units kg/cm2

TABLE 5.2 Allowable Bonding Stress of Steel Bar to Concrete (N/mm2, kg /cm2)

Item	Serviceability strength		Remarks
	Top bars	Other bars	
ϕ6,ϕ9,ϕ12	0.9	1.3	
	9	13.5	
D10,D13,D16	1.6	2.4	
D19,D22,D25,D29	16.2	24.3	

upper: SI units N/mm2

lower: MKS units kg/cm2

5.2 Load Table

TABLE 5.3 Dead Load

Loc.	item	thickness	kg/m2	total kg/m2	Remarks
Foundation	Leveling motar	2.5	63		
	Concrete slab	60cm	1500		
				1563	<-------- MKS UNIT
				15328	<-------- SI UNIT

TABLE 5.4 Live Load and Floor Load

kg/m2 (Girder, Sub beam : Self weight not included)

Loc.	load type	Foundation	beam	girder	Remarks	
Mechanical eq.	Dead Load	-	-	-		
	Live Load	30000.0	-	-		Load of heay equipment
	Total Load	30000.0	-	-		
	SI unit	294300	-	-		<-------- SI UNIT

5.3.Wall of cylindrical tanks for Secondary Sedimentation Tanks (/)

1) Spec of Tank

Diameter	d	28	m	Unit Water load	DI	1.0 t/m3=	9.81 kN/m3
Water Depth	h	4	m	Supporting condition of bottom :		Rigid	
Wall Thickness	t	600	mm			αe:	15
Wall height	h1	4.2	m	f st =	120 N/mm2		
				f ct =	2.00 N/mm2	fcu=	30
Unit concrete weight		23.544	kN/m3	permissible tensile stress		not used	

2) Employed Equation for analysis

*Same with the former section

3) Forces and Bending Moment /Reinforcement

0 h^2/d/t= 0.952 then K1= 0.045 K2= 0.55 K3= 0.26

By table 184, pp.405

1 BM at bottom= 28.25 kNm/m

2 Position height of max tension = 2.2 m above the bottom

3 Max circumference tension = 142.83 kN/m around the position of the above

4 Reqired As= 45.8 cm2 for tension

Reinforcement

5 Min. thickness of wall = 210.59 mm — 5— D25

6 Direct comp.= 1478.71 kN/m2 — 5— D25

= 1.479 N/mm2 — As= 49.1 cm2

pt= 0.82 %>0.3%

7 Shearing force V1=F/PI/d

= 24.50 kN

8 Distribution Rebar

5— D22

5.4 Foundation

1) Effect of water pressure

Ground Level =	345.0 m
Ground Water Level =	343 m
Bottom slab level=	341.3 m
Height of Bottom slab=	0.7 m
Soffit of bottom slab=	2.4 m

Upward thrust by water pressure

p= 9.81 kN/m3 × 2.4 = 23.54 kN/m2

A= 824.5 m2 (including wall thickness)

P= 19411.6 kN

2) Bottom slab depth

*Basement including structure wall must be designed to prevent flotation

Weight			
GL slab	0 kN	(Slab thickness	0 m)
wall	5331 kN		
Total	5331 kN		

Required weight for bottom 19411.59 − 5331 = 14080.7 kN

Minimum depth Fs=1.0 t= 0.725377 m

*No upward thrust will not affect to this structure.

*Reinfocement

Radial reinforcement 200@ D25

3) Weight of SST

*Structure

	Diameter	height	thickness	unitweight	weight	
Wall	28.6	4.2	0.6	23.544	5,331	kN
Base	30.2		0.6	23.544	10,119	kN
Water	28.0	4		9.81	24,162	kN
Total					39,612	kN

*Equipment

Sludge collecter	design weight 30 t	294	kN

*Grand total		39,906	kN

Unit load strength per m2

39906.3 kN	/	716.3 m2	=	55.7 kN/m2

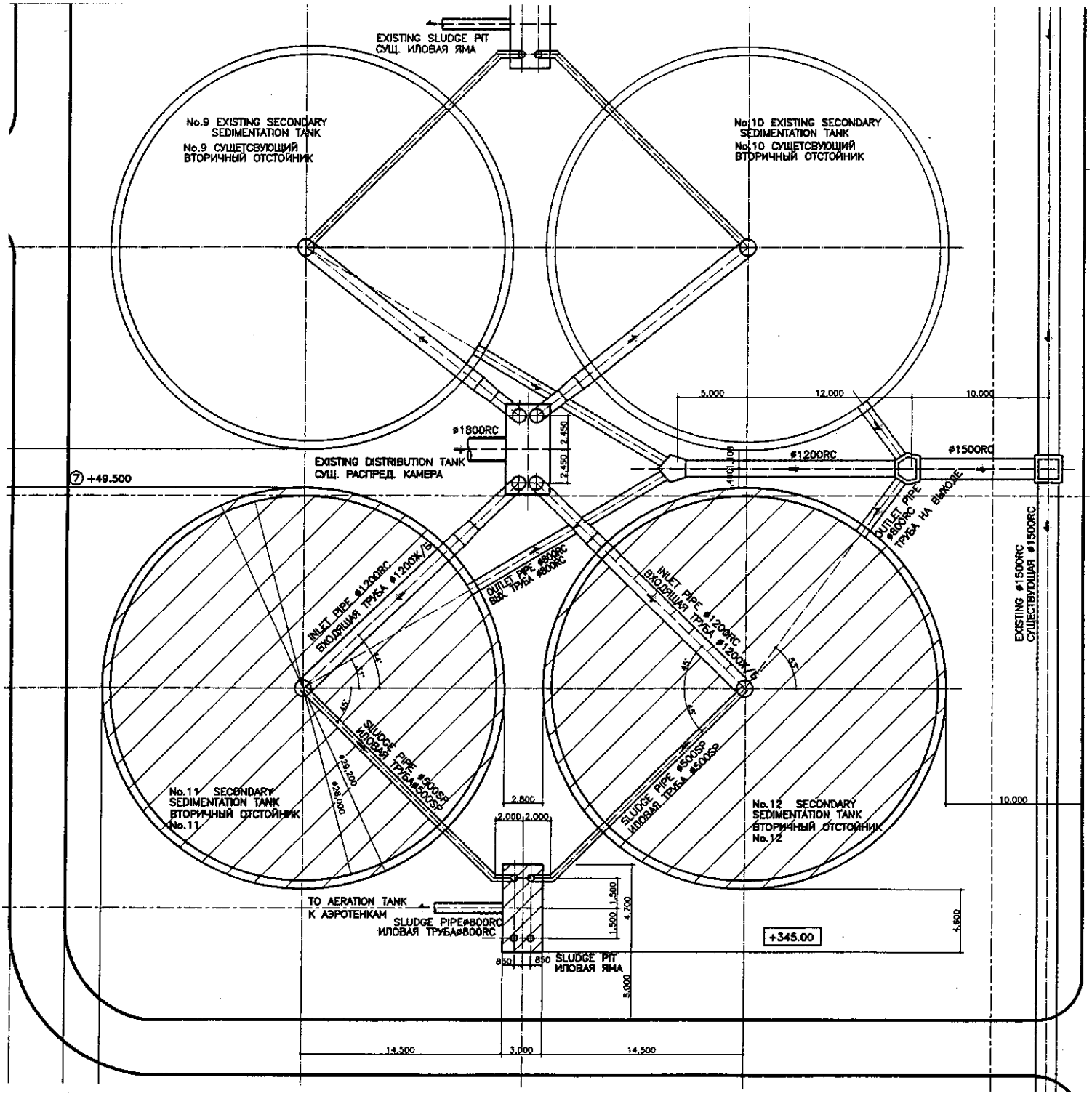
3.6 Limit state analysis

5.5Rectanglar section design and limited state analysis						(1/1)
Concrete Permissible Strength		f'ck=	17	N/mm2	by use of B30	30
	Direct tensile stress	ft=	2.00	N/mm2		
	Elasticity ratio	n=	15			
	Elasticity	E=	200000	N/mm2		
Permissible strength		σsa=	250	N/mm2	round	from BS
		σsa=	140	N/mm2	deforme	from BS
Ultimate strength (characteristic strength)		σs=	365	N/mm2		

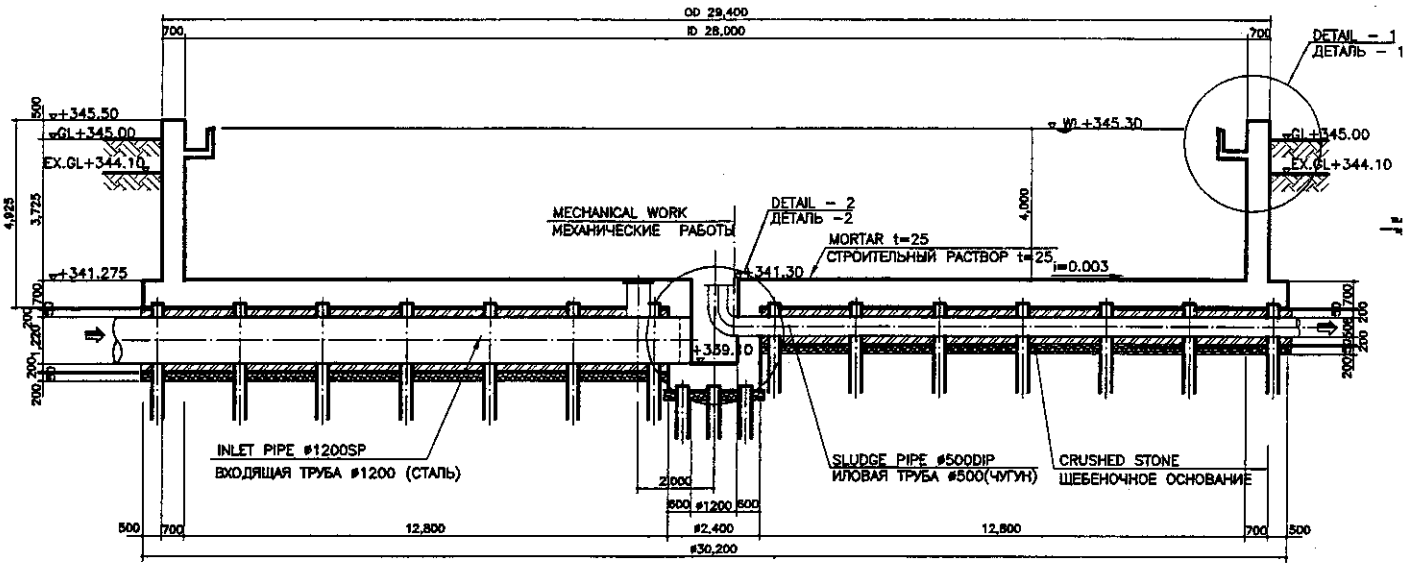
Check point				Wall	
Force	Bending Moment	Md	kN·m	28.3	
	Shearing force	Sd	kN	24.5	
Section Spec	Width	b	cm	100	
	Height	h	cm	60	
	Cover	dt	cm	5	
	Effective Height	d	cm	55	
Rebar Cross Section	Tension Rebar		cm^2	5— D25	
				As= 30.80	
	Compression Rebar		cm^2	5— D25	
				As= 30.80	
Stress	Concrete stress		N/mm2	0.5	
	Rebar stress		N/mm2	17.8	
	Shearing stress		N/mm2	0.049	
B.M value for crack		Mcr	kNm	83.00	
Crack width	Rebar interval	cs	mm	200	
	Rebar diameter	φ	mm	25	
	Cover depth	c	mm	70	
	Rebar stress	σse	N/mm2	18.4	
	Crack width	wcr	mm	0.097	
Judgement: wcr<0.2 : OK				**OK**	
Examination with the Ultimate BM Strength					
Ultimate B.M Strength		Mud	kNm	586.39	
γi·Md/Mud				0.048	
Judgement: γi·Md/Mud<1.0 : OK				OK	

Crack width shall be controled as follows:

1 normal condition	crack width＜0.3mm
2 severe condition	crack width＜0.2mm
3 very severe condition	crack width＜0.1mm

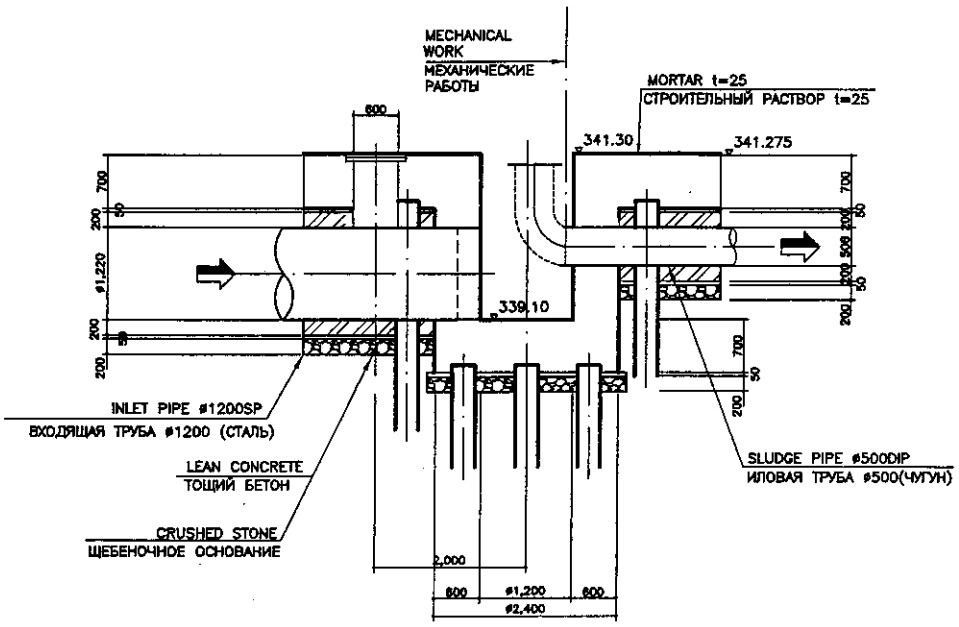

EXISTING SLUDGE PIT
СУЩ. ИЛОВАЯ ЯМА
No.9 EXISTING SECONDARY SEDIMENTATION TANK
No.9 СУЩЕТСВУЮЩИЙ ВТОРИЧНЫЙ ОТСТОЙНИК
No.10 EXISTING SECONDARY SEDIMENTATION TANK
No.10 СУЩЕТСВУЮЩИЙ ВТОРИЧНЫЙ ОТСТОЙНИК
ø1800RC
EXISTING DISTRIBUTION TANK
СУЩ. РАСПРЕД. КАМЕРА
ø1200RC
ø1500RC
+49.500
5,000
12,000
10,000
2,450
2,450
4,600
INLET PIPE ø1200RC
ВХОДЯЩАЯ ТРУБА ø1200Ж/БЕТ
OUTLET PIPE ø800RC
ВЫХ. ТРУБА ø800RC
OUTLET PIPE ø800RC
ТРУБА НА ВЫКОДЕ
EXISTING ø1500RC
СУЩЕСТВУЮЩАЯ ø1500RC
INLET PIPE ø1200RC
ВХОДЯЩАЯ ТРУБА ø1200Ж/БЕТ
45°
45°
45°
45°
SLUDGE PIPE ø500SP
ИЛОВАЯ ТРУБА ø500SP
SLUDGE PIPE ø500SP
ИЛОВАЯ ТРУБА ø500SP
ø29,200
ø28,000
No.11 SECONDARY SEDIMENTATION TANK
ВТОРИЧНЫЙ ОТСТОЙНИК
No.11
No.12 SECONDARY SEDIMENTATION TANK
ВТОРИЧНЫЙ ОТСТОЙНИК
No.12
2,800
2,000
2,000
10,000
TO AERATION TANK
К АЭРОТЕНКАМ
SLUDGE PIPE ø800RC
ИЛОВАЯ ТРУБА ø800RC
1,500
1,500
4,700
4,600
+345.00
850
850
SLUDGE PIT
ИЛОВАЯ ЯМА
5,000
14,500
3,000
14,500

SST structure(2/2)



SECTION A–A
РАЗРЕЗ A–A

SCALE 1:100



DETAIL – 3
ДЕТАЛЬ – 3

SCALE 1:50

6. Blower base

6.1Material and Allowable stress

TABLE 6.1 Allowable Stress (N/mm2, kg /cm2)

Item		Serviceability strength			Ultimate strength		
		Compression	Tension	Shear	Compression	Tension	Shear
Concrete	B30	10		0.8	30		1.2
		100	-------	8	300	-------	12
Steel Bar Round Bar	A- I	157.0	157.0	157.0	235.4	235.4	235.4
		1600	1600	1600	2400	2400	2400
Steel Bar Deformed Bar	A-Ⅱ	196.2	196.2	196.2	358.1	358.1	358.1
		2000	2000	2000	3650	3650	3650

upper: SI units N/mm2

lower: MKS units kg/cm2

TABLE 6.2 Allowable Bonding Stress of Steel Bar to Concrete (N/mm2, kg /cm2)

Item	Serviceability strength		Remarks
	Top bars	Other bars	
ϕ6,ϕ9,ϕ12	0.9	1.3	
	9	13.5	
D10,D13,D16 D19,D22,D25,D29	1.6	2.4	
	16.2	24.3	

upper: SI units N/mm2

lower: MKS units kg/cm2

6.2 Load Table

TABLE 6.3 Dead Load

Loc.	item	thickness	kg/m2	total kg/m2	Remarks
slab	Mortar	-	-		
	Concrete slab	30cm	750		
				750	<------- MKS UNIT
				7358	<------- SI UNIT
Common slab	Leveling motar	-	-		
	Concrete slab	20cm	500		
				500	<------- MKS UNIT
				4905	<------- SI UNIT

TABLE 6.4 Live Load and Floor Load

kg/m2 (Girder, Sub beam : Self weight not included)

Loc.	load type	slab	beam	girder	Remarks	
slab	Dead Load	750.0	750.0	750.0		
	Live Load	1421.6	1421.6	1421.6	**)	
	Total Load	2171.6	2171.6	2171.6		
	SI unit	21303	21303	21303		<------- SI UNIT

**) Blower

Live load : 29ton = 284.49 kN

Base daimension 6.0 * 3.4 = 20.4 m2

Average load 1,421.6 kg/m2

13.9 kN/m2

Frequency = 50 Hz

6.3 Facility weight

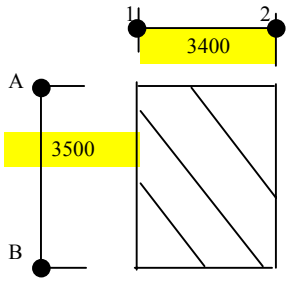
Table6.5 Grit Chamber Weight

Story	Load type	Unit w (kN/m2,m)	width /hight (m) or unit	Length (m)	Area or L (m2), (m)	Weight (kN)	Small Total (t)	S Wi (t)
	slab	7.36	3.4	6.00	20.40	150.09		
	Machine	13.95	3.4	6.00	20.40	284.49		
1st story	Girder 2.2m	8.09	2	2.20	4.40	35.61		
	Girder 1.2m	8.09	2	1.20	2.40	19.42		
	Girder 1.7m	8.09	3	1.70	5.10	41.28		
							530.89	530.89
Column	800*800	7.36	4.4	6.00	26.40	194.24		
	h=4.25m	15.70	6	4.25	25.50	400.25		
							594.49	1125.38
		Base Area	**20.40**	**(m2)**			**Total W=**	**1,125.38**
							W-Base=	**530.9**

reaction =W/(Base area)= **55.166** (kN/m2)

6.4 SLAB

S1 Load condition



		Area		unit weight	kN
Floor slab=		11.90	x	21.3=	253.51
Wall=			x		0.00
				Σ =	253.5

lx= 3.4 m
ly= 3.5 m
λ = 1.03

t(cm)= 30
d(cm)= 25
cover(cm)= 5

A= 11.9 m2

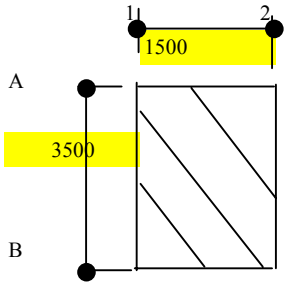
	a	wlx2(kNm2)	M(Nm)	Additional M from wall	Total M	at= M/(σ sjd)	re-bars	
Mx1=	0	260.96	0.0		0	0.000 cm2	upper 4-D10-->D10@200	3.93cm2
Mx2=	0.035	260.96	9,133.7			2.128 cm2	bottom4 -D10-->D10@200	3.93cm2
								0.3%
My1=	0	260.96	0.0	0	0	0.000 cm2	upper 4-D10-->D10@200	3.93cm2
My2=	0.042	260.96	10,960.4			2.554 cm2	bottom 4-D10-->D10@200	3.93cm2
		wlx	Q(N)			ϕ=Q/(τa jd)		0.3%
Qx =	0.44	74.56	32,806.8			6.29 cm <	15.7 ok	
Qy =	0.44	74.56	32,806.8			6.29 cm <	15.7 ok	

Suffix 1: end of span
Suffix 2: middle of span
From nomogram of two-way slab of free-support

Q cap
196,200 N > Q out
196,200 N > Q out

No adjustment, since beam width(60cm) covers the area of "out".

S2 Load condition



		Area		unit weight	kN
Floor slab=		5.25	x	21.3=	111.84
Wall=			x		
				Σ =	111.8

lx= 1.5 m
ly= 3.5 m
λ = 2.33

t(cm)= 30
d(cm)= 25
cover(cm)= 5

A= 5.25 m2

	a	wlx2(kNm2)	M(Nm)	Additional M from wall	Total M	at= M/(σ sjd)	re-bars	
Mx1=			0.0		0	0.000 cm2	upper 2-D10-->D10@200	3.93cm2
Mx2=	0.105	47.93	5,032.9			1.173 cm2	bottom 2-D10-->D10@200	3.93cm2
								0.3%
My1=			0.0	0	0	0.000 cm2	upper 2-D10-->D10@200	3.93cm2
My2=	0.014	47.93	671.0			0.156 cm2	bottom 2-D10-->D10@200	3.93cm2
		wlx	Q(N)			ϕ=Q/(τa jd)		0.3%
Qx =	0.5	31.95	15,977.3			3.06 cm <	15.7 ok	
Qy =	0.46	31.95	14,699.1			2.82 cm <	15.7 ok	

Suffix 1: end of span
Suffix 2: middle of span
From nomogram of two-way slab

Q cap
196,200 N > Q ok
196,200 N > Q ok

6.5 BEAMS

1) **B1**

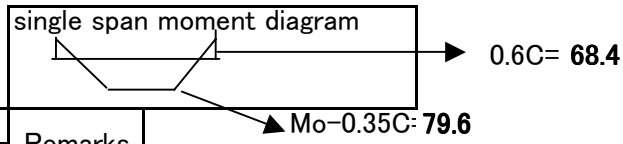
Typical example of the beam is the 2.2m length .

B1	Load form	(slab load)		(slab load)		(girder load)+ other loads		Σ
		C/w	Co	Co/w	Co	w/l	Co	kNm
	Co			5.13	109.22	4.70	4.80	114.02
		M/w	Mo	Mo/w	Mo	w/l	Mo	kNm
bxD 40x60	Mo			5.27	112.35	4.70	7.20	119.55
(cm)		Q/w	Q	Q/w	Q	w/l	Q	kN
	Q			1.13	23.99	4.70	8.23	32.21
	Slab load =	21.3	(kN/m2)	ly=	3.5	m		
	Span =	3.5	(m)	lx=	1.70	m		λ= 2.06

1.Girder load= 4.70 kN/m
dead load

2.Line load = 0.00 kN/m + kN/m = 0.00 kN/m
roof wall

Total = 4.70 kN/m



2) Determination of beam B1

Beam ID	B1			Remarks
Position	B end	Mid	C end	
D.L] M(kNm) top	68.4		68.4	
+] bott.		79.6		seismic force neglected
L.L] Q (kN)	32.21		32.21	
] b x D (cm)	40	x	50	
Size] d (cm)			45	
] j(cm)			39.375	
top	8.9		8.9	cm2
	3D25		3D25	at= M/(σ sjd)
bottom		10.3		cm2
		3D25		
τ=Q/bjd	0.20		0.20	N/mm2
top	1.03		1.03	min.0.4%
Pt (%) bott.		1.03		
top	18.48		18.48	
at (cm2) bott.		18.48		
Main top	3	3	3	
Bars		28		
bott	3	3	3	
φ (cm)	23.55		23.55	
Q /fa.j (cm)	0.35		0.35	max
judge	ok		ok	1.7
fs.bj LT(ST)	121.3		121.3	kN
(t)	D10-250	D10-250	D10-250	
judge	ok		ok	

6.6 Column Profile

Column ID		Blower Base								Remarks
Direction		X		Y		X		Y		
Position		T	B	T	B	T	B	T	B	
LT	N (t)		4.83		4.83					
	M(tm)									
	Q(t)									
ET	N (t)									
	M(tm)									
	Q(t)									
ST	N (t)		4.83		4.83					
	M(tm)	0	0	0	0					
	Q(t)		0		0					
Size	b x d (cm), J(cm)	80	80	80	80					
	$bD(x10^2)$,$bDD(x10^3)$		6.4		5.12					
LT	N/ bD (kg/cm2)		0.76		0.75					
	M/bD2 (kg/cm2)		0.00	0.00	0.00					
	Pt(%)	0.20	0.20	0.20	0.20					
ST	N/ bD (kg/cm2)									
	M/bD2 (kg/cm2)									
	Pt(%)									
at (cm2)			12.8		12.8					
					25.6					
Main Bars D22 arrangement			3 Y 3 X - X D22 Y 3		30.4					
LT or ST	ϕ (cm)	28.26	28.26	28.26	28.26					
	Q/fa.j (cm)		0		0					
	judge		ok		ok					
	QA=fs.bj (t)		40.425		40.425					
	judge		ok		ok					
Pw (%)										
hoop			D10 - 150							

6.7 Limit state analysis

Rectanglar section design and limited state analysis (1/1)

Concrete Permissible Strength	f'ck=	17	N/mm2	by use of B30	30
Direct tensile stress	ft=	2.00	N/mm2		
Elasticity ratio	n=	15			
Elasticity	E=	200000	N/mm2		
Permissible strength	σsa=	250	N/mm2	round	from BS
	σsa=	140	N/mm2	deforme	from BS
Ultimate strength (characteristic strength)	σs=	365	N/mm2		

Check point				B1	
Force	Bending Moment	Md	kN·m	68.4	
	Shearing force	Sd	kN	32.2	
Section Spec	Width	b	cm	40	
	Height	h	cm	50	
	Cover	dt	cm	5	
	Effective Height	d	cm	45	
Rebar Cross Section	Tension Rebar		cm^2	3－ D28	
				As= 18.48	
	Compression Rebar		cm^2	3－ D28	
				As= 18.48	
Stress	Concrete stress		N/mm2	2.9	
	Rebar stress		N/mm2	88.3	
	Shearing stress		N/mm2	0.201	

B.M value for crack		Mcr	kNm	24.94
Crack width	Rebar interval	cs	mm	170
	Rebar diameter	φ	mm	28
	Cover depth	c	mm	50
	Rebar stress	σse	N/mm2	92.5
	Crack width	wcr	mm	0.183
Judgement: wcr<0.2 : OK				**OK**

Examination with the Ultimate BM Strength

Ultimate B.M Strength	Mud	kNm	279.65
γi·Md/Mud			0.245
Judgement: γi·Md/Mud<1.0 : OK			OK

Crack width shall be controled as follows:

1 normal condition	crack width＜0.3mm
2 severe condition	crack width＜0.2mm
3 very severe condition	crack width＜0.1mm

6.8 Examination of vibration by equipment

lx=	3.5	m	
ly=	6	m	Weight of Equipmen 29 t
t=	30	cm	= 29000 kg
w=	2171	kg/m2	

Concrete unit weight = 2400 kg/m3
= 0.0024 kg/cm3

volume unit weight Equipment g
Total mass =(6,300,000 x 0.00240 + ####) / 980 = 45.02 kg s2/cm

Effective mass= 0.234 x 45.02 = 10.53 kg s2/cm
from nomogram 11.4

Slab Natural Frequency 129 Hz (E= 2.1 x 10 ^5 kg/cm2)
from nomogram 11.2

Blower Rotation = 3000 r.p.m

Therefore, Natural Frequency of slab is small enough compared with the vibration of Blower.
Resonannce phenomenon shall be avoided.

* The following is a examination by K-value in "DIN 4025" on the assumtion that impact value of jumping at upstair is the same with the blower.

Impact value Vo= 1.8 kg s at jumping on the upstair by adult man

Impact time = 0.0200000 0.02

to fv= 0.02000000 x 129 = 2.58 ⇒ kδ = 0.145

Decay coefficient = 0.05

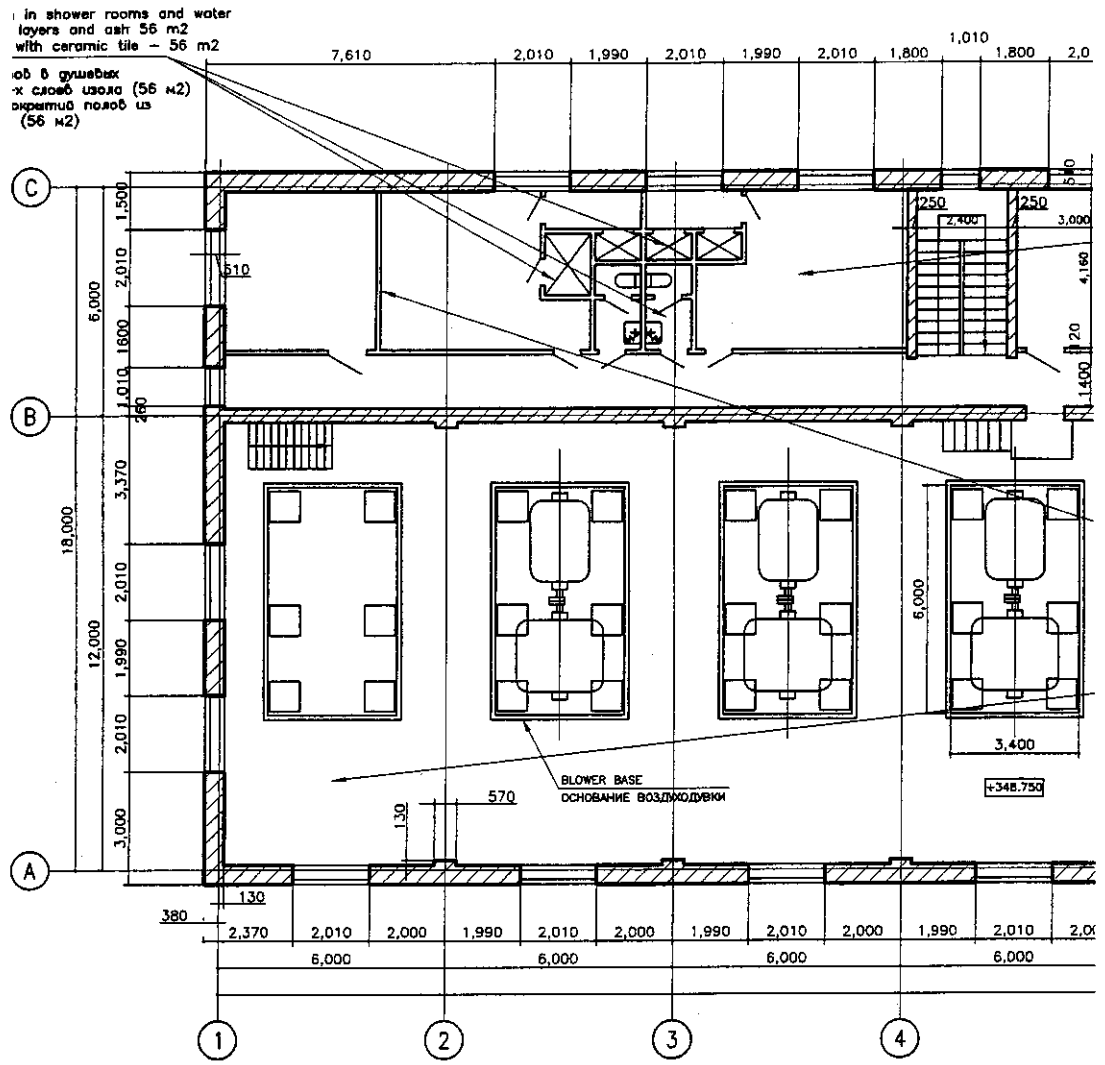
δ = 0.145 × 1.8 / (2π × 129 × 10.53)

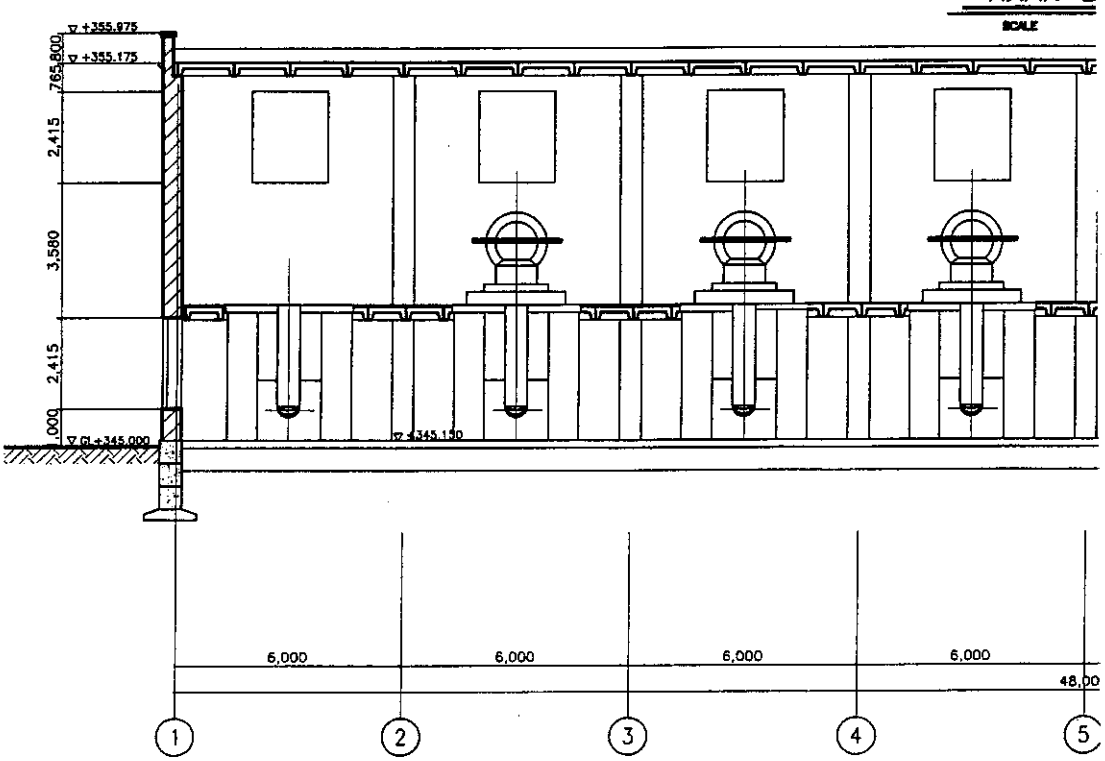
= 3.057E-05 = 0.3057 μ

K value is from 0.1 to 0. from the figure

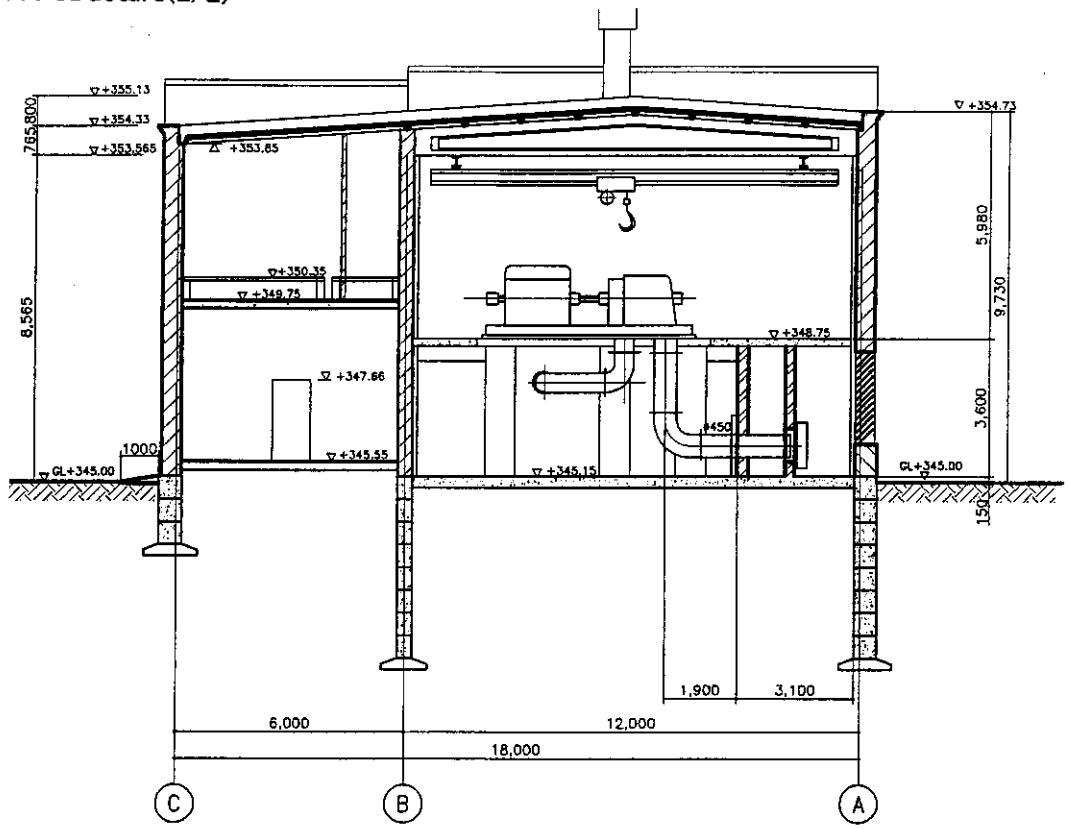
Vibration noticeable but able to withstand.
No influence

Blower base structure(1/2)



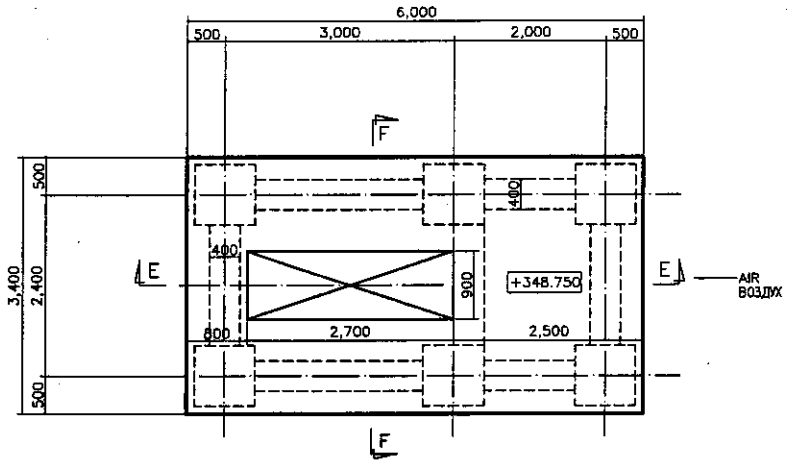


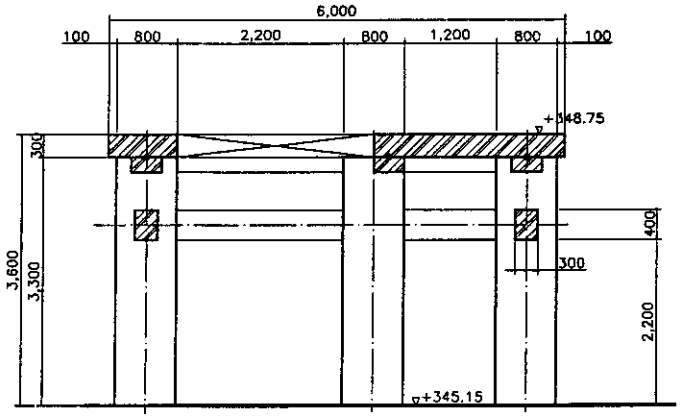
Blower base structure(2/2)



SECTION C–C
РАЗРЕЗ D–D

SCALE 1:100





7.Distribution chamber

7.1Material and Allowable stress

TABLE 7.1 Allowable Stress (N/mm2, kg /cm2)

Item		Serviceability strength			Ultimate strength		
		Compression	Tension	Shear	Compression	Tension	Shear
Concrete	B30	10		0.8	30		1.2
		100	-------	8	300	-------	12
Steel Bar Round Bar	A- I	157.0	157.0	157.0	235.4	235.4	235.4
		1600	1600	1600	2400	2400	2400
Steel Bar Deformed Bar	A-Ⅱ	196.2	196.2	196.2	358.1	358.1	358.1
		2000	2000	2000	3650	3650	3650

upper: SI units N/mm2

lower: MKS units kg/cm2

TABLE 7.2 Allowable Bonding Stress of Steel Bar to Concrete (N/mm2, kg /cm2)

Item	Serviceability strength		Remarks
	Top bars	Other bars	
ϕ6,ϕ9,ϕ12	0.9	1.3	
	9	13.5	
D10,D13,D16 D19,D22,D25,D29	1.6	2.4	
	16.2	24.3	

upper: SI units N/mm2

lower: MKS units kg/cm2

7.2 Load Table

TABLE 7.3 Dead Load

Loc.	item	thickness	kg/m2	total kg/m2	Remarks
Slab	Concrete slab	20cm	500	500	<------- MKS UNIT
				4905	<------- SI UNIT
foundation	Leveling motar	-	-		
	Concrete slab	50cm	1250	1250	<------- MKS UNIT
				12263	<------- SI UNIT

TABLE 7.4 Live Load and Floor Load

kg/m2 (Girder, Sub beam : Self weight not included)

Loc.	load type	slab	Remarks	
slab	Dead Load	360.0		
	Live Load	500.0		
	Total Load	860.0		
	SI unit	8437		<------- SI UNIT

7.3 Facility weight

Table7.5 Tank Weight

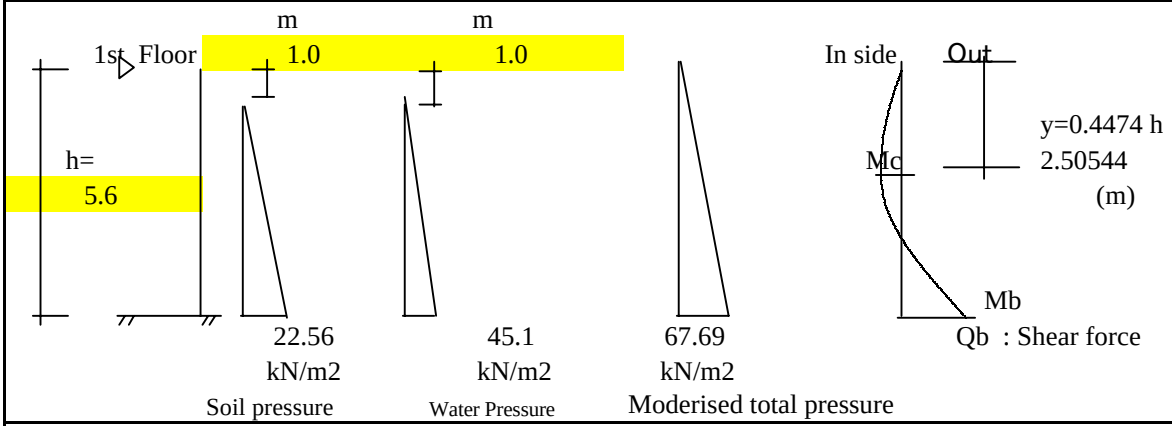
Story	Load type	Unit w (kN/m2,m)	width /hight (m) or unit	Length (m)	Area or L (m2), (m)	Weight (kN)	Small Total (t)	S Wi (t)
	slab	4.91	2.5	7.00	17.50	85.84		
	Wall 1	4.91	12	5.60	67.20	329.62		
Chamber	Wall 2	4.91	14	5.60	78.40	384.55		
	Water 1	9.81	4.5	2.50	7.00	772.54		
							1572.54	1572.54
Base	t500 Base	12.26	7	8.40	58.80	721.04		
								(kN)
				Σ	58.80	(m2)	721.04	2293.58
		Base Area	**58.80**	**(m2)**			**Total W=**	**2,293.58**
							W-Base=	**1,572.5**

soil reaction =W/(Base area)= **39.006** (kN/m2)

7.5 Wall and Foundation

Wall 7−1

LOAD CONDITION For wall's unit width (1m)



Soil pressure	p= Ka γ h			
Ka :	0.5			
γ = :	2	Soil specific weight		
γ '= :	1	Soil specific weight in water		
Soil pressure				
		2.3	t/m2 --->	22.56 kN/m2
pw= 1 x 5.6x 9.81=		45.1	kN/m2	

BENDING MOMENT and SHEAR FORCE

For wall's unit width

Mc= 0.06 W h =	63.68	kNm	W=	189.5 kN
Mb= - 2/15 W h =	-141.52	kNm		
Qb= 4/5 W=	151.62	kN		

Wall Profile

	external		inner	
Wall thickness t :	30	cm	re-bar inside	
d :	23	cm	26	cm
j= 7/8 d :	0.201	m	0.2275	m
Re bar ft :	200	N/mm2	200	N/mm2
	(196.2≒200)			

at = Mc/(ft x j) =	14.00	cm2/ (m wi	5 —	D20	15.71	cm2
at = Mb/(ft x j) =	35.16	cm2/ (m wi	10 —	D25	49.09	cm2
				w Mc=	0.68	%
				w Mb=	2.13	%

Wall Shear Stress

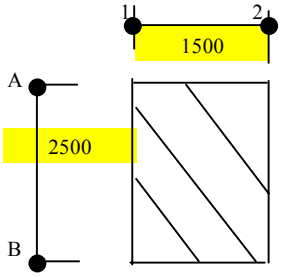
Wall thickness t :	30	cm		
d :	23	cm		
j= 7/8 d :	0.201	m		
Width Wa :	100	cm		
Qb :	151.62	kN		
Shear stress= Qb/(Wa j)=	0.75	N/mm2 <	0.80	N/mm2

Bottom profile

slab thickness t :	50	cm				
d :	43	cm				
j= 7/8 d :	0.376	m				
Re bar ft :	200	N/mm2				
at = Mb/(ft x j) =	18.81	cm2/ (m wi	10 —	D22	38.01	cm2
				w Mc=	0.88	%

7.6 SLAB

Load condition



			Area		unit weight	kN
Floor slab=			3.75	x	8436.6=	31.64
Wall=				x		0.00
					Σ =	31.6
	lx=		1.5	m		
	ly=		2.5	m	t(cm)=	20
	λ =		1.67		d(cm)=	15
	A=		3.75	m2	cover(cm)=	5

	a	wlx2(kNm2)	M(Nm)	Additional M from wall	Total M	at= M/(σ sjd)	re-bars	
Mx1=	0.075	18.98	1,423.7		1,424	0.553 cm2	upper -->D10@200	3.93cm2
Mx2=	0.05	18.98	949.1			0.369 cm2	bottom -->D10@200	3.93cm2
								0.5%
My1=	0.042	18.98	797.3		797	0.310 cm2	upper -->D10@200	3.93cm2
My2=	0.028	18.98	531.5			0.206 cm2	bottom -->D10@200	3.93cm2
		wlx	Q(N)			ϕ=Q/(τa jd)		0.5%
Qx =	0.52	21.09	10,967.6			3.50 cm <	15.7 ok	
Qy =	0.46	21.09	9,702.1			3.10 cm <	15.7 ok	

Suffix 1: end of span

Suffix 2: middle of span

From nomogram of two-way slab

Q cap

117,720 N > Q ok

117,720 N > Q ok

7.7 Limit state analysis

Rectanglar section design and limited state analysis (1/2)

Concrete Permissible Strength		f'ck=	17 N/mm2	by use of B30	30
	Direct tensile stress	ft=	2.00 N/mm2		
	Elasticity ratio	n=	15		
	Elasticity	E=	200000 N/mm2		
Permissible strength		σsa=	250 N/mm2	round	from BS
		σsa=	140 N/mm2	deformed	from BS
Ultimate strength (characteristic strength)		σs=	365 N/mm2		

Check point				Wall	Slab
Force	Bending Moment	Md	kN·m	141.5	1.4
	Shearing force	Sd	kN	151.6	11.0
Section Spec	Width	b	cm	100	100
	Height	h	cm	30	20
	Cover	dt	cm	5	5
	Effective Height	d	cm	25	15
Rebar Cross Section	Tension Rebar		cm^2	10－ D25	5－ D10
				As= 49.09	As= 3.93
	Compression Rebar		cm^2	5－ D20	5－ D10
				As= 15.71	As= 3.93
Stress	Concrete stress		N/mm2	7.9	0.5
	Rebar stress		N/mm2	131.3	25.5
	Shearing stress		N/mm2	0.720	0.079

B.M value for crack		Mcr	kNm	28.54	8.47
Crack width	Rebar interval	cs	mm	100	200
	Rebar diameter	φ	mm	25	10
	Cover depth	c	mm	40	40
	Rebar stress	σse	N/mm2	137.0	26.0
	Crack width	wcr	mm	0.177	0.082
Judgement: wcr<0.2 : OK				**OK**	**OK**

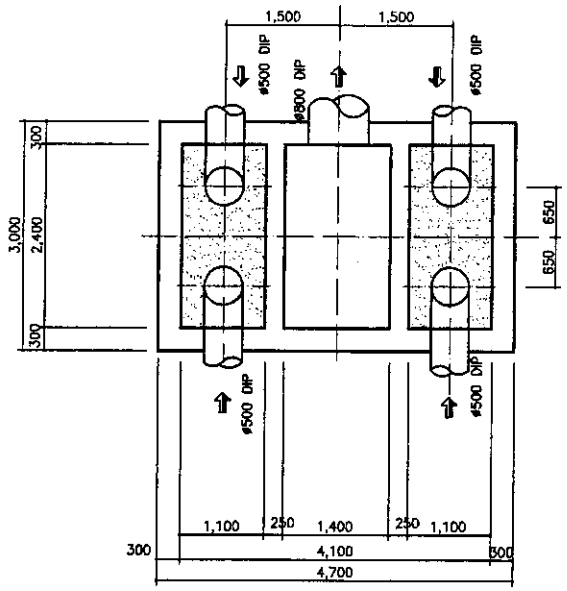
Examination with the Ultimate BM Strength

Ultimate B.M Strength		Mud	kNm	379.62	30.35
γi·Md/Mud				0.373	0.047
Judgement: γi·Md/Mud<1.0 : OK				OK	OK

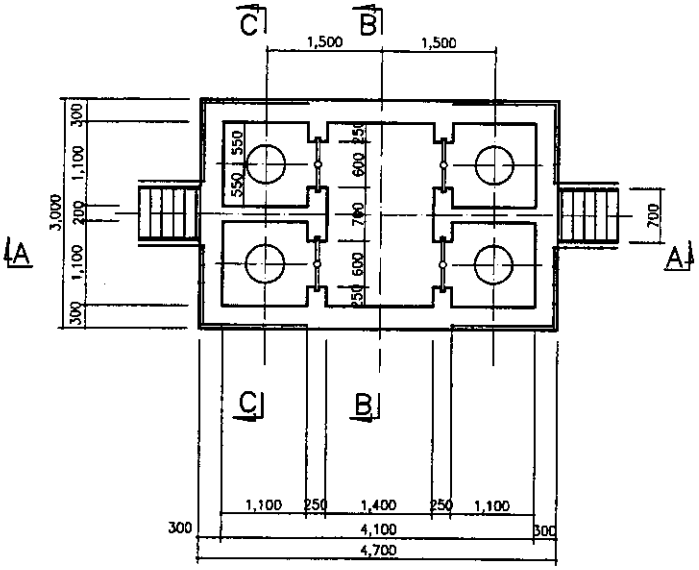
Crack width shall be controled as follows:

1 normal condition	crack width＜0.3mm
2 severe condition	crack width＜0.2mm
3 very severe condition	crack width＜0.1mm

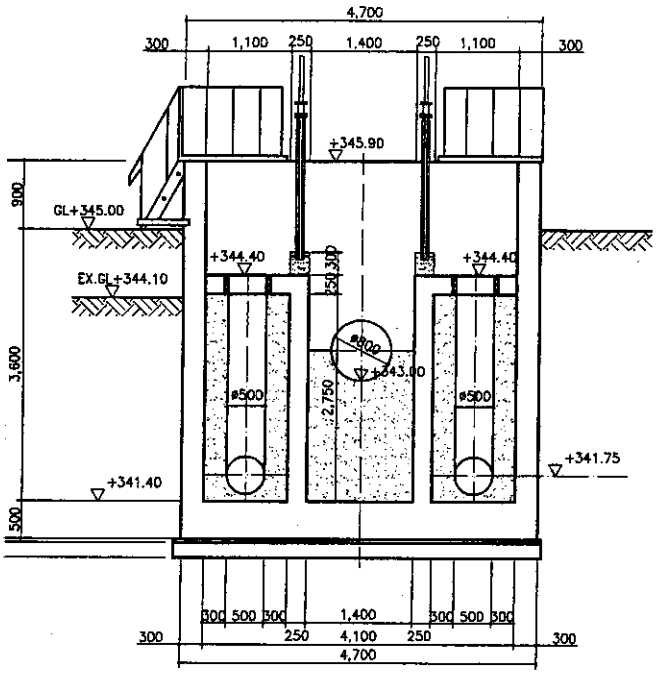
DSTR structure(1/2)



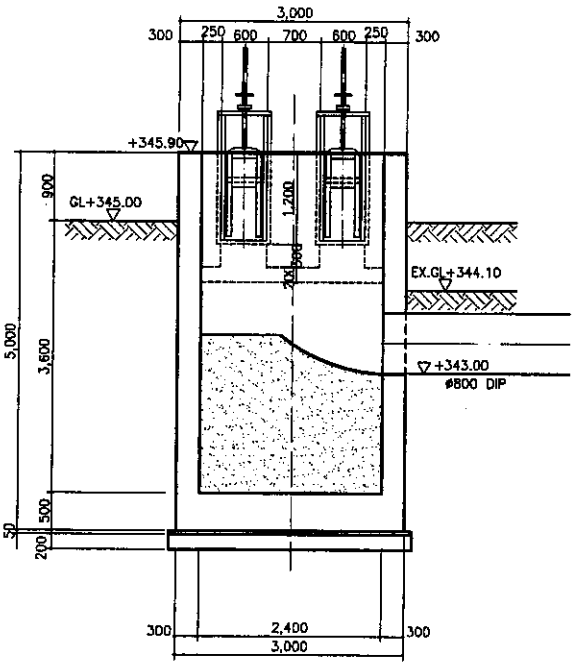
BASE PLAN
ПЛАН ОСНОВАНИЯ
scale 1:50



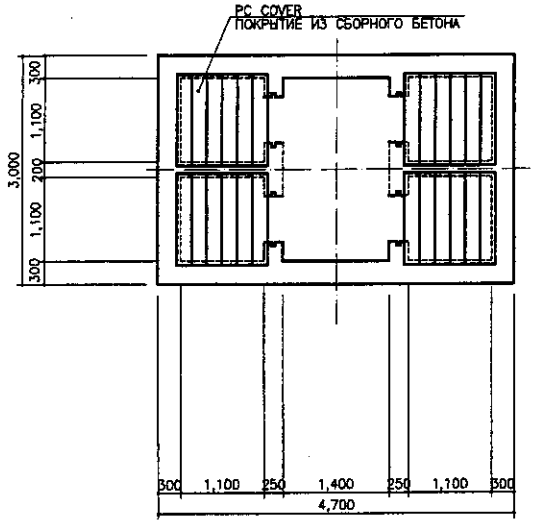
MIDDLE PLAN
ПЛАН СРЕДНЕЙ ЧАСТИ
scale 1:50



SECTION A–A
РАЗРЕЗ А–А
scale 1:50

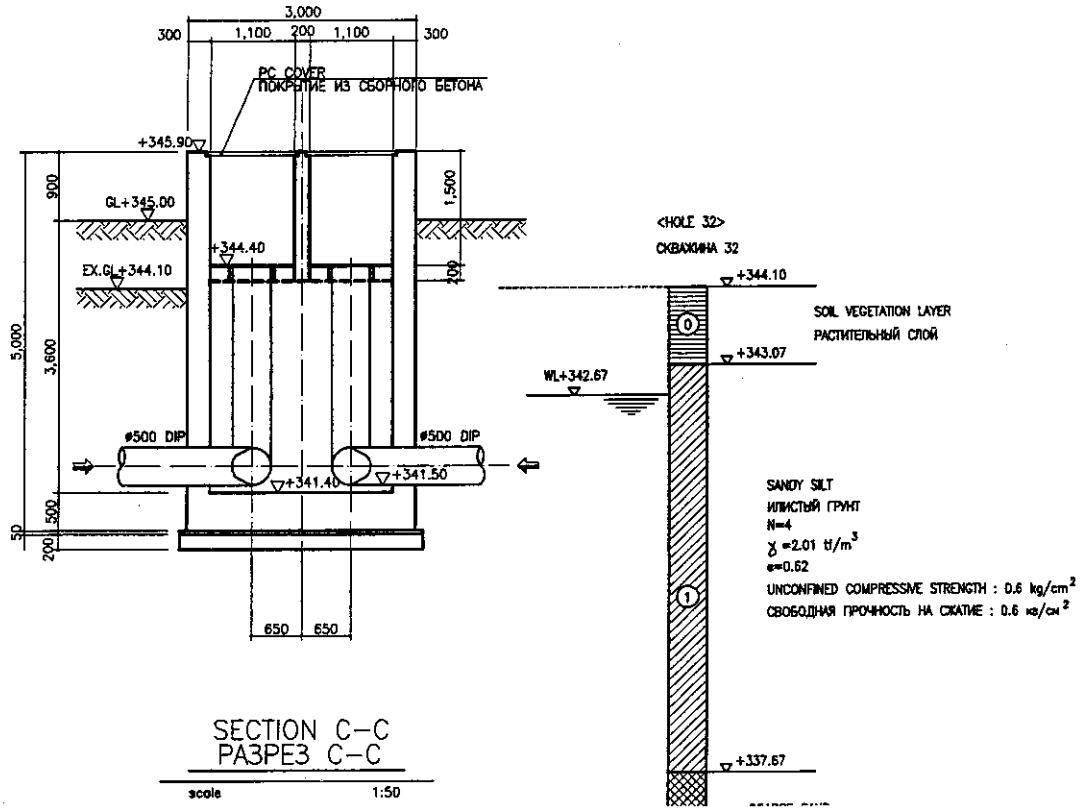


SECTION B–B
РАЗРЕЗ В–В
scale 1:50



TOP PLAN
ВЕРХНИЙ ПЛАН

scale 1:50



SECTION C–C
РАЗРЕЗ С–С

scale 1:50

8. Temprary Discharge Pumping Station

8.1Material and Allowable stress

TABLE 8.1 Allowable Stress (N/mm2, kg /cm2)

Item		Serviceability strength			Ultimate strength		
		Compression	Tension	Shear	Compression	Tension	Shear
Concrete	B30	10		0.8	30		1.2
		100	-------	8	300	-------	12
Steel Bar Round Bar	A- I	157.0	157.0	157.0	235.4	235.4	235.4
		1600	1600	1600	2400	2400	2400
Steel Bar Deformed Bar	A- II	196.2	196.2	196.2	358.1	358.1	358.1
		2000	2000	2000	3650	3650	3650

upper: SI units N/mm2

lower: MKS units kg/cm2

TABLE 8.2 Allowable Bonding Stress of Steel Bar to Concrete (N/mm2, kg /cm2)

Item	Serviceability strength		Remarks
	Top bars	Other bars	
ϕ6,ϕ9,ϕ12	0.9	1.3	
	9	13.5	
D10,D13,D16 D19,D22,D25,D29	1.6	2.4	
	16.2	24.3	

upper: SI units N/mm2

lower: MKS units kg/cm2

8.2 Load Table

TABLE 8.3 Dead Load

Loc.	item	thickness	kg/m2	total kg/m2	Remarks
Common slab	Leveling motar	-	-		
	Concrete slab	20cm	500		
				500	<-------- MKS UNIT
				4905	<-------- SI UNIT

TABLE 8. 4 Live Load and Floor Load

kg/m2 (Girder, Sub beam : Self weight not included)

Loc.	load type	slab	beam	girder	Remarks	
Other floor	Dead Load	500.0	500.0	500.0		
	Live Load	1000.0	1000.0	1000.0		Load of heay equipment
	Total Load	1500.0	1500.0	1500.0		
	SI unit	14715	14715	14715		<-------- SI UNIT

8.3 Facility weight

Table8.4 Temp. I.P.S Weight

Story	Load type	Unit w (kN/m2,m)	width /hight (m) or unit	Length (m)	Area or L (m2), (m)	Weight (kN)	Small Total (kN)	S Wi (kN)
structure	slab	14.72	7	-	62.39	918.05		
	Girder 6m	2.94	1	6.00	6.00	17.66		
	Beam 3m*2	2.94	2	3.00	6.00	17.66		
	Machine	34.335	3	-	-	103.01		
	Wall.1 6.415m	12.263	6.415	20.42	131.00	1606.35		
	Water	9.81	6.415	28.27	181.38	1779.34		
							4442.06	4442.06
Base	t600 Base	14.72	1	28.27	28.27	416.06		
								(kN)
				Σ	28.27	(m2)	416.06	4858.12

Base Area 28.27 (m2) **Total W= 4,858.12**

W-Base= 4,442.1

soil reaction =W/(Base area **171.820** (kN/m2)

Foundation's design force= 157.105 (kN/m2)

1) Spec of Tank

Diameter	d	6	m	Unit Water load	Dl	1.0 t/m3=	9.81	kN/m3
Water Depth	h	4.1	m	Supporting condition of bottom :			Rigid	
Wall Thickness	t	500	mm			αe:	15	
Wall height	h1	6.415	m	f st =	120	N/mm2		
				f ct =	2.00	N/mm2	fcu=	30
Unit concrete weight		23.544	kN/m3	permissible tensile stress			not used	

2) Employed Equation for analysis

*Same with the former section

3) Forces and Bending Moment /Reinforcement

0 h^2/d/t= 5.6033 then K1= 0.02 K2= 0.44 K3= 0.51

By table 184, pp.405

1 BM at bottom= 196.2 kN/m

2 Position height of max tension = 1.804 m above the bottom

3 Max circumference tension = 61.54 kN/m around the position of the above

4 Reqired As= 5.1282 cm2

Reinforcement

5 Min. thickness of wall = 46.25 mm — 4－D16 /m

6 Direct comp.= 415.67 kN/m2 — 4－D16 /m

= 0.4157 N/mm2 — As= 16.085 cm2

pt= 0.3217 %＞0.3%

7 Distribution Rebar 1rank lower spec. of main rebar---------- 4－D14 /m

8.4 Foundation

1) Effect of water pressure

Ground Level =	343.4 m
Ground Water Level =	342 m
Bottom slab level=	337.0 m
Height of Bottom slab=	0.6 m
Soffit of bottom slab=	5.6 m

Upward thrust by water pressure

p= 9.81 kN/m3 × 5.6 = 54.94 kN/m2

A= 50.3 m2 (including wall thickness)

P= 2761.4 kN

2) Bottom slab depth and reinfocement

*Basement including structure wall must be designed to prevent flotation

Weight			
GL slab	236.7	kN	(Slab thickness 0.2 m)
wall	1542	kN	
Total	1779	kN	

Cohesion Force 29.43 kN/m2 × 141.0 m2 = 4150

*no cohesion Required weight for bottom 2761.4 − 1778.8 = 982.6 kN

Minimum depth Fs=1.0 t= 0.83 m

*cohesion included 2761.4 − 5928.5 = −3167.1 kN

When cohesion force between wall and soil included, additional depth for bottom slab is not necessary.

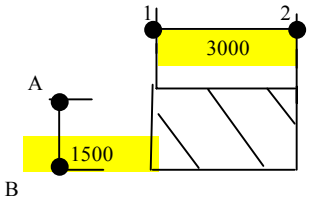
The depth shall be decided by the structural requirements. .------> t= 0.6 m

*Reinfocement

Radial reinforcement 250@ D16

8.5 Slab

Load condition



		Area		unit weight	kN
Floor slab=		4.50	x	14,715.0	66.22
Wall=			x		0.00
				Σ =	66.2

Soil reaction load= 14.72 kN/m2

lx= 1.5 m

ly= 3 m

λ = 2.00

A= 4.5 m2

t(cm)= 20

d(cm)= 15

cover(cm)= 5

	a	wlx2(kNm2)	M(Nm)	Additional M from wall	Total M	at= M/(σ sjd)	re-bars	
Mx1=	0.078	33.11	2,582.5	0	2,582	1.003 cm2	bottom 2-D10-->D10@100	7.85cm2
Mx2=	0.052	33.11	1,721.7			0.669 cm2	upper 2-D10-->D10@100	7.85cm2
								1.0%
My1=	0.042	33.11	1,390.6	0	1,391	0.540 cm2	bottom 2-D10-->D10@100	7.85cm2
My2=	0.028	33.11	927.0			0.360 cm2	upper 2-D10-->D10@100	7.85cm2
		wlx	Q(N)			ϕ=Q/(τa jd)		1.0%
Qx =	0.52	22.07	11,477.7			3.67 cm <	31.4 ok	
Qy =	0.46	22.07	10,153.4			3.24 cm <	31.4 ok	

Suffix 1: end of span

Suffix 2: middle of span

From nomogram of two-way slab

Q cap

117,720 N > Q ok

117,720 N > Q ok

8.6 BEAMS

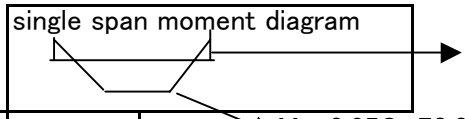
1) Beam **B1**

	Load form	(slab load)		(slab load) *2		(girder load)+ other loads		Σ
B1		C/w	Co	Co/w	Co	w/1	Co	kNm
	Co	0.00	0.00	7.03	103.42	4.11	3.08	106.51
		M/w	Mo	Mo/w	Mo	w/1	Mo	kNm
bxD 40x60	Mo	0.00	0.00	7.22	106.25	4.11	4.63	110.87
(cm)		Q/w	Q	Q/w	Q	w/1	Q	kN
	Q	0.00	0.00	1.69	24.83	4.11	6.17	31.00
	Slab load =	14.715	(kN/m2)	ly=	3	m		
	Span =	3	(m)	lx=	1.50	m		λ= 2.00

1.Girder load= 4.11 kN/m
dead load

2.Line load = 0.00 kN/m + 0.00 kN/m = 0.00 kN/m
roof wall

Total = 4.11 kN/m



2) Determination of beam B1

Beam ID	B1			Remarks
Position	B end	Mid	C end	
D.L] M(kNm	63.9		63.9	
+] bott.		73.6		seismic force neglected
L.L] Q (kN)	31.00		31.00	
] b x D (cr	35	x	50	
Size] d (cm)			45	
] j(cm)			39.375	
top	8.3		8.3	cm2
	3D22		3D22	at= M/(σsjd)
bottom		9.5		cm2
		3D22		
τ=Q/bjd	0.22		0.22	N/mm2
top	0.72		0.72	min.0.4%
Pt (%) bott.		0.72		
top	11.4		11.4	
at (cm2) bott.		11.4		
Main	3	3	3	
Bars		D22		
b	3	3	3	
ϕ (cm)	20.724		20.724	
Q /fa.j (cm)	0.38		0.38	max
judge	ok		ok	1.7
fs.bj LT(ST)	106.1		106.1	kN
(t)	D10-250	D10-250	D10-250	
judge	ok		ok	

2) Girder **G1**

	Load form		(slab load) *2		(slab load)		P	(gider load)+	Σ
		Co/w	Co	Co/w	Co	w/1	Co	
2B2	Co	8.16	120.02	-	0.00	0.56	1.69	121.71
		Mo/w	Mo	Mo/w	Mo	w/1	Mo	
bxD 30x75	Mo	13.50	198.65	-	0.00	0.56	2.53	201.18
		Q/w	Q	Q/w	Q	w/1	Q	
	Q	6.75	99.33	-	0.00	0.56	1.69	101.01
	Slab load =	14.715	(kN/m2)	ly=	3.00	m		
	Span =	6	(m)	lx=	3.00	m		λ= 1.00

1.Girder load= 5.64 kN/m
dead load

2.Line load = 0.00 kN/m + 0.00 kN/m = 0.00 kN/m
roof wall

Total = 5.64 kN/m

single span moment diagram

0.6C= **73.0**

Mo−0.35C= **158.6**

2) Determination of beam B1

Beam ID	B1			Remarks
Position	B end	Mid	C end	
D.L] M(kNm) t	73.0		73.0	
+] bott.		158.6		seismic force neglected
L.L] Q (kN)	101.01		101.01	
] b x D (cm)	40	x	60	
Size] d (cm)			55	
] j(cm)			48.125	
top	7.7		7.7	cm2
	3D20		3D20	at= M/(σsjd)
bottom		16.8		cm2
		4D25		
τ=Q/bjd	0.73		0.73	N/mm2
top	0.43		0.43	min.0.4%
Pt (%) bott.		0.89		
top	9.42		9.42	
at (cm2) bott.		19.64		
Main top	3	3	3	
Bars		D20		
		D25		
bot	2	4	2	
φ (cm)	18.84		18.84	
Q /fa.j (cm)	1.11		1.11	max
judge	ok		ok	1.7
fs.bj LT(ST)	148.2		148.2	kN
(t)	D10-250	D10-250	D10-250	
judge	ok		ok	

8.7 Limit state analysis

Rectanglar section design and limited state analysis (1/2)

Concrete Permissible Strength		f'ck=	17 N/mm2	by use of B30	30
	Direct tensile stress	ft=	2.00 N/mm2		
	Elasticity ratio	n=	15		
	Elasticity	E=	200000 N/mm2		
Permissible strength		σsa=	250 N/mm2	round	from BS
		σsa=	140 N/mm2	deformed	from BS
Ultimate strength (characteristic strength)		σs=	365 N/mm2		

Check point				Beam B1	Girder G1
Force	Bending Moment	Md	kN·m	63.9	73.0
	Shearing force	Sd	kN	31.0	101.0
Section Spec	Width	b	cm	35	40
	Height	h	cm	50	60
	Cover	dt	cm	5	5
	Effective Height	d	cm	45	55
Rebar Cross Section	Tension Rebar		cm^2	3－ D20	3－ D20
				As= 9.42	As= 9.42
	Compression Rebar		cm^2	2－ D25	3－ D20
				As= 9.82	As= 9.42
Stress	Concrete stress		N/mm2	4.2	3.4
	Rebar stress		N/mm2	160.6	149.8
	Shearing stress		N/mm2	0.217	0.502
B.M value for crack		Mcr	kNm	20.28	32.16
Crack width	Rebar interval	cs	mm	80	100
	Rebar diameter	φ	mm	20	20
	Cover depth	c	mm	40	40
	Rebar stress	σse	N/mm2	166.2	153.9
	Crack width	wcr	mm	0.198	0.199
Judgement: wcr<0.2 : OK				**OK**	**OK**

Examination with the Ultimate BM Strength

Ultimate B.M Strength		Mud	kNm	146.02	181.55
γi·Md/Mud				0.438	0.402
Judgement: γi·Md/Mud<1.0 : OK				OK	OK

Crack width shall be controled as follows:

1 normal condition	crack width＜0.3mm
2 severe condition	crack width＜0.2mm
3 very severe condition	crack width＜0.1mm

Rectanglar section design and limited state analysis (2/2)

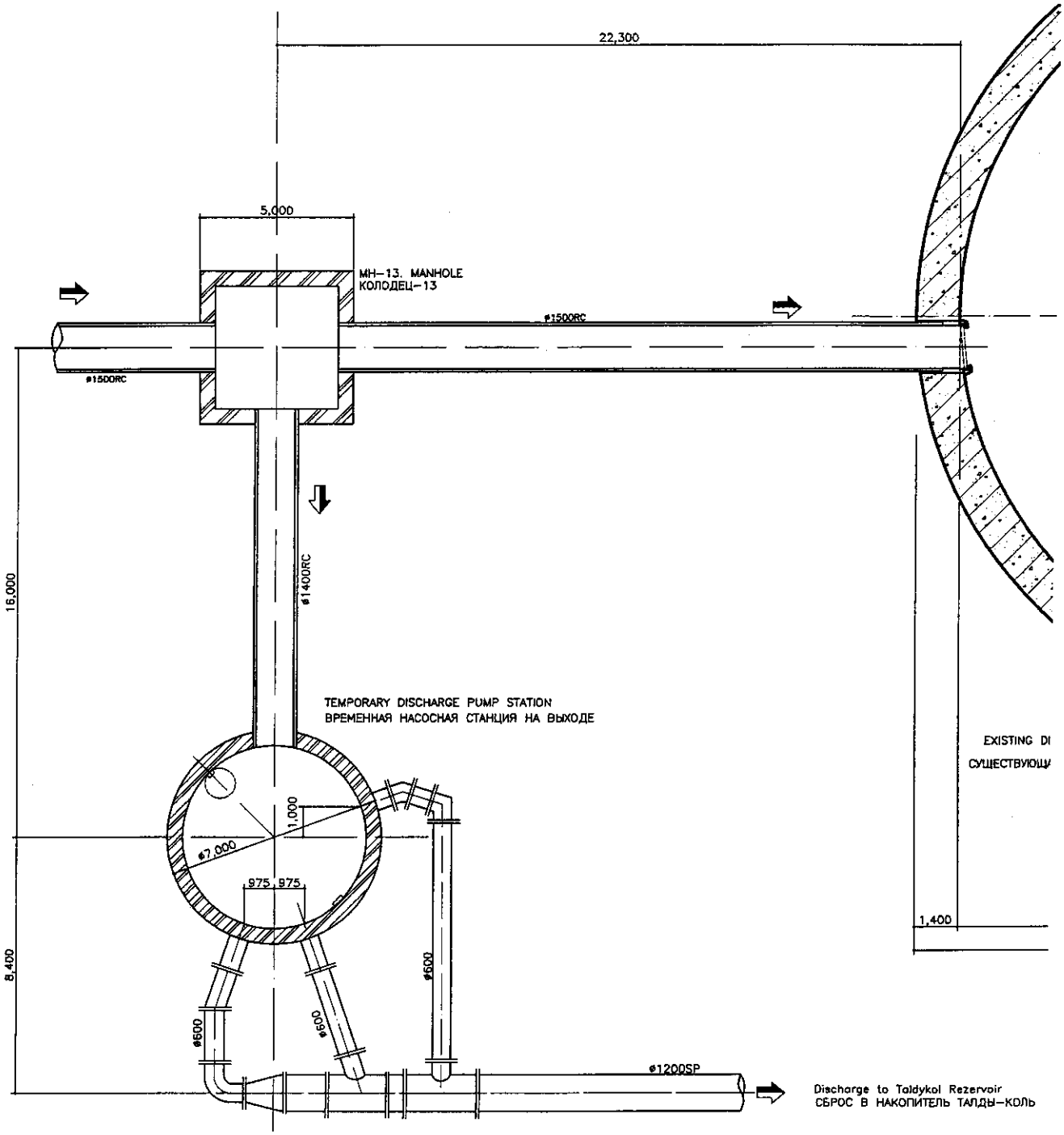
Concrete Permissible Strength		f'ck=	17 N/mm2	by use of B30	30
	Direct tensile stress	ft=	2.00 N/mm2		
	Elasticity ratio	n=	15		
	Elasticity	E=	200000 N/mm2		
Permissible strength		σsa=	250 N/mm2	round from BS	
		σsa=	140 N/mm2	deforme from BS	
Ultimate strength (characteristic strength)		σs=	365 N/mm2		

Check point				Slab	
Force	Bending Moment	Md	kN·m	2.6	
	Shearing force	Sd	kN	11.5	
Section Spec	Width	b	cm	100	
	Height	h	cm	20	#REF!
	Cover	dt	cm	5	5
	Effective Height	d	cm	15	#REF!
Rebar Cross Section	Tension Rebar		cm^2	10— D10	0— D0
				As= 7.85	
	Compression Rebar		cm^2	10— D10	0— D0
				As= 7.85	
Stress	Concrete stress		N/mm2	0.6	#VALUE!
	Rebar stress		N/mm2	23.4	#VALUE!
	Shearing stress		N/mm2	0.084	#DIV/0!
B.M value for crack		Mcr	kNm	9.15	#REF!
Crack width	Rebar interval	cs	mm	100	0
	Rebar diameter	φ	mm	10	0
	Cover depth	c	mm	40	0
	Rebar stress	σse	N/mm2	24.1	#VALUE!
	Crack width	wcr	mm	0.060	#VALUE!
Judgement: wcr<0.2:OK				**OK**	**0.00**
Examination with the Ultimate BM Strength					
Ultimate B.M Strength		Mud	kNm	48.21	#DIV/0!
γi·Md/Mud				0.054	#DIV/0!
Judgement: γi·Md/Mud<1.0:OK				OK	0

Crack width shall be controled as follows:

1 normal condition	crack width＜0.3mm
2 severe condition	crack width＜0.2mm
3 very severe condition	crack width＜0.1mm

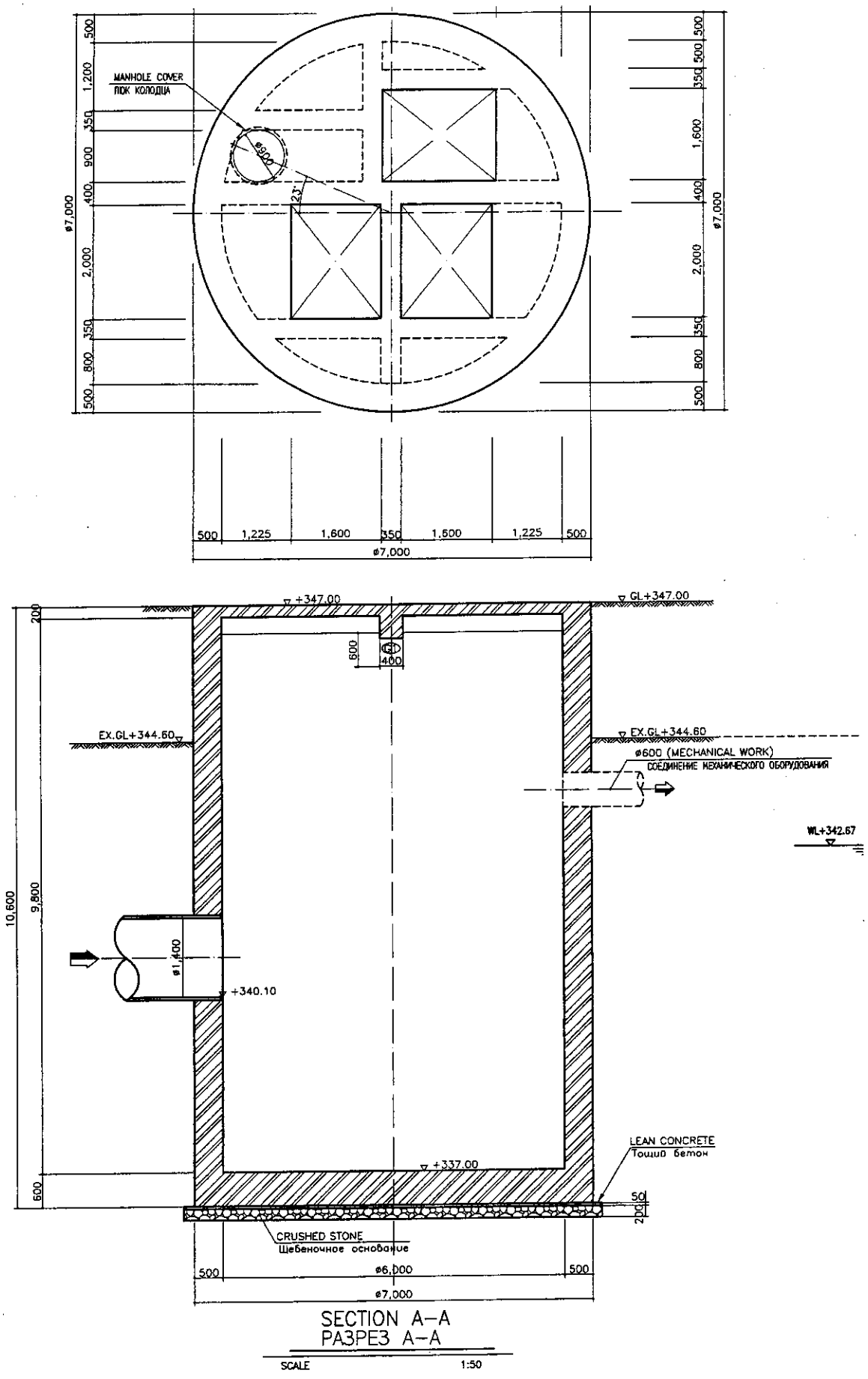
Temp Discharge PS structure(1/2)



DISCHARGE PUMP FACILITY LAYOUT
ГЕН. ПЛАН СООРУЖЕНИЙ Н.С. НА ВЫХОДЕ

SCALE 1:

Temp Discharge PS structure(2/2)



SECTION A–A
РАЗРЕЗ A–A

SCALE 1:50

9. Manhole pump station

9.1Material and Allowable stress

TABLE 3.1 Allowable Stress (N/mm2, kg /cm2)

Item		Serviceability strength			Ultimate strength		
		Compression	Tension	Shear	Compression	Tension	Shear
Concrete	B30	10		0.8	30		1.2
		100	-------	8	300	-------	12
Steel Bar Round Bar	A- I	157.0	157.0	157.0	235.4	235.4	235.4
		1600	1600	1600	2400	2400	2400
Steel Bar Deformed Bar	A- II	196.2	196.2	196.2	358.1	358.1	358.1
		2000	2000	2000	3650	3650	3650

upper: SI units N/mm2

lower: MKS units kg/cm2

TABLE 3.2 Allowable Bonding Stress of Steel Bar to Concrete (N/mm2, kg /cm2)

Item	Serviceability strength		Remarks
	Top bars	Other bars	
ϕ6,ϕ9,ϕ12	0.9	1.3	
	9	13.5	
D10,D13,D16	1.6	2.4	
D19,D22,D25,D29	16.2	24.3	

upper: SI units N/mm2

lower: MKS units kg/cm2

9.2 Load Table

TABLE 3.3 Dead Load

Loc.	item	thickness	kg/m2	total kg/m2	Remarks
Common slab	Leveling motar	-	-		
	Precast concrete cover	15cm	375		
				375	<-------- MKS UNIT
				3679	<-------- SI UNIT

TABLE 3. 4 Live Load and Floor Load

kg/m2 (Girder, Sub beam : Self weight not included)

Loc.	load type	slab	beam	girder	Remarks	
Other floor	Dead Load	375.0	375.0	375.0		
	Live Load	360.0	360.0	360.0		Load of heay equipment
	Total Load	735.0	735.0	735.0		
	SI unit	7210	7210	7210		<-------- SI UNIT

3.3 Facility weight

Table3.4 Temp. I.P.S Weight

Story	Load type	Unit w (kN/m2,m)	width /hight (m) or unit	Length (m)	Area or L (m2), (m)	Weight (kN)	Small Total (kN)	S Wi (kN)
structure	cover	7.21	2.5	-	7.96	57.38		
	Machine	3.5316	2	-	-	7.06		
	Wall.1 9.03m	12.263	9.03	20.42	184.40	2261.16		
	Water	9.81	9.03	28.27	255.32	2504.67		
							4830.27	4830.27
Base	t600 Base	14.72	1	28.27	28.27	416.06		
								(kN)
				Σ	28.27	(m2)	416.06	5246.33

Base Area 28.27 (m2) **Total W= 5,246.33**

W-Base= 4,830.3

soil reaction =W/(Base area)= **185.550** (kN/m2)

Foundation's design force= 170.835 (kN/m2)

9.3.1 H=6.9(IH) and 7.0(28)

1) Spec of Tank

Diameter	d	2.5	m	Unit Water load	Dl	1.0 t/m3=	9.81	kN/m3
Water Depth	h	2.15	m	Supporting condition of bottom :			Rigid	
Wall Thickness	t	400	mm			αe:	15	
Wall height	h1	7.00	m	f st =	120	N/mm2		
				f ct =	2.00	N/mm2	fcu=	30
Unit concrete weight		23.544	kN/m3	permissible tensile stress			not used	

2) Employed Equation for analysis

*Same with the former section

3) Forces and Bending Moment /Reinforcement

0 h^2/d/t= 49.00 then K1= 0.002 K2= 0.195 K3= 0.83

By table 184, pp.405

1 BM at bottom= 19.62 kN/m

2 Position height of max tension = 0.419 m above the bottom

3 Max circumference tension = 21.88 kN/m around the position of the above

4 Reqired As= 1.82 cm2

Reinforcement

5 Min. thickness of wall = 10.11 mm — 4— D16 /m

6 Direct comp.= 112.3 kN/m2 — 4— D16 /m

= 0.112 N/mm2 — As= 16.085 cm2

pt= 0.40212 %>0.3%

7 Shearing force √1=F/PI/d

= 1.34 kN

8 Distribution Rebar 1rank lower spec. of main rebar---------- 4— D14 /m

3.2. Foundation

1) Effect of water pressure

Ground Level =	360.4 m
Ground Water Level =	358.4 m
Bottom slab level=	353.4 m
Height of Bottom slab=	0.5 m
Soffit of bottom slab=	5.5 m

Upward thrust by water pressure

p= 9.81 kN/m3 × 5.5 = 53.96 kN/m2

A= 13.2 m2 (including wall thickness)

P= 712.3 kN

2) Bottom slab depth and reinfocement

*Basement including structure wall must be designed to prevent flotation

Weight				
GL slab	46.63	kN	(Slab thickness	0.15 m)
wall	600.6	kN		
cutting edge	51.48	kN		
underwater concrete	33.71	kN	t=0.5m	
Total	732.4	kN >	712.3	OK

Cohesion Force 29.43 kN/m2 × 72.5 m2 = 2135

*no cohesion Required weight for bottom 712.3 − 732.42 = −20.1 kN

Minimum depth Fs=1.0 t= −0.06 m

*cohesion included 712.3 − 2867.1 = −2154.7 kN

When cohesion force between wall and soil included, additional depth for bottom slab is not necessary.

The depth shall be decided by the structural requirements. .-------> t= 0.4 m

*Reinfocement

Radial reinforcement 250@ D16

9.3.2 H=4.5(34) and 4.8(37)

1) Spec of Tank

Diameter	d	2.5	m	Unit Water load	Dl	1.0 t/m3=	9.81	kN/m3
Water Depth	h	1.7	m	Supporting condition of bottom :		Rigid		
Wall Thickness	t	300	mm			α e:	15	
Wall height	h1	4.80	m	f st =	120	N/mm2		
				f ct =	2.00	N/mm2	fcu=	30
Unit concrete weight		23.544	kN/m3	permissible tensile stress		not used		

2) Employed Equation for analysis

*Same with the former section

3) Forces and Bending Moment /Reinforcement

0 h^2/d/t= 30.72 then K1= 0.0045 K2= 0.25 K3= 0.78

By table 184, pp.405

1 BM at bottom= 44.15 kN/m

2 Position height of max tension = 0.425 m above the bottom

3 Max circumference tension = 16.26 kN/m around the position of the above

4 Reqired As= 1.36 cm2

Reinforcement

5 Min. thickness of wall = 7.99 mm — 4— D14 /m

6 Direct comp.= 118.3 kN/m2 — 4— D14 /m

= 0.118 N/mm2 — As= 12.3151 cm2

pt= 0.4105 %>0.3%

7 Shearing force √1=F/PI/d

= 1.06 kN

8 Distribution Rebar 1rank lower spec. of main rebar---------- 4— D12 /m

3.2. Foundation

1) Effect of water pressure

Ground Level =	346.7 m
Ground Water Level =	344.7 m
Bottom slab level=	341.9 m
Height of Bottom slab=	0.5 m
Soffit of bottom slab=	3.3 m

Upward thrust by water pressure

p= 9.81 kN/m3 × 3.3 = 32.37 kN/m2

A= 10.8 m2 (including wall thickness)

P= 348.1 kN

2) Bottom slab depth and reinfocement

*Basement including structure wall must be designed to prevent flotation

Weight				
GL slab	37.97	kN	(Slab thickness	0.15 m)
wall	298.2	kN		
cutting edge	37.28	kN		
underwater concrete	33.71	kN	t=0.5m	
Total	407.2	kN >	348.1	OK

Cohesion Force 29.43 kN/m2 × 46.7 m2 = 1375

*no cohesion Required weight for bottom 348.1 − 407.19 = −59.1 kN

Minimum depth Fs=1.0 t= −0.23 m

*cohesion included 348.1 − 1782.3 = −1434.2 kN

When cohesion force between wall and soil included, additional depth for bottom slab is not necessary.

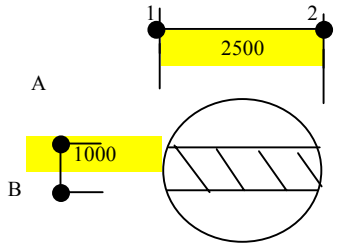
The depth shall be decided by the structural requirements. .-------> t= 0.4 m

*Reinfocement

Radial reinforcement 250@ D14

9.4 Cover (Common for 4 MPS)

Load condition



Diameter 2500

	Area		unit weight	kN	
Floor slab=	2.50	x	7,210.4	18.03	
Wall=		x		0.00	
			Σ =	18.0	
	Soil reaction load=		7.21	kN/m2	
lx=	1	m			
ly=	2.5	m	t(cm)=	15	
λ =	2.50		d(cm)=	10	
A=	2.5	m2	cover(cm)=	5	

	a	wlx2(kNm2)	M(Nm)	Additional M from wall	Total M	at= M/(σ sjd)	re-bars	
Mx1=	0.078	7.21	562.4	0	562	0.328 cm2	bottom 2-D10-->D10@100	7.85cm2
Mx2=	0.052	7.21	374.9			0.218 cm2	upper 2-D10-->D10@100	7.85cm2
								1.6%
My1=	0.042	7.21	302.8	0	303	0.176 cm2	bottom 2-D10-->D10@100	7.85cm2
My2=	0.028	7.21	201.9			0.118 cm2	upper 2-D10-->D10@100	7.85cm2
		wlx	Q(N)			ϕ=Q/(τa jd)		1.6%
Qx =	0.52	7.21	3,749.4			1.80 cm <	31.4 ok	
Qy =	0.46	7.21	3,316.8			1.59 cm <	31.4 ok	

Suffix 1: end of span

Suffix 2: middle of span

From nomogram of two-way slab

Q cap

78,480 N > Q ok

78,480 N > Q ok

9.4 Limit state analysis

Rectanglar section design and limited state analysis (1/2)

Concrete Permissible Strength	f'ck=	17	N/mm2	by use of B30	30
Direct tensile stress	ft=	2.00	N/mm2		
Elasticity ratio	n=	15			
Elasticity	E=	200000	N/mm2		
Permissible strength	σsa=	250	N/mm2	round	from BS
	σsa=	140	N/mm2	deformed	from BS
Ultimate strength (characteristic strength)	σs=	365	N/mm2		

Check point				cover	Wall No.28 PS
Force	Bending Moment	Md	kN·m	0.56	19.6
	Shearing force	Sd	kN	0.30	1.3
Section Spec	Width	b	cm	100	100
	Height	h	cm	15	40
	Cover	dt	cm	5	5
	Effective Height	d	cm	10	35
Rebar Cross Section	Tension Rebar		cm^2	10— D10	4— D14
				As= 7.85	As= 6.16
	Compression Rebar		cm^2	10— D10	4— D14
				As= 7.85	As= 6.16
Stress	Concrete stress		N/mm2	0.2	1.4
	Rebar stress		N/mm2	7.6	95.7
	Shearing stress		N/mm2	0.003	0.004
B.M value for crack		Mcr	kNm	5.41	32.65
Crack width	Rebar interval	cs	mm	80	125
	Rebar diameter	φ	mm	10	14
	Cover depth	c	mm	40	40
	Rebar stress	σse	N/mm2	7.9	97.0
	Crack width	wcr	mm	0.040	0.151
Judgement: wcr<0.2 : OK				**OK**	**OK**

Examination with the Ultimate BM Strength

Ultimate B.M Strength		Mud	kNm	33.87	85.77
γi·Md/Mud				0.017	0.229
Judgement: γi·Md/Mud<1.0 : OK				OK	OK

Crack width shall be controled as follows:

1 normal condition	crack width＜0.3mm
2 severe condition	crack width＜0.2mm
3 very severe condition	crack width＜0.1mm

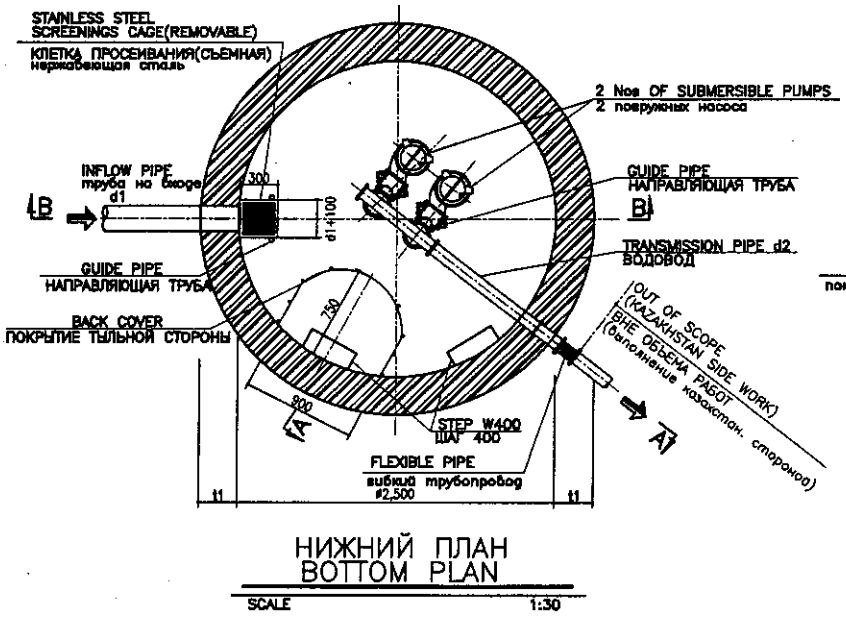
Dimensions of Manhole Type Pump Station

Размеры КНС колодезного типа

Symbol Символ	Item Наименование	PS No. 28 КНС-28	PS No. 34 КНС-34	PS No. 37 КНС-37	PS No. IH КНС-IH
GL	Ground Level Отметка земли	+360.35m	+345.30m	+346.70m	+356.78m
d1	Inflow Pipe Diameter Диаметр трубы на входе	⌀150CIP	⌀300CIP	⌀200CIP	⌀300CIP
IL1	Inflow Pipe Invert Level Отметка дна трубы на входе	+355.50m	+342.50m	+343.60m	+351.80m
d2	Transmission Pipe Diameter Диаметр водовода	⌀150SP	⌀300SP	⌀100SP	⌀100SP
IL2	Transmission Pipe Invert Level Отметка дна водовода	+357.70m	+342.50m	+344.90m	+353.80m
WL1	Pump Start Level Уровень включения насоса	+355.50m	+342.50m	+343.60m	+351.80m
WL2	Pump Stop Level Уровень остановки насоса	+354.80m	+341.70m	+342.80m	+350.78m
BL	Manhole Bottom Level Отметка дна колодца	+353.35m	+340.80m	+341.90m	+349.88m
H1	Manhole Depth Глубина колодца	7.000	4.500	4.800	6.900
t1	Manhole Wall Thickness Толщина стен колодца	400	300	300	400
t2	Manhole Wall Thickness Толщина стен колодца	500	500	500	500
	Pump TAG No. НОМЕР НАСОСА	S64 IP 01/02	S65 IP 01/02	S66 IP 01/02	S67 IP 01/02
Qp	DISCHARGE CAPACITY производительность	1.3m³/min	0.84m³/min	0.84m³/min	0.84m³/min
H3	TOTAL HEAD общий напор	28.0m	4.0m	30.0m	15.0m
N	PUMP QUANTITY КОЛ-ВО НАСОСОВ	2 UNITS (1 STANDBY)	2 UNITS (1 STANDBY)	2 UNITS (1 STANDBY)	2 UNITS (1 STANDBY)
K	MOTOR OUTPUT мощность двигателя	22kW	3.7kW	18.5kW	7.5kW

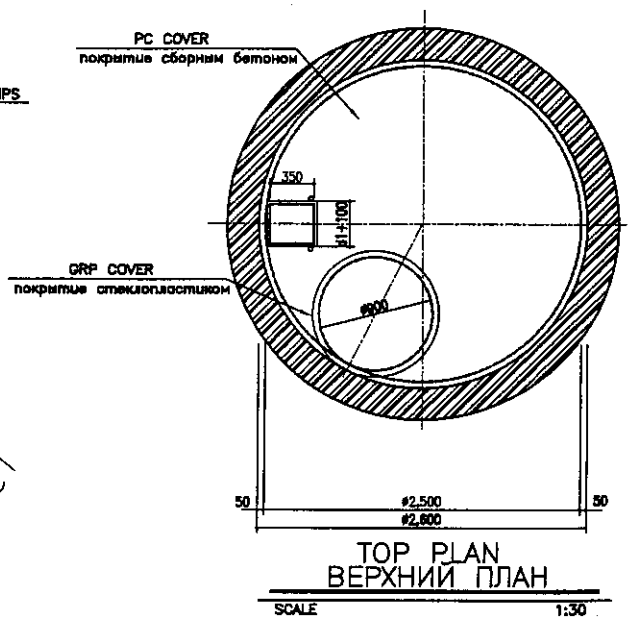
Remarks:
Примечание

PS No. 28: "Avtomatika" Industrial Workshop
КНС-28: Комбинат "Автоматика"
PS No. 34: PDU Settlement – Astrakhansky Settlement
КНС-34: Поселок ПДУ, Астраханская трасса
PS No. 37: Kotovsky St.
КНС-37: Ул. Котовского
PS No. IH: Isolation Hospital
КНС-IH: Больничный комплекс



НИЖНИЙ ПЛАН
BOTTOM PLAN

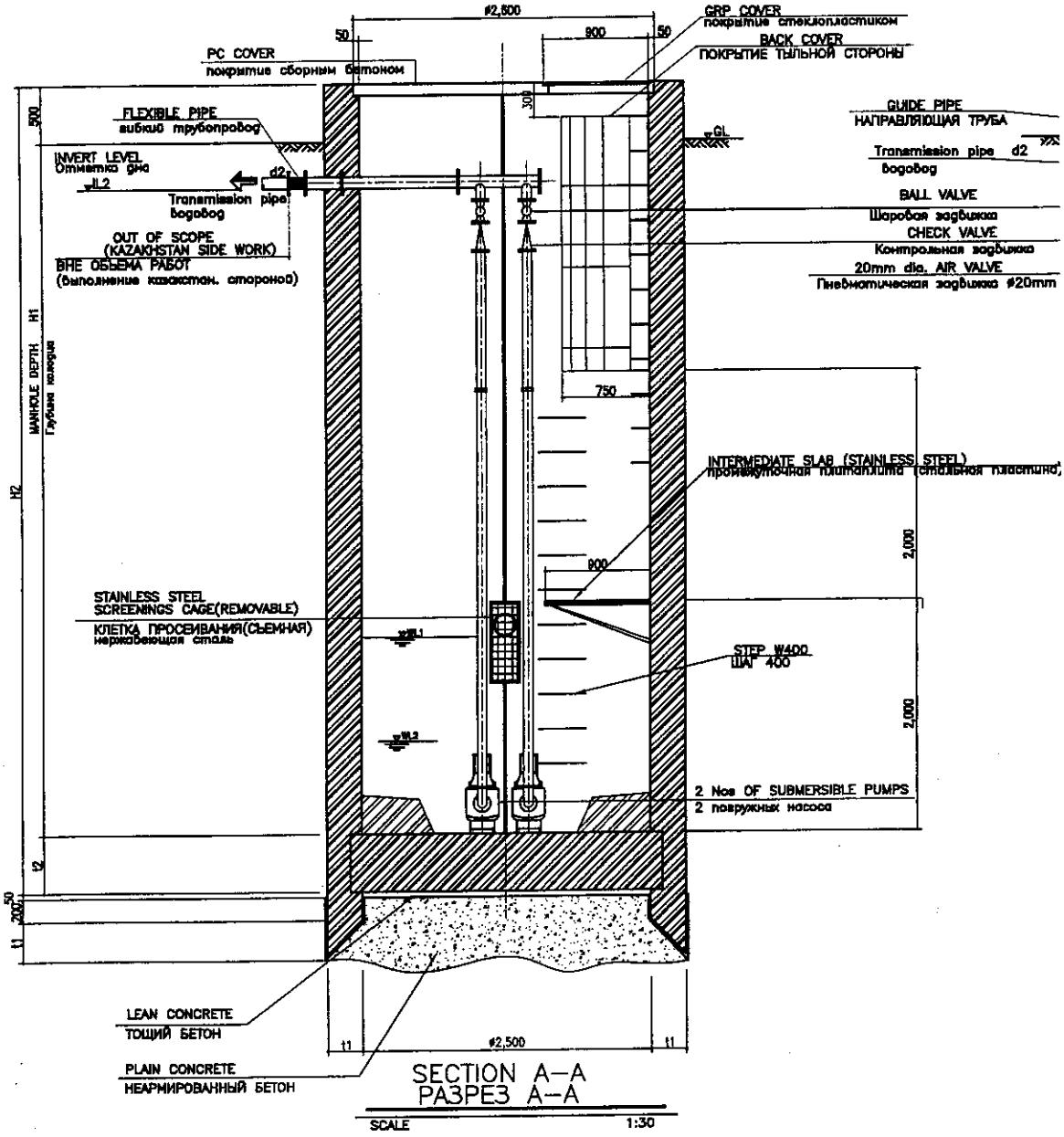
SCALE 1:30



TOP PLAN
ВЕРХНИЙ ПЛАН

SCALE 1:30

MHP structure (2/2)



10. Pile foundation calculation

Table 10.1 Pile numbers examination by static formulae of Terzaghi

note: Penetration into last strata shall be larger than 2*size, that is 1m

Facility	Pile length (m)	Support strata	embedded length (m)	estimated mean N	pile cross-sectional area			Pile perimeter			strata for the frictional resistance		length in the strata	frictional resistance C	safe load on the pile in kN Size of pile(mm)			structure area	structure load	pile spec	Size of pile(mm)			judgement
					300	400	500	300	400	500													
					m2	m2	m2	m	m	m			m	t/m2	300	400	500	m^2	kN		300	400	500	
Grit Chamber	2.5	1st **sandy silt**	1	**3**	0.1	0.2	0.3	1.2	1.6	2	①	1st	2.5	3	55	86	122	220	11,612	nums.	**212**	**136**	**96**	
											②		0	0						area	1.04	1.62	2.29	
											③		0	0						ctr dist	1.01	1.27	1.51	unable to support
	3.5	2nd **silty sandy**	1	**3**	0.1	0.2	0.3	1.2	1.6	2	①	1st	2.5	3	61	94	132	220	11,612	nums.	**191**	**124**	**88**	
											②	2nd	1	1.5						area	1.15	1.77	2.50	
											③		0	0						ctr dist	1.07	1.33	1.58	unable to support
	7	4th **coarse sand**	2	**26**	0.1	0.2	0.3	1.2	1.6	2	①	1st	3	3	283	479	726	220	11,612	nums.	**42**	**25**	**16**	
											②	2nd	3	1.5						area	5.23	8.79	13.73	300 adopted
											③	4th	1	0.2						ctr dist	2.28	2.96	3.70	
Sludge Cake House	4	1st	4	**3**	0.1	0.2	0.3	1.2	1.6	2	①	1st	4	3	73	109	151	344	24,696	nums.	**339**	**227**	**164**	
											②		0	0						area	1.01	1.52	2.10	
											③		0	0						ctr dist	1.00	1.23	1.44	unable to support
	7.5	4th	3	**26**	0.1	0.2	0.3	1.2	1.6	2	①	1st	4.5	3	283	479	727	344	24,696	nums.	**88**	**52**	**34**	
											②	4th	3	0.1						area	3.91	6.62	10.12	300 adopted
											③		0	0						ctr dist	1.97	2.57	3.18	
	11.5	6th **clay silt**	3	**9**	0.1	0.2	0.3	1.2	1.6	2	①	1st	4.5	3	161	250	357	344	24,696	nums.	**154**	**99**	**70**	
											②	4th	6	0.1						area	2.23	3.47	4.91	
											③	6th	1	6.9						ctr dist	1.49	1.86	2.21	not economical
Primary Sedimentation Tank	4	2nd	1.5	**3**	0.1	0.2	0.3	1.2	1.6	2	①	1st	2.5	3	64	98	137	716	36,378	nums.	**569**	**372**	**266**	
											②	2nd	1.5	1.5						area	1.26	1.93	2.69	
											③		0	0						ctr dist	1.12	1.38	1.64	unable to support/arrange
	6	4th	3	**26**	0.1	0.2	0.3	1.2	1.6	2	①	1st	2.5	3	273	467	711	716	36,378	nums.	**134**	**78**	**52**	
											②	2nd	2.5	1.5						area	5.35	9.18	13.78	300 adopted
											③	4th	1	0.1						ctr dist	2.31	3.03	3.71	
Secondary Sedimentation Tank	2	1st	-	**3**	0.1	0.2	0.3	1.2	1.6	2	①	1st	2	3	49	78	112	716	39,906	nums.	**815**	**512**	**357**	
											②		0	0						area	0.88	1.40	2.01	
											③		0	0						ctr dist	0.93	1.18	1.41	unable to support/arrange
	3.5	4th	1	**26**	0.1	0.2	0.3	1.2	1.6	2	①	1st	2.5	3	259	447	686	716	39,906	nums.	**155**	**90**	**59**	
											②	4th	1	0.1						area	4.62	7.96	12.14	300 adopted
											③		0	0						ctr dist	2.14	2.82	3.48	
Return Sludge Pump House	4	1st	–	**3**	0.1	0.2	0.3	1.2	1.6	2	①	1st	4	3	73	109	151	429	30,689	nums.	**421**	**282**	**204**	
											②		0	0						area	1.02	1.52	2.10	not adopted
											③		0	0						ctr dist	1.00	1.23	1.45	unable to support/arrange
	6	4th	3	**26**	0.1	0.2	0.3	1.2	1.6	2	①	1st	5	3	288	486	735	429	30,689	nums.	**107**	**64**	**42**	
											②	4th	1	0.1						area	4.01	6.70	10.21	300 adopted
											③		0	0						ctr dist	2.00	2.58	3.19	