# COLUMN type 1

b (cm)	h (cm)	cover	diameter main bar (cm)	diamoter stirrup (cm)	fc (kg/cm2)	fy (kg/cm2)	fv (kg/cm2)
30	40	4	1.6	0.8	187	3,200	2,400

	Fra	me elemer	nt Force				Desi	g n	
Member	Axial (kg)	Torsion (kg.cm)	Moment 2 (kg.cm)	Moment 3 (kg.cm)	Main bar (mm)	Stirrup (mm)	Pu (kg)	Max (kg.cm)	May (kg.cm)
1 2 13 15	9,122 7,416 7,380 12,662	0 0 0	0 0 0 0	165,315 30,190 106,215 124,176	8D16 8D16 8D16 8D16	08-250 08-250 08-250 08-250	9,121 7,416 7,727 1,266	707,047 694,023 696,415 732,991	21,891 17,800 18,577 30,397

# COLUMN type 2

(cm)	h (cm)	cover	diameter main bar (cm)	diameter stirrup (cm)	fc (kg/cm2)	fy (kg/cm2)	fv (kg/cm2)
25	40	4	1.6	0.8	187	3,200	2,400

11.11	Fra	me elemer	nt Force	199-4411-19			Desi	g n	
Member	Axial (kg)	Torsion (kg.cm)	Moment 2 (kg.cm)	Moment 3 (kg.cm)	Main bar (mm)	Stirrup (mm)	Pu (kg)	Max (kg.cm)	May (kg.cm)
	7.77	•	,	400414	5	0.00	0.740	204.005	
- 4 5	6,717 5,578	0	0	162151 162151	8D16 8D16	o8-250 o8-250	6,718 5,579	691,885 683,815	15,115 12,554
6	4,438	0	0	187366		o8-250	4,440	675,596	9,920
7	5,226	0	0	165,803	8D16	08-250	5,229	681,294	11,765
8	6,366 7,505	0	0	57,863 87,386	8D16 8D16	o8-250 o8-250	6,367 7,504	689,416 697,363	14,326 16,886
Ĭ	.,000		Ĭ	0.,000		33 200	7,004	007,000	10,000

# COLUMN type 3

b (cm)	h (cm)	cover (cm)	diameler main bar (cm)	diameter stirrup (cm)	fc (kg/cm2)	fy (kg/cm2)	fv (kg/cm2)
25	25	4	1.6	0.8	187	3,200	2,400

1 1	Fra	me elemer	t Force		n nakaju e	- <del>2 - 2 - 2 - 2 - 2</del> - 2 - 2 - 2 - 2 - 2 -	Desi	g i n - 15-17-3-16	
Member	Axial (kg)	Torsion (kg.cm)	Moment 2 (kg.cm)	Moment 3 (kg.cm)	Main bar (mm)	Stirrup (mm)	Pu (kg)	Max (kg.cm)	May (kg.cm)
11	1,532	0	0	21,562	4D16	o8-250	1,532	195,257	3,447

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Φ	١
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ىد	1
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Ш	1
m	1

	653,947
um)	
	3D16 2012 2D16 3D16 2012 2D16 3D16 2012 2D16 010-200
kight bars Middle Bottom	2016
Right bars Middle	2012
do 1 C C C C C C C C C C C C C C C C C C	30 30 30 30 30
ild bars Middle Bottom	2018 2016
Mid bars	2012
Top Top	3016 5106
Bottom	2D16
(kg/cm2) 2,400 2,400 Left bars Middle Bottom	3016 2012 2016
fy fv (kg/cm2) 3,200 2,400 Left bars Top Middle	8 5 5 6 5 6
(kg/cm2) (kg/cm2) 187 3,200 Main bar Top (mm) Top	7 O 5 &
diameter stirrup (cm) (0.8 Moment (kg.cm)	124,176 D16
υμ ω Ι σ	00
cover main bar (cm) (cm) (cm) (cm) (cm) (cm) (cm) (cm)	3,018
	4
h (cm) 50 Axial (kg)	<b>50</b>

# BEAM type b

12 20 20 4 1.6 0.8 187 3,200 2,400	<b>a</b> (b)	(cm)	cover (cm)	diameter cover main bar (cm) (cm)	diameter stirrup (cm)	fc (kg/cm2) (k	fy (kg/cm2)	fv (kg/cm2)	
	12	20	4	1.6	8.0	187	3,200	2,400	

		٥	ž	Σ	
				Top	2016 2016
				Bottom	2016 2016
4			Left bars	Middle	
				Тор	6 2016 6 2016
			Main bar	(mm)	22
			Moment Main bar		1,221
		nt Force	Axial Shear Torsion	(kg) (kg.cm)	00
		Frame Element, Force	Shear	(kg)	<b>4</b> 8
		n.		(ka)	3.8 4.0 4.0 4.0 4.0 4.0 4.0 4.0 4.0 4.0 4.0
			Member	7	17
	Ţ.			45.2	

Mu (kg.cm)

Stirrup (mm)

Bottom

Bottom

2D16 2D16

2D16 2D16

2016 2016

# BEAM type c

11			
		(xa/cm2)	3,200 2,400
1	, <sub>2</sub>	Kg/cmz) (Kg/cmz) (Kg/cmz)	3,200
		~	187
diameter	0	(cm)	
diameter	main bar	(Cin)	9.
	Š S •	(E)	25 4
	Ē	(E)	
1	Ω	(E)	25

	Fra	Frame Element Force	nt Force					1		9 0		u	-		
Member	Axia	Shear	Torsion	Moment	Main bar		Left bars			Mid bars			Right bars	Stirrup	Mc
	(kg)	(kg)	(kg.cm)	(kg.cm)	]. (mm) [	Top	Middle	Bottom	Top	Middle	Bottom	Top	Middle Bottom		(kg.cm)
										-					
5	4.141	516	0	36.857	010	2016		2D16	2D16		2D16	2D16		3 08-250	
12	4,042	340	0	21,143		2016	•	2016 2016	2D16		2016 2016 -	2016	<del></del> ;	2016   08-250	191.278
								12						********	

# COLUMN type 1

b (cm)	h (cm)	cover	diameter main bar (cm)	diameter stirrep (cm)	fc (kg/cm2)	fy (kg/cm2)	fv (kg/cm2)
30	40	4	1.6	0.8	187	3,200	2,400

8 8 8	Fra	me elemer	nt Force				Desi	g n	
Member	Axial (kg)	Torsion (kg.cm)	Moment 2 (kg.cm)	Moment 3 (kg.cm)	Main bar (mm)	Stirrup (mm)	Pu (kg)	Max (kg.cm)	May (kg.cm)
1 2 13 15	9,859 7,323 7,819 12,755	0 0 0	0 0 0 0	113,536 24,258 161,532 258,070	8D16 8D16 8D16 8D16	08-250 08-250 08-250 08-250	9,865 124,489 7,819 12,758	712,628 412,345 697,126 733,645	23,677 29,877 18,766 30,619

# COLUMN type 2

b (cm)	h (cm)	cover (cm)	diameter main bar (cm)	diameter stirrup (cm)	fc (kg/cm2)	fy (kg/cm2)	fv (kg/cm2)
25	40	4	1.6	0.8	187	3,200	2,400

	Fra	me eleme	nt Force	para ara ara da di		n tradition	Desi	g n	
Member	Axial (kg)	Torsion (kg.cm)	Moment 2 (kg.cm)	Moment 3 (kg.cm)	Main bar (mm)	Stirrup (mm)	Pu (kg)	Max (kg.cm)	May (kg.cm)
				1 3 AU. 3					
4	6,613	0	0	170,149	8D16	o8-250	6,614	691,156	14,882
5	5,474	0	0	170,149	8D16	o8-250	5,476	683,070	12,321
6	4,334	0	0	183,050	8D16	o8-250	4,336	674,819	9,758
7	5,187	0	0	155,583	8D16	o8-250	5,189	681,010	11,676
8	6,326	0	0	37,564	8D16	o8-250	6,328	689,139	14,238
9	7,446	0	0	38,928	8D16	o8-250	7,465	697,091	16,797
1						4 m = 41 m			And the same

# COLUMN type 3

b (cm)	h (cm)	cover	diameter main bar (cm)	diameter stirrup (cm)	fc (kg/cm2)	fy (kg/cm2)	fv (kg/cm2)
25	25	4	1.6	0.8	187	3,200	2,400

	Fra	me elemer	nt Force		1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	€ <b>3</b> 3 9 3 3 4	Desi	g n	
Member	Axial (kg)	Torsion (kg.cm)	Moment 2 (kg.cm)	Moment 3 (kg.cm)	Main bar (mm)	Stirrup (mm)	Pu (kg)	Max (kg.cm)	May (kg.cm)
11 3 11	1,491	0	0	27,467	4D16	o8-250	1,491	195,079	335,566

	Mu (kg.cm) 653,947			Mu (kg.cm)	121,989			Mu (kg.cm)	189,207 189,207
	Stirrup (mm) 012-300			Stirrup (mm)	012-200			Stirrup (mm)	012-250
	Bottom 3D16 3D16			Bottom	2016 2016			Bottom	2D16 2D16
	Right bars Middle 2012 2012			Right bars Middle	1 ( ) ( ) ( ) ( ) ( ) ( ) ( ) ( ) ( ) (			Right bars Middle	
	3016 3016 3016			- LOD	2D16 2D16			8	2016 2016
	8 1 g Bottom 3D16- 3D16-			Bottom	2016 2016		ν	Botton	2016 2016
	Mid bars Middle 2012 2012		3 p 3/1 4/1	id bars			о О	Mid bars Middle	I I
	3D16 3D16			Top	2D16 2D16			Тор	2016 2016
	Bottom 3D16 3D16			Bottom	2016 2016			Bottom	2016 2016
fv (kg/cm2) 2,400	eff bars Middle 2012 2012	fv (kg/cm2)	2,400	Left bars Middle		fv (kg/cm2) 2,400		Left bars Middle	
fy (kg/cm2) (1	70p 3D16 3D16	fy (kg/cm2) ((	3,200	Top	2016 2016	fy (kg/cm2) (( 3,200		Top	2016 2016
fc (kg/cm2)	Main bar (mm) D16	fc (kg/cm2)	187	Main bar (mm)	016 016	fc (kg/am2)		Main bar (mm)	0 10 0 9
diameter stirrup (cm)	Moment (kg.cm) 28,176	diameter stirrup (cm)	8.0	Moment (kg.cm)	1,221	diameter stirrup (cm)		Moment (kg.cm)	36,989
diameter main bar (cm) 1.6	Torsion (kg.cm)	diameter main bar (cm)	1.6 TF Force	Torsion (kg.cm)	00	diameter main bar (cm)	ot Force	Torsion (kg.cm)	00
cover (cm)	Frame Element Force    Shear Torsion	cover (cm)	20 4 1.6 Frame Element Force	Shear (kg)	88	cover (cm)	Frame Element Force	Shear (kg)	528 387
(cm)	Axial (kg) 0	BEAM type b	20 Fran	Axial (kg)	8 % 4 %	이	Fran	Axia (kg)	3,853
(cm) 30	Member 3	BEAM (cm)	7	Member	16	BEAM type  b h cm) (cm) (cm) 25 2.		Метрег	25

# ROOF K-3 COLUMN type 1

b (cm)	h (cm)	cover (cm)	diameter main bar (cm)	diameter stirrup (cm)	fc (kg/cm2)	fy (kg/cm2)	fv (kg/cm2)
30	40	4	1.6	0.8	187	3,200	2,400

	Fra	me elemei	nt Force				Desi	g n	and the second
Member	Axial (kg)	Torsion (kg.cm)	Moment 2 (kg.cm)	Moment 3 (kg.cm)	Main bar (mm)	Stirrup (mm)	Pu (kg)	Max (kg.cm)	May (kg.cm)
1 14 15 16 17 18	1,333 1,170	0 0 0 0 0	000000	251,148 157,444 388,983 48,563 60,131 415,873	8D16 8D16 8D16 8D16 8D16 8D16	010-250 010-250 010-250 010-250 010-250 010-250	5,684 5,088 1,333	680,296 676,483 671,841 641,966 640,647 680,528	14,822 13,641 12,212 3,200 1,808 16,894

# ROOF K-3 COLUMN type 2

b (cm)	h (cm)	(cm)	diameter main bar (cm)	diameter stirrup (cm)	fc (kg/cm2)	fy (kg/cm2)	fv (kg/cm2)
25	40	4	1.6	0.8	187	3,200	2,400

14 1	Fra	me elemer	nt Force		2 T		Desi	n	
Member	Axiat (kg)	Torsion (kg.cm)	Moment 2 (kg.cm)	Moment 3 (kg.cm)	Main bar (mm)	Stirrup (mm)	Pu (kg)	Max (kg.cm)	May (kg.cm)
3 4 5 10 11 12	3,776 2,749 1,723 212 1,173 2,199	00000	0 0 0 0 0	252,370 163,224 163,324 153,402 153,402 158,666	8D16 8D16 8D16 8D16 8D16 8D16	o10-250 o10-250 o10-250 o10-250 o10-250 o10-250	3,777 2,750	642,775 635,846 628,872 618,422 625,086 632,124	8,499 6,187 3,879 478 2,640 4,949

Mu (kg.cm) 341,292 341,946 338,666

ROOF K-3 BEAM type a

fv (kg/cm2)	2,400
fc fy (kg/cm2) (kg/cm2)	3,200
fc (kg/cm2)	187 3,200 2,400
diameter stirrup (cm)	8.0
diameter cover main bar (cm) (cm)	1.6
cover (cm)	<b>7</b>
h (cm)	09
b (cm)	25

	×	4	
c		Top	3D16
Desig		Middle Bottom	2D16
е О	Mid bars	Middle	2012
		Top	3D16 2012
		Bottom	3016
	Left bars	Top Middle Bottom Top	2012 3016 3016
		Тор	2D16
	Main bar	(mm)	D16
	Moment Main bar	(kg) (kg.cm) (kg.cm)	531,420 D16 2D16 2012 3D16 3D16 2012 2D16 3D16
e Element Force	Shear Torsion	(kg.cm)	)
те Еете	Shear	(kg)	3,224
Fra	Axial	(kg)	1,348
	Member		9

785,443

08-250

2D16

Stirrup (mm)

Bottom

ROOF K-3 BEAM type b

.≱	(kg/cm2)	2,400
4	kg/cm2) (kg/cm2) (kg/cm2	3,200
Ç	(kg/cm2)	0.8 187 3,200 2,400
diameter	(cm)	8.0
diameter over main bar	(cm)	φ.
8ver	(cm)	4
£	(cm)	40
۵	(m <sub>2</sub> )	25

ı			
	Stirrup		000
	S	Middle Bottom	2016 2016 2016
	Right bars	Middle	k I i
c		Тор	2016 2016 2016
S 1 S		Midale Bottom	2016 2016 2016
Des	Mid bars	Midale	2012 2012 2012
		Top	2D16 2012 2D16 2D16 2D16 2012 2D16 2D16 2D16 2012 2D16 2D16
		Middle Bottom	6 2012 2D16 6 2012 2D16 6 2012 2D16
	Left bars	Middle	2012 2012 2012
		Тор	2 2 2 2 2 2 2 2 2 3 3 4 3 4 3 4 3 4 3 4
	Main bar	(mm)	136 756 D16 954
	Moment	(kg.cm)	142,436 148,756 00,954 016
nt Force	Torsion	(ka.cm)	000
Frame Element For	Shear	(Kg)	968 980 723
E L	Axial	(80)	7 2.643 8 3,306 19 365
Ì	ember		<b>1</b> , ∞ 0.

# ROOF K-3 BEAM type c

	fv (kg/cm2)	2,400
	(kg/cm2) (kg/cm2)	187 3,200 2,400
	fc (kg/cm2)	
diameter diameter	stimup fc (cm) (kg/cm2)	0.8
diameter	(cm) (cm) (cm)	1.6
	cover (cm)	4
	h (cm)	20
	ရ <del>(၂</del>	72

	Mu	(kg.cm)	114,429
	Stirrup	(mm)	2D16 08-200 2D16 08-200
	s	Top   Middle Bottom	2016 2016
	Right bars	Middle	1 1
c	. 1	1	2D16 2D16 2D16 2D16
s I		Middle   Bottom	2D16 2D16
D e s i	Mid bars	Middle	
		Top	2D16 2D16
		Bottom	2D16 2D16 - 2D16 -
	Left bars	Middle Bottom	
		Top	2D16 2D16
	Main bar	(mm)	D16 D16
	Moment	(kg.cm)	1,224
ot Force	Torsion	(kg.cm)	00
ne Elemer	Shear	(kg)	22
Fran	Axial	(kg)	88
	Member		45

# WALL type 3 COLUMN type 1

<u>(</u>)

b (cm)	h (cm)	(cm)	diameter main bar (cm)	diameter stirrup (cm)	fc (kg/cm2)	fy (kg/cm2)	fv (kg/cm2)
30	40	4	1.6	0.8	187	3,200	2,400

1	⊸ ⊁⊸ i .a Fra	me elemer	nt Force 🔻	<ul> <li>* 1 * 1 * 1 * 1.2 *</li> </ul>	25 November 2017		Desi	g n	
Member	Axial (kg)	Torsion (kg.cm)	Moment 2 (kg.cm)	Moment 3 (kg.cm)	Main bar (mm)	Stirrup (mm)	Pu (kg)	Max (kg.cm)	May (kg.cm)
1 2 3 7 8 9 10 15 16 17 18	3,735 1,936 439 7,524 5,743 2,877 600			60,588 42,440 40,262 78,956 24,257 33,872 9,477 64,442 37,825 18,877 16,337	8D16 8D16 8D16 8D16 8D16 8D16 8D16 8D16	08-250 08-250 08-250 08-250 08-250 08-250 08-250 08-250 08-250	37,355 1,937 439 7,525 5,744 2,679 600 5,119 3,325 1,932 437	664,960 650,377 638,078 694,881 680,965 656,416 639,406 676,020 661,649 650,338 638,062	89,662 46,493 10,545 180,608 137,872 64,293 1,440 12,297 7,980 4,637 1,049

Asin Pump Control Building Structure Calculation 20 · 30

WALL type 3 BEAM type a

	1	(kg/cm2)	2,400
		kg/cm2)   (kg/cm2)   (kg/cm2)	187 3,200
	ပ္	(kg/cm2)	187
diameter	stirup	(cm)	0.8
diameter	main bar	(cm)	1.6
	cover	(cm)	4
	£	(E)	20
	Ω	(E)	15

ı				00
		رم در	Bottom	2D16 2D16
		Right bars	Middle	
	c		To O	2D16 2D16
	s i		Bottom	2016 2016 2016 2016
	D e s	Mid bars	Middle	
			Тор	2D16 2D16 2D16 2D16
			Bottom	2D16 2D16
	:	Left bars	Middle	
			Top	2D16 2D16
		Main bar	(mm)	010 910
	rame Element Force	Moment	(kg.cm)	00
		Torsion	(kg.cm)	00
		Shear	(6y)	162 162
	Frai	Axial	(8g)	204 326
		Member		4.5

WALL type 3 BEAM type b

	fv (ka/cm2)	2,400
	fc	187 3,200
	fc (ko/cm2)	187
diameter	stirrup (cm)	0.8
diameter	cover main bar	1.6
* * * * *	Cover (Cm)	4
	ւ (ա <u>ն</u>	25
	ှာ (ညီ	20

	Me	(kg.cn	189 189 189
	Stirrup	(mm)	2D16 08-250 2D16 08-250 2D16 08-250
	Ş	Middle Bottom	2D16 2D16 2D16
	Right bars	Middle	
c	S.	Top	2D16 2D16 2D16
S i g		Middle Bottom	2D16 2D16 2D16
D. e. s	Mid bars	Middle	
6, 7		Тор	2016 2016 2016 2016 2016 2016
		Middle Bottom	2D16 2D16 2D16
	Left bars	Middle	
. =		Top	2D16 2D16 2D16
	Main bar	(mm)	010 010
-	Moment	(kg.cm)	36,403 35,877 40,664
nt Force	Shear Torsion	(kg.cm)	000
Frame Element Force		(kg)	581 582 597
Fra	Axial	(kg)	70 216 146
	Aember		2 t t

WALL type 3 BEAM type c

	1.50	
	fy fy kg/cm2)	,200 2,400
	fy: (kg/cm2)	3,200
33	fc (kg/cm2) (k	0.8 187 3,200 2,400
diameter	stirrup (cm)	0.8
diameter	cover   main bar   (cm)	1.6
	cover (cm)	7
	h (cm)	25
	ი (cm)	20

	F.B	Frame Element Force	nt Force				41.7			0	S	c					
ember Axi	Axial	Shear	Torsion	Moment	Main bar		Left bars			Aid bars			Right bars		Stirrup	Mu	
	(kg)	(kg)	(kg.cm)	(kg.cm)	(mm)	Top	Middle	Middle Bottom	GO.	Middle	Middle Bottom	go E	Middle	Bottom	(mm)	(kg.cm)	
	27					1,3											
ဖ	4	1,660	0	103,006	010	2D16	•	2D16	2016	•	2016	2016		2016	08-100	189,035	
7	673	1.655	0	102,262	ე დ	3016		2D16 2D16	2016	:	2016	2016   2016		2016	2D16   08-100	188,800	
	1				1 1 1 1 1 1	1	) 			1	•					•	

# WALL type 4 COLUMN type 1

b (cm)	h (cm)	cover	diameter main bar (cm)	diameter stirrup (cm)	fc (kg/cm2)	fy (kg/cm2)	fv (kg/cm2)
30	40	4	1.6	0.8	187	3,200	2,400

111111	Frai	me elemer	it Force			1	Desi	g n	art et al es al
Member	Axial	Torsion	Moment 2	Moment 3	Main bar	Stirrup	Pu	Max	May
	(kg)	(kg.cm)	(kg.cm)	(kg.cm)	(mm)	(mm)	(kg)	(kg.cm)	(kg.cm)
							e Properties		
1	4,408	0	0	55,504	8D16	o8-250	4,407	870,343	10,577
2	1,928	0	0	45,108	8D16	08-250	1,930	650,318	4,632
3	437	0	0	9,822	8D16	o8-250	437	638,062	1,049
7	887	0	0	10,590	8D16	08-250	124,489	336,122	298,775
8	5,755	0	0	32,880	8D16	08-250	5,757	681,064	13,817
9	2,682	0	0	29,355	8D16	o8-250	2,683	656,454	8,440
10	501	0	0	8,738	8D16	o8-250	601	639,418	1.444
15	4,942	0	0	55,431	8D16	o8-250	4,944	674,625	11.865
16	3,332	0	0	34,542	8D16	o8-250	33,322	661,712	7 999
17	1,934	0	0	21,045	8D16	o8-250	1,934	650,359	4.643
18	438	0	0	14,608	8D16	o8-250	438	638,067	1,051
19	6,013	0	0	45,462	8D16	08-250	6,014	68,309	14,435

# WALL type 4 BEAM type a

()

fc fy fv fv (kg/cm2) (kg/cm2)	2,400
fc fy kg/cm2)	3,200
fc (kg/cm2)	0.8 187 3,200 2,400
fiameter diameter nain bar stirrup (cm) (cm)	0.8
diameter main bar (cm)	1.6
cover (cm)	7
h (cm)	20
ر (ق و	15

0	Н		
. i		Middle   Bottom	2016 2016
e (	Aid bars	Middle	
	2	Top	2016 2016
		Middle   Bottom	2D16 2D16
	Left bars		
		Top	2D16 2D16
	Main bar	(mm)	D16 2D16 D16 2D16
	Moment	(kg.cm)	10,202
nt Force	Torsion	(kg.cm)	0
Frame Element Force	Shear	(gy)	182 182
Fra	ž	(ga)	119 306
	Member		4.1

131,229

08-200

2D16 2D16

2D16 2D16

Mu (kg.cm)

Stirrup (mm)

WALL type 4 BEAM type b

1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1		diameter	diameter diameter		•	
c	cover	h cover main bar	stirrup	ည	* *	.≱
(cm)	(cm)	(cm)	(cm)		(kg/cm2)   (kg/cm2)   (kg/cm2)	(kg/cm2)
25	4	1.6	0.8		187 3,200 2,400	2,400

	Γ		7 8 7 8 5 8 8 9 9
	Mc	(kg.cm)	189,071 189,938 189,113 189,065
	Stirrup	(mm)	2D16 010-250 2D16 010-250 2D16 010-250 2D16 010-250
	ρ	Bottom	2016 2016 2016 2016
	Right bars	Middle	1 1 1 1
c		dol	2222 2022 2010 2010 8
s		Middle Bottom	2016 2016 2016 2016
Desi	Mid bars	Middle	
		Top	2222 2022 6000 6000
2		Bottom	2002 2004 2016 2016
	Left bars	Middle	
	Let	Top	2016 2016 2016 2016
	Main bar	(mm)	0000 0000
	Moment	(kg.cm)	36,994 101,569 35,654 39,366
of Force	Torsion	(kg.cm)	0000
Frame Element	Shear	(kg)	1,651 560 560 592
Frag	Axial	(kg)	135 135 99
	Member		υ φ <u>τ</u> τ

WALL type 4 BEAM type c

-		
	(kg/cm2)	2,400
	fc   fy   fv   fv   kg/cm2)	187 3,200 2,400
	fc (kg/cm2)	187
diameter	stimp (cm)	0.8
diameter	main bar (cm)	4 1.6
	Sver (cm)	4
	<u>-</u> (ξ	25
	<u>ှိ</u> မြိ	20

	J.W.	(kg.cm)	2,000	277	188,937	
		(kg	•	-		
	Stirrup	(EE)	00000	201-00	2D16   08-200	
	S,	Middle Bottom	3000	3	2016	:
	Right bars	Middle		•	•	-
С	ш,	Top	37.00	0	2016 2016	:
6 .1 s		Bottom	2000	5	2016	
ه ۵	Mid bars	Middle Bottom			•	
		Top	20046 20046	27	2016	
		Bottom	20,46	) )	2016	
	Left bars	Middle			•	5 1 1 1 1 1 1 1
		Тор	2016	ď	2016	
	Main bar	(mm)	03.200 D16	2	94,334 D16	
	Moment	(kg.cm)	03.200	20,400	94,334	
nt Force	Torsion	(kg.cm)		>	0	
Frame Element Force	Shear	(kg)	1 480	3	1 492	1 1
Frai	Axial	( <u>X</u>	328	3	9	
	Member		4	]	 8	\$ .

Checking of Column reinforcement bar & stress of Roof Portal Frame Type K - 1

At support reaction of right column as the biggest bending moment.

Bending Moment = 178,841 kgcm  
b (width) = 30 cm  
h<sub>t</sub> (height) = 40 cm  
Concrete cover = 5 cm  
h = h<sub>t</sub> - d = 225 kg/cm<sup>2</sup> 
$$\overline{\sigma}'_{b}$$
 = 130 kg/cm<sup>2</sup>  
Fu = 3,200 kg/cm<sup>2</sup>  $\overline{\sigma}_{a}$  = 2,600 kg/cm<sup>2</sup>  
n = 14  
 $\delta = 1$  (symetrical reinforcement)  
 $\phi_{0} = \frac{\sigma_{a}}{nx\sigma'_{b}} = \frac{2,600}{14x130} = 1.43$ 

$$Ca = \frac{h}{\sqrt{\frac{nxM}{bx\sigma_a}}} = \frac{35}{\sqrt{\frac{14x178,841}{30x2,600}}} = 6.18$$

$$\Rightarrow \phi = 4.31 > \phi_0 = 1.43 \text{ (OK)}$$

$$\phi' = 8.11$$

$$n\omega = 0.028$$

Stresses

$$\overline{\sigma}_{a} = 2,600 \text{ kg/cm}^{2}$$

$$\overline{\sigma}_{b} = \overline{\sigma}_{a} = 2,600 = 43.09 \text{ kg/cm}^{2} < \overline{\sigma'}_{b} = 130 \text{ kg/cm}^{2} \text{ (OK)}$$

$$\overline{nx\phi} = \overline{\sigma}_{a} = 2,600 = 320.59 \text{ kg/cm}^{2} < \overline{\sigma}_{a} = 2,600 \text{ kg/cm}^{2} \text{ (OK)}$$

$$\overline{\sigma}_{a} = \overline{\sigma}_{a} = 2,600 = 320.59 \text{ kg/cm}^{2} < \overline{\sigma}_{a} = 2,600 \text{ kg/cm}^{2} \text{ (OK)}$$

Reinforcement

hrordement
$$A = \frac{\text{obh}}{n} = \frac{0.028 \times 30 \times 35 = 2.1 \text{ cm}^2}{14}$$

$$A_{\text{steel}} = 2.1 \text{ cm}^2 < 1 \% \times 900 \text{ cm}^2 \text{ (sectional area of column)}$$

Hence applied: A steel  $= 16.08 \text{ cm}^2 = 16.08 \times 100 \% \text{ A concrete}$ 

= 1.34 % A concrete (OK)

Checking of Beam reinforcement bar & stress of Roof Portal Frame Туре К - 1

At left side roof slope as the biggest bending moment.

= 187,366 kgcmBending Moment

()

b (width) 
$$= 25 \text{ cm}$$

$$h_t \text{ (height)} = 40 \text{ cm}$$

$$\text{Concrete cover} = 5 \text{ cm}$$

$$h = h_t - d = 40 - 5 = 35 \text{ cm}$$

$$= 225 \text{ kg/cm}^2 \longrightarrow \overline{\sigma'}_b = 130 \text{ kg/cm}^2$$
Fu
$$= 3,200 \text{ kg/cm}^2 \longrightarrow \overline{\sigma}_a = 2,600 \text{ kg/cm}^2$$

$$= 14$$

$$\delta = 1 \text{ (symetrical reinforcement)}$$

$$\phi_0 = \frac{\sigma_a}{n \times \overline{\sigma}'_b} = \frac{2,600}{14 \times 130} = 1.43$$

$$Ca = \frac{h}{\sqrt{\frac{n \times M}{b \times \sigma_a}}} = \frac{35}{\sqrt{\frac{14 \times 187,366}{25 \times 2,600}}} = 5.51$$

#### Stresses

$$\overline{\sigma}_{a} = 2,600 \text{ kg/cm}^{2}$$

$$\overline{\sigma}_{b} = \overline{\sigma}_{a} = 2,600 = 51.59 \text{ kg/cm}^{2} < \overline{\sigma'}_{b} = 130 \text{ kg/cm}^{2} \text{ (OK)}$$

$$\overline{\sigma}_{a} = \overline{\sigma}_{a} = 2,600 = 390.98 \text{ kg/cm}^{2} < \overline{\sigma}_{a} = 2,600 \text{ kg/cm}^{2} \text{ (OK)}$$

$$\overline{\sigma}_{a} = \overline{\sigma}_{a} = 2,600 = 390.98 \text{ kg/cm}^{2} < \overline{\sigma}_{a} = 2,600 \text{ kg/cm}^{2} \text{ (OK)}$$

#### Reinforcement

nforcement
$$A = \frac{\omega bh}{n} = \frac{0.035}{14} \times 25 \times 35 = 2.19 \text{ cm}^{2}$$

$$A_{\text{steel}} = 2.19 \text{ cm}^{2} < 1 \% \times 1,000 \text{ cm}^{2} = A_{\text{concrete}} \text{ (sectional area)}$$
Hence applied:
$$A_{\text{steel}} = 8 \text{ D } 16$$

$$= 16.08 \text{ cm}^{2} = \frac{16.08}{25 \times 40} \times 100 \% \text{ A}_{\text{concrete}}$$

= 1.61 % A concrete (OK)

# Checking of Beam reinforcement bar & stress of Wall Portal Frame Type K - 1

On Rail Beam, member F5 as the biggest bending moment.

= 266,680 kgcmBending Moment : 50 CM b (width) 50 cmh<sub>t</sub> (height)

Concrete cover 
$$\begin{array}{lll} = & 5 & \text{cm} \\ h = h_t - d & = & 50 - 5 = 45 & \text{cm} \\ = & 50 - 5 = 45 & \text{cm} \\ = & 225 & \text{kg/cm}^2 & \longrightarrow \overrightarrow{\sigma'}_b = 130 & \text{kg/cm}^2 \\ \text{Fu} & = & 3,200 & \text{kg/cm}^2 & \longrightarrow \overrightarrow{\sigma}_a = 2,600 & \text{kg/cm}^2 \\ n & = & 14 \\ \delta = 1 & \text{(symetrical reinforcement)} \end{array}$$

$$\phi_0 = \frac{\sigma_a}{n x \overline{\sigma'_b}} = \frac{2,600}{14 \times 130} = 1.43$$

$$Ca = \frac{h}{\sqrt{\frac{n x M}{b x \sigma_a}}} = \frac{45}{\sqrt{\frac{14 \times 266,680}{50 \times 2,600}}} = 8.39$$

#### Stresses

$$\overline{\sigma}_a = 2,600 \text{ kg/cm}^2$$

$$\overline{\sigma}_{b} = \overline{\sigma}_{a} = \frac{2,600}{14x5.45} = 34.08 \text{ kg/cm}^{2} < \overline{\sigma'}_{b} = 130 \text{ kg/cm}^{2} \text{ (OK)}$$

$$\sigma_{a} = \frac{\overline{\sigma}_{a}}{\phi'} = \frac{2,600}{15.36} = 169.27 \text{ kg/cm}^2 < \sigma_{a} = 2,600 \text{ kg/cm}^2 \text{ (OK)}$$

# Reinforcement

Fu

A = 
$$\frac{\text{obh}}{n}$$
 =  $\frac{0.0152 \times 50 \times 45 = 2.44 \text{ cm}^2}{14}$   
A steel = 2.44 cm<sup>2</sup>

Checking of Beam reinforcement bar & stress of Wall Portal Frame туре к - 1

On Tunnel Beam, member F39 as the biggest bending moment.

 $= 123,478 \text{ kgcm}^{-1}$ Bending Moment 25 CM b (width) 40 cmht (height) Concrete cover 40 - 5 = 35 cm  $h = h_t - d$ 225  $kg/cm^2 \rightarrow \overline{\sigma'}_b = 130 kg/cm^2$ FC 3,200 kg/cm<sup>2</sup>  $\rightarrow \overline{\sigma}_a = 2,600 \text{ kg/cm}^2$ 

 $(\cdot)$ 

 $\delta = 1$  ( symetrical reinforcement )

$$\phi_0 = \frac{\sigma_a}{nx\sigma'_b} = \frac{2,600}{14x130} = 1.43$$

$$Ca = \frac{h}{\sqrt{\frac{nxM}{bx\sigma_a}}} = \frac{35}{\sqrt{\frac{14x123,478}{25x2,600}}} = 6.79$$

= 14

# Stresses

 $\overline{\sigma}_a = 2,600 \text{ kg/cm}^2$ 

$$\overline{\sigma}_{b} = \overline{\sigma}_{a} = \frac{2,600}{14 \times 4.41} = 42.11 \text{ kg/cm}^{2} < \overline{\sigma'}_{b} = 130 \text{ kg/cm}^{2} \text{ (OK)}$$

$$\sigma_a = \overline{\sigma}_a = \frac{2,600}{9.59} = 271.12 \text{ kg/cm}^2 < \sigma_a = 2,600 \text{ kg/cm}^2 \text{ (OK)}$$

### Reinforcement

$$A = \frac{\omega bh}{n} = \frac{0.023 \times 25 \times 35 = 1.44 \text{ cm}^2}{14}$$

$$A_{\text{steel}} = 2.44 \text{ cm}^2$$

Hence applied:

at button that the co

$$A_{\text{steel}} = 2 D 16$$
  
=  $4.16 \text{ cm}^2 > A_{\text{steel}} = 1.44 \text{ cm}^2$  (OK)

# Checking of Beam reinforcement bar & stress

On Beam No. F14

Maximum Bending Moment	= 124,178 kgcm	The second of the second
b (width)	= 30 cm	
h <sub>t</sub> (height)	= 50 cm	
Concrete cover	= 4 cm	
FC	= 225   kg/cm2	$\rightarrow \overline{\sigma'}_b = 130 \text{ kg/cm}^2$
<b>Fu</b>	$= 3,200 \text{ kg/cm}^2$	$\rightarrow \overline{\sigma}_a = 2,600 \text{ kg/cm}^2$
ns A A A	= 14	

$$\phi_0 = \frac{\overline{\sigma}_a}{n \overline{\sigma'}_b} = \frac{2,600}{14 \times 130} = 1.43$$

For Maximum BM, M = 124,178 kgcm

$$b = 30$$
  
 $h_t = 50$ ;  $d = 4$   $\longrightarrow$   $h = h_t - d = 50 - 4 = 46 cm$ 

Ca = h = 46 = 9.7  

$$\sqrt{\frac{\text{nM}}{\text{b}\sigma_a}}$$
  $\sqrt{\frac{14x124,178}{30x2,600}}$ 

$$\delta$$
 = 0.4 ( required of minimum compression reinforcement bar )   
  $\rightarrow$   $\phi$  = 1.546 >  $\phi_0$  = 1.43 (OK)   
  $\phi'$  = 2.103   
  $n\omega$  = 0.0602

. Stresses

$$\overline{\sigma}_{a} = 2,600 \text{ kg/cm}^{2}$$

$$\overline{\sigma}_{b} = \overline{\sigma}_{a} = 2,600 = 120.13 \text{ kg/cm}^{2} < \overline{\sigma'}_{b} = 130 \text{ kg/cm}^{2} \text{ (OK)}$$

$$\overline{n\phi} = 14 \times 1.546$$

$$\sigma_a = \overline{\sigma_a} = 2,600 = 1,236 \text{ kg/cm}^2 < \overline{\sigma_a} = 2,600 \text{ kg/cm}^2 \text{ (OK)}$$

. Reinforcement bar

A steel (tensile) = 
$$\frac{\omega bh}{14}$$
 = 0.0043 x 30 x 46 = 5.934 cm<sup>2</sup>

A steel (compression) = 
$$\delta \times A$$
 steel (tensile)  
=  $0.4 \times 5.934$  cm<sup>2</sup> =  $2.374$  cm<sup>2</sup>

Used A steel (tensile) = 
$$3 D 16 = 6.028 cm^2$$
 (OK)

# Checking of Column reinforcement bar & stress

On Column No. F15

Maximum Bending Moment = 258,070 kgcm b (width) = 30 cm ht (height) = 40 cm Concrete cover = 4 cm = 
$$40 - 4 = 36$$
 cm

FC =  $225 \text{ kg/cm}^2 \longrightarrow \sigma_b = 130 \text{ kg/cm}^2$ 
Fu =  $3,200 \text{ kg/cm}^2 \longrightarrow \sigma_a = 2,600 \text{ kg/cm}^2$ 
ns =  $14$ 

$$\frac{\phi_0 = \overline{\sigma}_a = 2,600}{n \overline{\sigma}'_b 14x130} = 1.43$$

For Maximum BM M = 258,070 kgcm

Ca = h = 36 = 5,28  

$$\sqrt{\frac{\text{nM}}{\text{b}\sigma_a}}$$
  $\sqrt{\frac{14x258,070}{30x2,600}}$ 

$$\delta$$
 = 1 ( for symetrical reinforcement )   
 $\Rightarrow$   $\phi$  = 5.28 >  $\phi_0$  = 1.43 (OK)  $\phi'$  = 14.00  $\omega$  = 0.0164

. Stresses

$$\frac{\overline{\sigma_a}}{\overline{\sigma_b}} = \frac{2,600 \text{ kg/cm}^2}{\frac{n}{\phi}} = \frac{2,600}{14 \times 5.25} = 35.37 \text{ kg/cm}^2 < \overline{\sigma_b} = 130 \text{ kg/cm}^2$$

$$\frac{\sigma_a}{\overline{\sigma_a}} = \frac{2,600}{14.00} = 185.71 \text{ kg/cm}^2 < \overline{\sigma_a} = 2,600 \text{ kg/cm}^2$$

Reinforcement

$$A = \omega bh = 0.0164 \times 30 \times 36 = 1.265 \text{ cm}^2$$

A  $_{\text{steel}} = 1.265 \text{ cm}^2 < 1 \% \text{ x 1,500 cm}^2 \text{ (sectional area of column)}$ 

Hence applied:

# CHAPTER 3 BANDARHARJO DRAINAGE SYSTEM IMPROVEMENT

3.1 Baru Pumping Station

- 3.1 Baru Pumping Station
- 3.1.1 Structural Calculation of Gate Leaf and Hoist

thus the lower to not whole the mains it is

	ame of ructure	Baru Gat	e to to	Category of calculation		ructural, ate Leaf	Page	1/25
)	Design	Conditions				tivati katiwa		eri Girlenia e
i. '	Functio	n of the gate	·					
	Tidal ba	rrier	$x \in \chi$	in strikure	rapia dik	e difference	: 1. m. 13.5	
					ماليد المحولات	erita johalis en	er <sub>e</sub> i k	
<b>?</b> .	Top elev	ation of the gate				31.34 Eff. 1		
	As the g	ate acts as a tidal	barrier, the	top elevation o	f the gat	e should be id	lentical t	o that of th
	tidal dil	e.			en e i e			
				ការប្រជាជាធិប្រជាជាក្រុម ស្រីស្រីស្រីស្រីស្រីស្រីស្រីស្រី	en e	ing in the second	e versioner i de la company de la company La company de la company d	
						2 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4		
	The top	elevation of the tid	al dike is +(					
	The top	elevation of the tid	al dike is +(				1	
		elevation of the tid		).45m+0.4m=+0	0.85m.			
				).45m+0.4m=+0	0.85m.			
	Therefo		of the gate	).45m+0.4m=+0	0.85m.			
	Therefo Bottom	e, the top elevation	of the gate	).45m+0.4m=+0 : should be +0.8	0.85m. 5m.	405m.		
	Therefo Bottom Design	e, the top elevation elevation of the gat iver bed elevation	n of the gate e of Semaran	).45m+0.4m=+0 should be +0.8 g River at No.31	0.85m. 5m.	405m.		
	Therefo Bottom Design	e, the top elevation	n of the gate e of Semaran	).45m+0.4m=+0 should be +0.8 g River at No.31	0.85m. 5m.	405m.		
	Therefo Bottom Design t L.W.L. i	e, the top elevation elevation of the gat iver bed elevation on n Baru Retarding I	of the gate e of Semaran Pond is -2.4	).45m+0.4m=+0 should be +0.8 g River at No.31 m.	0.85m. 5m.	405m.		
	Therefo Bottom Design t L.W.L. i	e, the top elevation elevation of the gat iver bed elevation	of the gate e of Semaran Pond is -2.4	).45m+0.4m=+0 should be +0.8 g River at No.31 m.	0.85m. 5m.	<b>405m.</b>		
	Therefo Bottom Design t L.W.L. i	re, the top elevation elevation of the gat liver bed elevation on Baru Retarding I	e of Semaran Pond is -2.4 iver is also	).45m+0.4m=+0 should be +0.8 g River at No.31 n.	.85m. 5m. l+8 is -2.	405m.		
	Therefo Bottom Design t L.W.L. i	e, the top elevation elevation of the gat iver bed elevation on n Baru Retarding I	e of Semaran Pond is -2.4 iver is also	).45m+0.4m=+0 should be +0.8 g River at No.31 n.	.85m. 5m. l+8 is -2.	405m.		
	Therefore  Bottom  Design  L.W.L. i  Design  Therefore	re, the top elevation elevation of the gat liver bed elevation on Baru Retarding I	e of Semaran Pond is -2.4 iver is also	).45m+0.4m=+0 should be +0.8 g River at No.31 n.	.85m. 5m. l+8 is -2.	405m.		

In definitive plan the water level was assumed as 0.25+0.1=0.35m and pump station was designed.

Same elevation shall be used for gate design.

Therefore, the design water level upstream is 0.35m.

6 Design Water Level Asin River Side
The bottom elevation of the gate is -2.4m.

Therefore, the design water level downstream is -2.4m.

7 Load Condition

(case-1) normal condition

hydraulic static load (U/S: +0.35m, D/S; -2.4m)

incremental coefficient: 1.00 (same as Japanese standard)

Name of Structure Asin gate Category of Ca

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and we also have been an in the analysis of a

(case-2) seismic condition

hydraulic static load (U/S; +0.35m+0.10m, D/S; -2.4m) calculation of seismic wave  $he=K~\tau~(\sqrt{(gH)})/(2^*\pi)$ 

 $K=0.11~m/s^2$  the transfer with a p . If E p a p e

 $\tau = 1 \sec$ 

hydraulic dynamic load (Westergaard formula)

7/12\*Kh\*W\*b\*h2

有风色的复数 化二氯甲基甲基

where Kh=0.11

incremental coefficient: 1.50 (same as Japanese standard)

#### ii) Structural Calculation

See attached calculation sheets.

# SPILLWAY GATE AND HOIST

# I. DESIGN CONDITION

Type : Fixed wheel gate made of steel

Quantity : 1 (one) set

Clear span : 4.0 m.

Gate height : 3.25 m.

Hwl : EL.  $\pm 0.35$  m.

Sill elevation : EL. - 2.40 m.

Design head : 2,750 m [(+0.35 - (-2.40 m)]]

Sealing method : 3 edges rubber seal at upstream

Seismic coefficient (Kh) : 0.11

Seismic wave height : 0.10 m.

Maximum deflection of beam : 1/800

Corrosion allowance : 3.0 mm.

Type of hoist : Electrically driven wire rope wound type stationary

hoist

(1 m 2 D type)

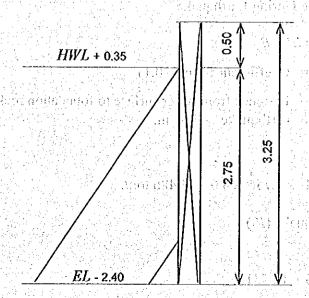
Operation speed : 0.3 m/min + 10%

Hoisting height : 5.0 m.

Operating method : Local

# II. HYDRAULIC LOAD (P)

# 1. Hydrostatic Pressure



man, his h

$$P_1 = \frac{W_0 \times H_0^2 \times B}{2}$$

where;

 $P_1 = \text{Hydraulic load (t)}$ 

 $H_0$  = Water head of bottom = 2.86 m.

B = Sealing span = 4.0 m.

$$W_0 = 1.0 \text{ t/m}^3$$

Thus;

$$P_1 = \frac{1.0 \times 2.75^2 \times 4.0}{2}$$
$$= 16.36 \, tf.$$

# 2. Water Pressure During Earthquake

# 2.1. Hydrostatic Pressure During Earthquake

$$Ps = \frac{1}{2} \times (hw + h)^2 \times B$$

where: hw = Height of waves due to earthquake = 0.1 m.

h = Water head = 2.75 m.

B = Sealing span = 4.0 m.

$$Ps = \frac{1}{2} \times (0.1 + 2.75)^2 \times 4.0$$
  
= 16.245 ton f

# 2.2. Dynamic Water Pressure During Earthquake

$$Pd = \frac{1}{12} \times K_h \times h_m^{\frac{1}{2}} \times h^{\frac{1}{2}} \times B$$

where:  $K_h = \text{Coefficient factor} = 0.11$ 

 $h_m$  = Distance from water surface to foundation rock during earthquake. = 4.51 m.

Thus;

$$Pd = \frac{1}{12} \times 0.11 \times 4.51^{\frac{1}{2}} \times 2.75^{\frac{1}{12}} \times 4.0 = 2.486 \text{ tonf.}$$

Total load during earthquake  $(P_2)$ 

$$P_2 = P_S + P_d$$
  
= 16.245 + 2.486 = 18.731 t.

Thus;

 $P_1 \langle P_2$ 

15.125 if ( 18.731 if.

There fore design shall be carried out based on the water pressures during earthquake.

BERTHAM BOAR BURE OF THE

$$P_{2} = \frac{W_{0} \times H_{0}^{2} \times B}{2}$$

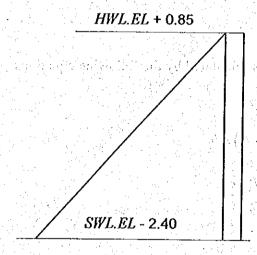
$$18.731 = \frac{1.0 \times H_{0}^{2} \times 4.0}{2}$$

$$H_{0} = \sqrt{\frac{18.731 \times 2}{1.0 \times 4.0}}$$

$$= 3.060 \text{ m.}$$

Thus: Design head of water is determined 3.25 m.

# Hydraulic Load During Earthquake (P)



$$P = \frac{W_0 \times H^2 \times B}{2} \text{ where };$$

P = Hydraulic load during earthquake (tf)

A 33. A

Section of the second

H = Water head of Bottom = 3.25 m.

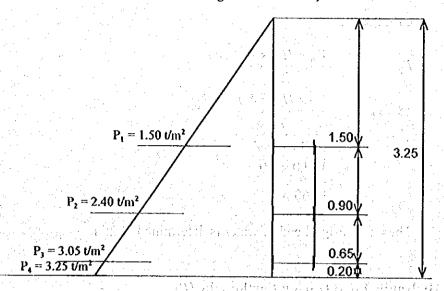
B = Sealing span = 4.0 m  $W_0 = 1.0 \text{ t/m}^3$ 

$$P = \frac{1.0 \times 3.25^2 \times 4.0}{2}$$
= 21,125 *tf*

#### III. HORIZONTAL MAIN BEAM

# 1. Arrangement of Main Beam

Three (3) numbers of main beam are arranged as follows:



# 2. Charging Load on Each Beam.

Charging load acting on each beam is calculated by the following equations

Beam A = 
$$0.5 \times P_1^2 + \frac{(2P_1 + P_2) \times b_2}{6}$$
  
Beam B =  $\frac{(P_1 + 2P_2) \times b_2}{6} + \frac{(2P_2 + P_3) \times b_3}{6}$   
Beam C =  $\frac{(P_2 + 2P_3) \times b_3}{6} + \frac{(P_3 + P_4) \times b_4}{2}$ 

Thus, calculation result is as follows;

Beam A

$$P_{\rm A} = 0.5 \times 1.50^2 + \frac{0.9 \times (2 \times 1.50 + 2.40)}{6} = 1.935 \, \text{tf/m}$$

Beam B

$$P_{\rm B} = \frac{0.9 \times (1.50 + 2 \times 2.40)}{6} + 0.65 \times \frac{(2 \times 2.40 + 3.05)}{6} = 1.795 \, \text{tf/m}$$

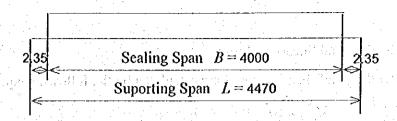
Beam C

$$P_{\rm c} = 0.65 \times \frac{(2.40 + 2 \times 3.05)}{6} + 0.5 \times (3.05 + 3.25) \times 0.2 = 1.551 \, \text{f/m}$$

#### 3. Bending Moment and Shearing Force.

#### 3.1. Bending Moment.

Maximum bending moment is calculated by the following equation.



$$M_{\text{max}} = \frac{W \times (2 \times L - B)}{8}$$

Where;  $M_{\text{max}} = \text{Maximum bending moment (} tf\text{-m}\text{)}$ 

W = Hydraulic load acting on each beam (tf)

$$= P_{\rm B} \times A$$

$$= 1.935 \times 4.0 = 7.740 \, tf$$

L = Supporting length 4.47 m

B = Sealing span = 4.0 mt.

$$M_{\text{max}} = \frac{7.740 \times (2 \times 4.47 - 4.0)}{8} = 3.780 \text{ tf-m}$$

#### 3.2. Shearing Force.

Maximum shearing force is calculated by the following equation;

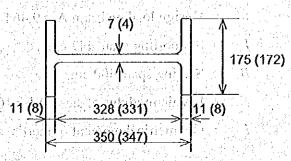
$$S_{\text{max}} = \frac{W}{2}$$
 Where;  $S_{\text{max}} = \text{Max shearing force (} tf)$ 

$$W = \text{Hydraulic load (} tf)$$

$$S_{\text{max}} = \frac{7.740}{2} = 3.870 \, tf$$

Note; As major design load acting's on beam A, bending moment and shearing force are calculated only beam A.

Sectional property of beams.



Moment of inertia 
$$I = 9116.8 \text{ cm}^4$$

$$Z = 525.5 \text{ cm}^3$$

Area of web at both end 
$$AW = 13.24 \text{ cm}^2$$

$$AW = 13.24 \text{ cm}^2$$

$$A = 40.76 \text{ cm}^2$$

# 3.3. Bending and Shearing Stress

Bending and shearing stress are calculated by the following equations;

$$\sigma b_{\max} = \frac{M_{\max} \times 10^5}{Z}$$

$$\tau_{\text{max}} = \frac{S_{\text{max}} \times 10^3}{AW}$$

Where; It is the best and selected the selection of the selection

 $\sigma b_{\text{max}} = \text{Maximum bending stress (kg/cm}^2)$ 

 $M_{\text{max}} = \text{Maximum bending moment (tf-m)}$ 

= Modulus of section (cm<sup>3</sup>)

 $\tau_{\text{max}}$  = Maximum shearing stress (kgf/cm<sup>2</sup>)

 $S_{\text{max}} = \text{Maximum shearing force } (tf)$ 

AW =Area of web at both end.

Thus;

$$\sigma b_{\text{max}} = \frac{4.780 \times 10^5}{525} = 910 \text{ kg.f/cm}^2 \ ( 1,200 \text{ kg/cm}^2)$$

$$\tau_{\text{max}} = \frac{3.870 \times 10^3}{13.24} = 292 \text{ kgf/cm}^2 \ \langle 700 \text{ kgf/cm}^2 \rangle$$

Not officially to

# 3.4. Deflection ( $\partial$ )

Maximum deflection of each beam is calculated by the following equation.

$$\partial = \frac{W}{48EI} \times \left( L^3 - \frac{L \times B^2}{2} + \frac{B^3}{8} \right)$$

Where the and state to be block.

 $\partial_{max}$  = Maximum deflection of beam A (cm)

W = Design load on beam A = 9.464 kgf

L =Supporting span 447 cm.

B =Sealing span 400 cm.

= Elastic modulus of steel  $2.1 \times 10^6 \text{ kg} f/\text{cm}^2$ 

= Geometrical moment of inertia = 20,299 cm<sup>4</sup>

Thus;

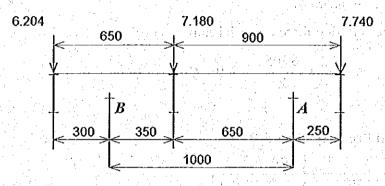
$$\partial = 0.611 \times \frac{W}{I} = 0.611 \times \frac{7,740}{9116.8} = 0.518 \text{ cm}$$

$$\frac{\partial}{L} = \frac{0.518}{447} = \frac{1}{863} \left\langle \frac{1}{800} \right\rangle$$
 (allowable deflection)

### IV. END BEAM

# 1. Arrangement of Main Wheels

Two main wheel are provided in each end beam of gate leaf and their arrangement is as follows;



#### 2. Reaction Force.

Moment at RA

$$7.740 \times 0.25 - 7.180 \times 0.65 + RB \times 1.0 - 6.204 \times 1.3 = 0$$

$$1.935 - 4.667 + RB - 6.065 = 0$$

$$RB = 10.797 tf$$

$$RA = 21.125 - 10.797 = 10.328 tf$$

Distributed load on each main wheel.

$$RB' = RB/2 = 10.797/2 = 5.396 \text{ if}$$

$$RA' = \frac{RA}{2} = 10.328/2 = 5.164 \text{ tf}$$

#### 3. Bending Moment and Shearing Force.

#### 3.1. Bending Moment.

$$M_1 = 0$$

$$M_2 = 7.74 \times 0.25 = 1.935 \, tf.m$$

$$M_3 = 7.74 \times 0.9 - 10.328 \times 0.65 = 0.253 \, tf.m$$

$$M_4 = 6.204 \times 0.3 = 1.861 \, tf.m$$

超性影片 法被审判证证法

Maximum Bending Moment;

$$M_{\text{max}} = \frac{M_3}{2} = \frac{1.935}{2} = 0.968 \text{ f/m}$$

# 3.2. Shearing Force.

$$S_1 = 7.74 tf.$$

$$S_2 = 7.74 - 10.328 = -2.588 \, tf.$$

$$S_3 = 7.74 - 10.328 + 7.180 = 4.592 \, tf.$$

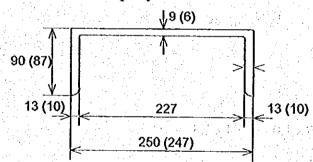
$$S_4 = 7.74 - 10.328 + 7.180 - 10.797 = -6.205 \text{ ff.}$$

$$S_5 = 6.205 tf.$$

Max shearing force on each beam

$$S_{\text{max}} = \frac{S_4}{2} = \frac{6.205}{2} = 3.102 \, \text{tf.}$$

# 4. Sectional Property of End Beam



$$I = 3030 \text{ cm}^4$$

$$Z = 245.3 \, \text{cm}^3$$

$$AW = 14.82 \, \mathrm{cm}^2$$

$$A = 31.02 \text{ cm}^2$$

# 5. Bending and Shearing Stress

Bending stress (ob)

$$\sigma b = \frac{M_{\text{max}}}{Z}$$

$$= \frac{0.968 \times W^5}{245.3} = 395 \text{ kgf/cm}^2 \langle 1,200 \text{ kgf/cm}^2 \rangle$$

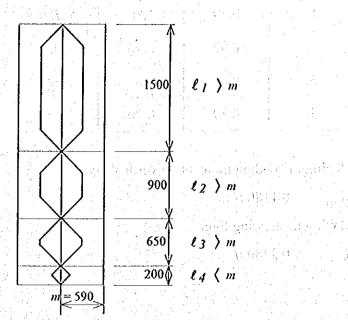
Shearing Stress (15)

$$\pi = \frac{S_{\text{max}}}{AW}$$

$$= \frac{3.102 \times W^3}{14.82} = 209 \text{ kgf/cm}^2 \ (700 \text{ kg kgf/cm}^2)$$

### V. VERTICAL GIRDER

1. Bending moment and shearing force are calculated by the following formula.



1.1.  $\ell \rightarrow \tilde{m}$  where  $\ell \in \mathbb{R}^n$  is a substitute of  $\ell \in \mathbb{R}^n$  and  $\ell \in \mathbb{R}^n$  is a substitute of  $\ell \in \mathbb{R}^n$  and  $\ell \in \mathbb{R}^n$  is a substitute of  $\ell \in \mathbb{R}^n$  and  $\ell \in \mathbb{R}^n$  is a substitute of  $\ell \in \mathbb{R}^n$  and  $\ell \in \mathbb{R}^n$  is a substitute of  $\ell \in \mathbb{R}^n$  and  $\ell \in \mathbb{R}^n$  is a substitute of  $\ell \in \mathbb{R}^n$  and  $\ell \in \mathbb{R}^n$  is a substitute of  $\ell \in \mathbb{R}^n$  and  $\ell \in \mathbb{R}^n$  is a substitute of  $\ell \in \mathbb{R}^n$  and  $\ell \in \mathbb{R}^n$  is a substitute of  $\ell \in \mathbb{R}^n$  and  $\ell \in \mathbb{R}^n$  is a substitute of  $\ell \in \mathbb{R}^n$  and  $\ell \in \mathbb{R}^n$  is a substitute of  $\ell \in \mathbb{R}^n$  and  $\ell \in \mathbb{R}^n$  is a substitute of  $\ell \in \mathbb{R}^n$  and  $\ell \in \mathbb{R}^n$  is a substitute of  $\ell \in \mathbb{R}^n$  and  $\ell \in \mathbb{R}^n$  is a substitute of  $\ell \in \mathbb{R}^n$  and  $\ell \in \mathbb{R}^n$  is a substitute of  $\ell \in \mathbb{R}^n$  and  $\ell \in \mathbb{R}^n$  is a substitute of  $\ell \in \mathbb{R}^n$  and  $\ell \in \mathbb{R}^n$  is a substitute of  $\ell \in \mathbb{R}^n$  and  $\ell \in \mathbb{R}^n$  is a substitute of  $\ell \in \mathbb{R}^n$  and  $\ell \in \mathbb{R}^n$  is a substitute of  $\ell \in \mathbb{R}^n$  and  $\ell \in \mathbb{R}^n$  is a substitute of  $\ell \in \mathbb{R}^n$  in  $\ell \in \mathbb{R}^n$  and  $\ell \in \mathbb{R}^n$  is a substitute of  $\ell \in \mathbb{R}^n$  and  $\ell \in \mathbb{R}^n$  is a substitute of  $\ell \in \mathbb{R}^n$  and  $\ell \in \mathbb{R}^n$  is a substitute of  $\ell \in \mathbb{R}^n$  and  $\ell \in \mathbb{R}^n$  is a substitute of  $\ell \in \mathbb{R}^n$  and  $\ell \in \mathbb{R}^n$  is a substitute of  $\ell \in \mathbb{R}^n$  and  $\ell \in \mathbb{R}^n$  is a substitute of  $\ell \in \mathbb{R}^n$  and  $\ell \in \mathbb{R}^n$  is a substitute of  $\ell \in \mathbb{R}^n$  and  $\ell \in \mathbb{R}^n$  is a substitute of  $\ell \in \mathbb{R}^n$  and  $\ell \in \mathbb{R}^n$  is a substitute of  $\ell \in \mathbb{R}^n$  and  $\ell \in \mathbb{R}^n$  is a substitute of  $\ell \in \mathbb{R}^n$  and  $\ell \in \mathbb{R}^n$  is a substitute of  $\ell \in \mathbb{R}^n$  and  $\ell \in \mathbb{R}^n$  is a substitute of  $\ell \in \mathbb{R}^n$  and  $\ell \in \mathbb{R}^n$  is a substitute of  $\ell \in \mathbb{R}^n$  and  $\ell \in \mathbb{R}^n$  is a substitute of  $\ell \in \mathbb{R}^n$  and  $\ell \in \mathbb{R}^n$  is a substitute of  $\ell \in \mathbb{R}^n$  and  $\ell \in \mathbb{R}^n$  is a substitute of  $\ell \in \mathbb{R}^n$  and  $\ell \in \mathbb{R}^n$  is a substitute of  $\ell \in \mathbb{R}^n$  and  $\ell \in \mathbb{R}^n$  is a substitute of  $\ell \in \mathbb{R}^n$  and  $\ell \in \mathbb{R}^n$  is a substitute of  $\ell \in \mathbb{R}^n$  and  $\ell \in \mathbb{R}^n$  is a substitute of  $\ell \in \mathbb{R}^n$  and  $\ell \in \mathbb{R}^n$  and  $\ell \in \mathbb{R}^n$  and  $\ell \in \mathbb{R}^n$ 

Bending moment

$$M = \frac{p \times m \times (3\ell^2 - m^2)}{24}$$

Shearing force

$$S = \frac{p \times m \times \left(\ell + \frac{m}{2}\right)}{2}$$

1.2.  $\ell \leq m$ 

$$M = \frac{p \times m \times \ell^2}{12}$$

Shearing force

$$S = \frac{p \times m \times \ell}{4}$$
 where;  $M = Maximum bending moment (tf-m)$ 

p = Mean water pressure (tf/m<sup>2</sup>)

m = Pitch of vertical girder (m)

 $\ell$  = Distance between horizontal beam (m)

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S = Maximum shearing force (11)

PORITION		: <u>[</u> []	jù,		
1.	0.59	1.50	0.750	0.1180	0.2666
2.	0.59	0.90	1.950	0.0998	0.3480
3.	0.59	0.65	2.725	0.0616	0.2854
4.	0.59	0.20	3.150	0.0062	0.0929

Maximum bending moment on vertical beam

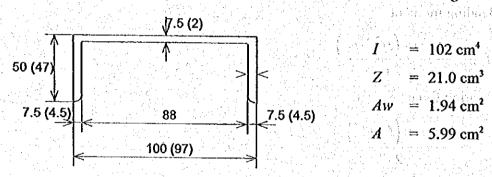
$$M_{\text{max}} = 0.1180 \, tf\text{-m}$$

Maximum shearing force

$$S_{\text{max}} = 0.3480 \, tf$$

# 2. Sectional Property

JIS G.3192 hot ruller steel section  $H.350 \times 175 \times 7/11$  and following section are used.



# 3. Bending Stress and Shearing Stress

Bending Stress (ob)

$$\sigma b = \frac{M_{\text{max}}}{Z}$$

$$= \frac{0.1180 \times 10^5}{21.0} = 562 \text{ kg.} f/\text{ cm}^2 \ \langle 1,200 \text{ kg.} f/\text{ cm}^2 \rangle$$

Shearing Stress (15)

$$as = \frac{0.348 \times 10^3}{1.94} = 179 \text{ kg/cm}^2 \ \langle 700 \text{ kg/f/cm}^2 \rangle$$

#### VI. SKIN PLATE

্

PORTION		$\{[i][\ell]\}$	$p_{i}^{\prime}(z)$		
1.	0.59	1.50	0.750	0.1180	0.2666
2.	0.59	0.90	1.950	0.0998	0.3480
3.	0.59	0.65	2.725	0.0616	0.2854
4.	0.59	0.20	3.150	0.0062	0.0929

Maximum bending moment on vertical beam

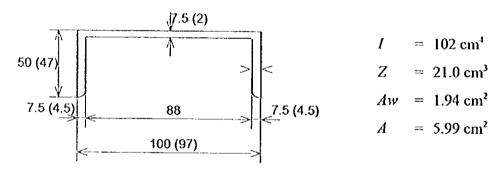
$$M_{\rm max} = 0.1180 \, tf$$
-m

Maximum shearing force

$$S_{\text{max}} = 0.3480 \, tf$$

#### 2. Sectional Property

JIS G.3192 hot ruller steel section  $H.350 \times 175 \times 7/11$  and following section are used.



# 3. Bending Stress and Shearing Stress

Bending Stress (ob)

$$\sigma b = \frac{M_{\text{max}}}{Z}$$

$$= \frac{0.1180 \times 10^5}{21.0} = 562 \text{ kg} f/\text{ cm}^2 \ \langle 1,200 \text{ kg} f/\text{ cm}^2 \rangle$$

Shearing Stress ( $\tau s$ )

$$\tau_S = \frac{0.348 \times 10^3}{1.94} = 179 \text{ kg/cm}^2 \ \langle 700 \text{ kg/f/cm}^2 \rangle$$

#### VI. SKIN PLATE

Bending stress of skin plate is calculated in accordance with following Timoshenko's formula.

$$t = \sqrt{\frac{K \times 0^2 \times p}{100}}$$
 where :  $\sigma a = \text{Bending stress} (\text{kg.}f/\text{cm}^2)$ 

K = Coefficient by b/a

a =Short span of plate (cm)

b = Long span of plate (cm)

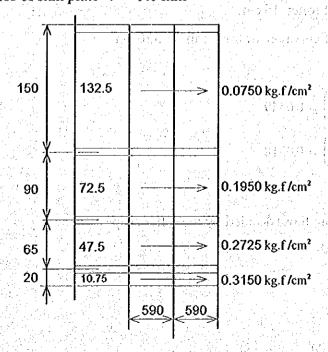
p = Mean design pressure (kg.f/cm<sup>2</sup>)

t = Thickness of plate (cm)

 $\varepsilon$  = Corrsion allowance 0.3 cm

No	Beam'	a e	1 - 44 · 5	b/a	K	P		$i_{i}$
1.	1 - 2	59.00	132.50	2.24	50.00	0.0750	0.33	0.63
2.	2 - 3	59.00	72.50	1.23	39.80	0.1950	0.47	0.77
3.	3 - 4	47.50	59.00	1.24	40.10	0.2725	0.45	0.75
4.	4 - 5	10.75	59.00	5.49	50.00	0.3150	0.12	0.42

Thickness of skin plate t = 9.0 mm



Bending stress of skin plate is calculated in accordance with following Timoshenko's formula.

$$t = \sqrt{\frac{K \times 0^2 \times p}{\sigma a \times 100}} \text{ where } : \sigma a = \text{Bending stress (kg.} f/\text{cm}^2\text{)}$$

K = Coefficient by b/a

a =Short span of plate (cm)

b = Long span of plate (cm)

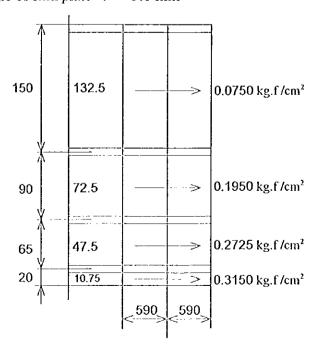
 $p = \text{Mean design pressure (kg.f/cm}^2)$ 

t = Thickness of plate (cm)

 $\varepsilon$  = Corrsion allowance 0.3 cm

No.	Beam?	a	$\hat{b}$	b/a	K //	Pick Samuel		1+8
1.	1 - 2	59.00	132.50	2.24	50.00	0.0750	0.33	0.63
2.	2 - 3	59.00	72.50	1.23	39.80	0.1950	0.47	0.77
3.	3 - 4	47.50	59.00	1.24	40.10	0.2725	0.45	0.75
4.	4 - 5	10.75	59.00	5.49	50.00	0.3150	0.12	0.42

Thickness of skin plate t = 9.0 mm



# VII. MAIN WHEEL ASSEMBLY

# 1. Main Wheels.

Main wheels are of point contact type, and their strength is calculated by the following Hertz's formula;

$$p = \frac{3}{2 \times \pi} \times \frac{P}{a \times b}$$

$$a = 1.109 \times m \times \sqrt[3]{\frac{P}{(A+B).E}}$$

$$b = 1.109 \times n \times \sqrt[3]{\frac{P}{(A+B).E}}$$

$$Z = \beta \times b$$

restorations of philadelity state and it property

$$A+B=\frac{1}{2}\times\left(\frac{1}{R}+\frac{1}{R'}\right) \qquad B-A=\frac{1}{2}\times\left(\frac{1}{R}-\frac{1}{R'}\right)$$

Where ;  $p = \text{Hertz's contact stress (kg.} f/\text{cm}^2)$ 

P = Working loaded one wheel = 6,291 kg f

a = Half the contact width (major diameter) (cm)

b = Half the contact width (minor diameter) (cm)

 $E = \text{Modulus of elasticity of wheel} = 2.1 \times 10^6 \text{ kg.} f/\text{cm}^2$ 

Z = Depth where maximum shearing stress cm.

 $\beta$  = Factor to give the depth where max shearing stress accurs (cm)

R = Radius of roller 15 cm.

R' =Radius of curvature of track rail = 320 cm.

Thus;

$$A + B = \frac{1}{2} \times \left(\frac{1}{15} + \frac{1}{320}\right) = 0.0349$$
$$B - A = \frac{1}{2} \times \left(\frac{1}{15} - \frac{1}{320}\right) = 0.0318$$

Shape factor (m and n) are those decided by the roller shape.

$$\theta = Cos^{-1} \times \frac{(B-A)}{(A+B)}$$

$$= Cos^{-1} \times \frac{0.0318}{0.0349}$$

$$= 24^{0}19'54.46'' = 24^{0}$$

$$m = 3.280 \qquad n = 0.446$$

$$a = 1.109 \times 3.280 \times \sqrt[3]{\frac{5,396}{0.0349 \times 2.1 \times 10^6}} = 1.524 \text{ cm}.$$

$$b = 1.109 \times 0.446 \times \sqrt[3]{\frac{5.396}{0.0349 \times 2.1 \times 10^6}} = 0.207 \text{ cm}.$$

$$p = \frac{3}{2 \times \pi} \times \frac{5,396}{1.524 \times 0.207} = 8167 \text{ kg.} f/\text{cm}^2$$

Allowable contact stress (pa) while the following the foll

$$pa = \frac{100 \times HE}{2 \times V}$$

where;  $pa = \text{Allowable contact stress (kg.} f/\text{cm}^2)$ 

V = Safety factor = 1.0

HB = Brinell hardness

 $= 185 \, \mathrm{kg.} f/\mathrm{cm}^2$ 

$$pa = \frac{185 \times 100}{2 \times 1.0} = 9250 \text{ kg} f/\text{cm}^2$$

Thus:

 $pa = 9,250 \text{ kg.f/cm}^2 > 8,167 \text{ kg.f/cm}^2$ 

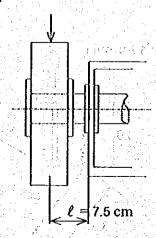
$$Z = \beta \times b \rightarrow \beta = \frac{a}{b} = \frac{1.524}{0.207} = 7.36 \approx 7.4$$
  
= 0.90 \times 0.207 \beta = 0.90  
= 0.186 cm

Thickness of track frame

 $T \geq 4 \times Z$ 

 $T = 4 \times 0.186 = 0.74 \text{ cm} \approx 10.0 \text{ mm}.$ 

#### 2. Shaft.



# Maximum bending moment

$$M_{\text{max}} = p \times \ell$$
  
= 5,396 × 7.5  
= 40,470 kg,f-cm

Material of shaft

SUS.304 (JIS G.4303)

Allowable stress (ob)

$$\sigma b = \frac{5,300}{5} = 1,060 \text{ kg/cm}^2$$

Diameter of shaft (d)

$$d = \sqrt[3]{\frac{32 \times M_{\text{max}}}{\pi \times \sigma b}}$$

$$= \sqrt[3]{\frac{32 \times 40,470}{\pi \times 1060}} = 7.30 \text{ cm} \approx 7.50 \text{ mm}.$$

Rechecking of bending and shearing stress

Section modulus (Z)

$$Z = \frac{\pi}{32} \times d^3 = \frac{\pi}{32} \times 7.50^3 = 41.42 \text{ cm}^3$$

Bending stress (
$$\sigma b$$
)  

$$\sigma b = \frac{M_{\text{max}}}{Z}$$

$$= \frac{40,470}{41.42} = 977 \text{ kg.} f/\text{cm}^2 \ (1,060 \text{ kg.} f/\text{cm}^2)$$

Shearing stress (15)

$$\tau = \frac{4 \times P}{\pi \times d^2}$$

$$= \frac{4 \times 5,396}{\pi \times 7.50^2} = 122 \text{ kg} f/\text{cm}^2 \ \langle \ 0.6 \times 1,060 \text{ kg} f/\text{cm}^2 \rangle$$

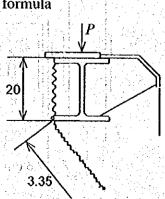
# VIII. GUIDE FRAME

Strength of the track frame is examined by Andre's formula

$$K = 0.0588 \times \frac{P}{\sqrt[3]{B^2 \times I}}$$

$$a = 0.75 \times \frac{P}{K \times B}$$

$$M = \frac{K \times a^2 \times B}{4}$$



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Where;

 $K = \text{Concrete bearing stress (kg.} f/\text{cm}^2)$ 

 $P = \text{Maximum distributed load wheel} = 5,396 \text{ kg} f_{\text{maximum distributed load}}$ 

 $B = Bottom width of flange (cm) <math>\frac{1}{1000}$  for the second section  $\frac{1}{1000}$ 

I = Geometrical moment of inertia (cm<sup>4</sup>)

M =Bending moment acting on track frame (kg.f-cm)

a = Half of stress distribution length of concrete at the bottom of track frame (cm)

Built up shape

$$H 200 \times 200 \times 8/12$$

$$I = 4720 \text{ cm}^4$$

$$Z = 472 \,\mathrm{cm}^3$$

$$A = 63.53 \text{ cm}^2$$

$$K = 0.0588 \times \frac{5,396}{\sqrt[3]{20^2 \times 4720}}$$

$$a = 0.75 \times \frac{5,396}{2.57 \times 20} = 78.74 \text{ cm}.$$

Bending moment on track frame (M)

$$M = \frac{2.57 \times 78.74^2 \times 20}{4} = 79,670 \text{ kg.f-cm}$$

Bending stress of track frame.

$$\sigma b = \frac{M}{Z}$$
=  $\frac{79,670}{472}$  = 169 kg.f/cm<sup>2</sup> \ 1200 kg.f/cm<sup>2</sup>

Shearing stress of concrete

$$\pi c = \frac{P}{Ac}$$
 where;  $\pi c = \text{Maximum shearing stress (kg.} f/\text{cm}^2)$ 

Ac = Shearing area of concrete

= 
$$20 + 33.5\sqrt{2} = 67.37$$
 cm.

Thus;

$$\pi c = \frac{2.57 \times 20}{67.37}$$

=  $0.76 \text{ kg.} f/\text{cm}^2 \ \langle 8.0 \text{ kg.} f/\text{cm}^2$ 

#### IX. OPERATING LOAD

1. Operating Condition. (1) The Appendix of th

The gate is normally closed and is designed to raise under water head 3.25 m.

- 2. Operation Load.
  - 2.1. Weight of gate ( wg ) = 4.0 tf
  - 2.2. Friction force due to main roller (Fw)

$$Fr = P \times \frac{\left(\mu_1 + \mu_2 \times r\right)}{R}$$

Where;

Fw = Friction force due to main roller

P = Design load = 21.125 tf

 $\mu_1$  = Rolling frictional coefficient 0.1

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 $\mu_2$  = Sliding frictional coefficient

at raising 0.2

at lowering 0.1

r = Radius of wheel shaft 3.75 cm

R = Radius of wheel 15 cm

Thus;

2.2.1. At Raising.

$$FwR = \frac{21.125 \times (0.1 + 0.2 \times 3.75)}{15}$$
= 1.197 \( y \)

2.2.2. At Lowering

$$FwL = \frac{21.125 \times (0.1 + 0.1 \times 3.75)}{15}$$
= 0.669 tf

2.3. Friction force due to rubber seal (Fr)

$$Fr = \mu \times (q + P \times b) \times \varepsilon \ell$$

Where;

()

Fr = Friction force to rubber seal tf

 $\mu$  = Friction coefficient of rubber seal at starting = 1.5

at sliding = 0.7

 $P = \text{Mean design pressure} = 1.625 \text{ tf/m}^2$ 

q = Initial compression load on rubber seal = 0.05 tf/m

b = Contact width of rubber seal = 0.05

 $\varepsilon \ell$  = Total sliding length of rubber seal = 6.5 m.

Thus;

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2.3.1. At Raising

$$FrR = 1.5 \times (0.05 + 1.625 \times 0.05) \times 6.5$$
  
= 1.280 tf

2.3.2. At Lowering

$$FrL = 0.7 \times (0.05 + 1.625 \times 0.05) \times 6.5$$
  
= 0.597 tf

2.4. Down pull force at opening (Fd)

 $Fd = K \times Gw \times Hh \times Ad$ 

Where;

Fd = Down pull force (tf)

K = Down pull coefficient 0.15

Gw =Specific gravity of water = 1.0  $f/m^3$ 

Hh = Design head = 3.25 m

 $Ad = \text{Project area of bottom gate} = 0.24 \times 4.0 = 0.96 \text{ m}^2$ 

Thus;

 $Fd = 0.15 \times 1.0 \times 3.25 \times 0.96 = 0.468 \text{ ton.}$ 

## 2.5. Total Operation Load.

<b>ODescription</b>	Raising	Lowering
- Gate weight (Wg)	+ 4.000	+ 4.000
- Friction force due to main roller (Fw)	+1.197	- 0.669
- Friction force due rubber seal (Fr)	+ 1.280	- 0.597
- Down pull force (Fd)	+ 0.468	- 0.468
Total =	6.945	2.266

Thus;

Operating Load

Raising (incl. allowable) = 7.5 ton. f

Lowering

= 3.0 ton. f

# X. HOISTING EQUIPMENT

Hoisting Load (Fo) = 7.5 ton. f

**Operating Speed** = 0.3 m/min + 10%

**Operating Height**  $= 6.0 \,\mathrm{m}$ 

Type of hoist = 1 M 2 D Type

Electrically driven wire rope wound type stationary hoist.

#### Wire Rope.

# 1.1. Number of Falls

2 (two) falls of wire rope are provided on each side

Total number of wire rope falls (W) = 4

1.2. Tensile Load  $(T_1)$ 

$$T_{\rm L} = \frac{Fo}{W \times \eta_s}$$
 where ; 
$$T_{\rm L} = \text{Tensile load } tf$$
 
$$Fo = \text{Operating load} = 7.5 tf$$
 
$$W = \text{Number of falls} = 4$$

$$= \frac{7.5}{4 \times (0.95)^2} = 2.078 \text{ ton.} f/\text{drum}$$

1.3. Selection of Wire Rope

 $6 \times 37$  galvanized wire rope per JIS G.3525 Class A wire rope diameter  $\{Dr\} = 18$  mm Breaking load = 17.5 ton.

 $\eta_s$  = Sheave effy. = 0.95

Safety factor = 
$$17.5/2.078 = 8.42 > 8$$

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2.1. Diameter of sheave

$$Ds = 17 \times Dr$$
 Where;  
 $Ds = \text{Diameter of sheave}$   
 $Dr = \text{Diameter of wire rope} = 18 \text{ mm}$   
 $= 17 \times 18 = 306 \text{ mm}$ .

Diameter of sheave is determined 350 mm.

2.2. Diameter of Drum

$$Dd = 19 \times Dr$$
 Where;  
 $Dd = \text{Diameter of drum}$   
 $Dr = \text{Diameter of wire rope} = 18 \text{ mm}$   
 $= 19 \times 18 = 342 \text{ mm}$ .

Diameter of drum is determined = 500 mm.

2.3. Winding Number of Wire Rope (Nw)

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$$Nw = \frac{Ns \times Oh}{\pi \times Dd} + dt$$

Where;

Nw = Number of winding

Ns = Number of falls on each side = 2

Oh = Operating height = 5.0 mt.

Dd = Diameter of drum = 0.5 m

dt =Number of dead turn = 3.

$$Nw = \frac{2 \times 5.0}{\pi \times 0.5} + 3 = 9.36$$

There fore number of winding is determined 12

### 2.4. Revolution

$$Nd = \frac{(Vo \times Ns)}{(\pi \times Dd)}$$

Where;

Nd = Drum revolution per minute (Rpm)

Vo = Operating speed 0.3 m/min

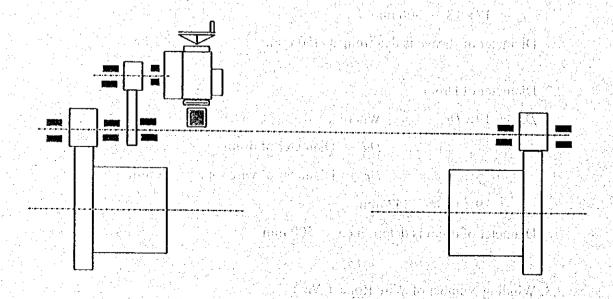
Ns = Number of wire rope falls on each side = 2

Dd = Diameter of drum 0.5 m.

Thus;

$$Nd = \frac{0.3 \times 2}{\pi \times 0.5} = 0.382 \text{ Rpm}.$$

## 3. Arrangement of Hosit.



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#### 3.1. Reduction Ratio.

# 3.1.1. Required Ratio

$$\iota R = \frac{Nd}{Nm}$$

Where;

iR = Required Gear Ratio

Nd = Rpm of drum = 0.382 Rpm.

Nm = Full load Rpm of motor = 1420 Rpm.

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### 3.1.2. Selected Ratio

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Drum gear / pinion =  $\frac{16}{97}$ 

Intermediate gear =  $\frac{16}{52}$ 

Bevel Gear =  $\frac{1}{2}$ 

Worm Gear =  $\frac{1}{63.33}$ 

Total actual gear ratio =  $\frac{1}{3743.4}$ 

Thus;

Actual Rpm of drum =  $\frac{1420}{3743.4}$  = 0.379

# 3.1.3. Hoisting Speed.

 $Vs = \frac{Na}{Nd} \times Vo$  Where;

Vs = Hoisting speed

Na = Actual Rpm of Drum 0.379 Rpm

Nd = Required Rpm of drum 0.382 Rpm

Vo = Operating speed = 0.3 m/min

Thus;

$$V_S = \frac{0.379}{0.382} \times 0.3$$

#### $= 0.298 \, \text{m/min}$

## 4. Electric Motor Operation.

### 4.1. Mechanical Efficiency

Sheave 0.95

Drum 0.95

Drum gear / pinion 0.95

Intermediate Gear 0.95

Bevel Gear

0.90

Worm Gear

0.44

Where;

Thus; Total mechanical efficiency on motor operation (Mt) = 0.3225

### 4.2. Motor Capacity.

$$Q = \frac{Fo \times Vo}{6.12 \times nt}$$

Q = Motor KW required

Fo = Operating load 7.5 ton.f

Vo = Operating speed = 0.298 m/min

 $\eta t = \text{Total efficiency} = 0.3225$ 

$$Q = \frac{8.0 \times 0.298}{6.12 \times 0.3225}$$

 $= 1.13 \text{ ton} \times 1.5 = 1.7 \text{ KW}.$ 

There fore 2.2 KW motor is adopted

# Motor specification;

Type: TEFC Class B with magnetic brake

Supply: 3 PH / 380 V AC / 50 HZ / 2.2 KW / 1420 Rpm.

Rating: Continuous duty.

# 5. Manual Operation;

5.1.	Reduction Ratio (tt) Mechanical Effy
	Drum gear / pinion (16/97) 0.95
	Intermediate gear (16/52 0.95
	Bevel gear (1/3) 0.90
	Worm gear (manual) (1/38) 0.30

0.2437

## 5.2. Torque at Drum

$$TD = \frac{TL \times R.Drum}{\eta} \times \eta d$$

Where;

TD = Torque at drum

TL = Tensile load = 2.078 ton.f

R.Drum = Drum Radius = 0.25 m.

 $\eta$  = Drum efficiency = 0.95

nd = Number of drum = 2

$$TD = \frac{2.078 \times 0.25}{0.95} \times 2$$

= 1.094 ton. f-m

= 1,094 kg. f-m

### 5.3. Rimpull Force;

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$$F = \frac{TD}{tt \times \eta t \times Rh}$$

Where;

F = Rimpull force

TD = Torque at drum 1,094 kg.f-m

tt = Total manual reduction ratio = 2,246.16

 $\eta t$  = Total manual mechanical efficiency = 0.2437

Rh = H wheel Radius = 0.23 m.

Thus;

$$F = \frac{1,094}{2,246.16 \times 0.2437 \times 0.23}$$
$$= 8.7 \text{ kg} f \langle 10 \text{ kg} f \rangle$$

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