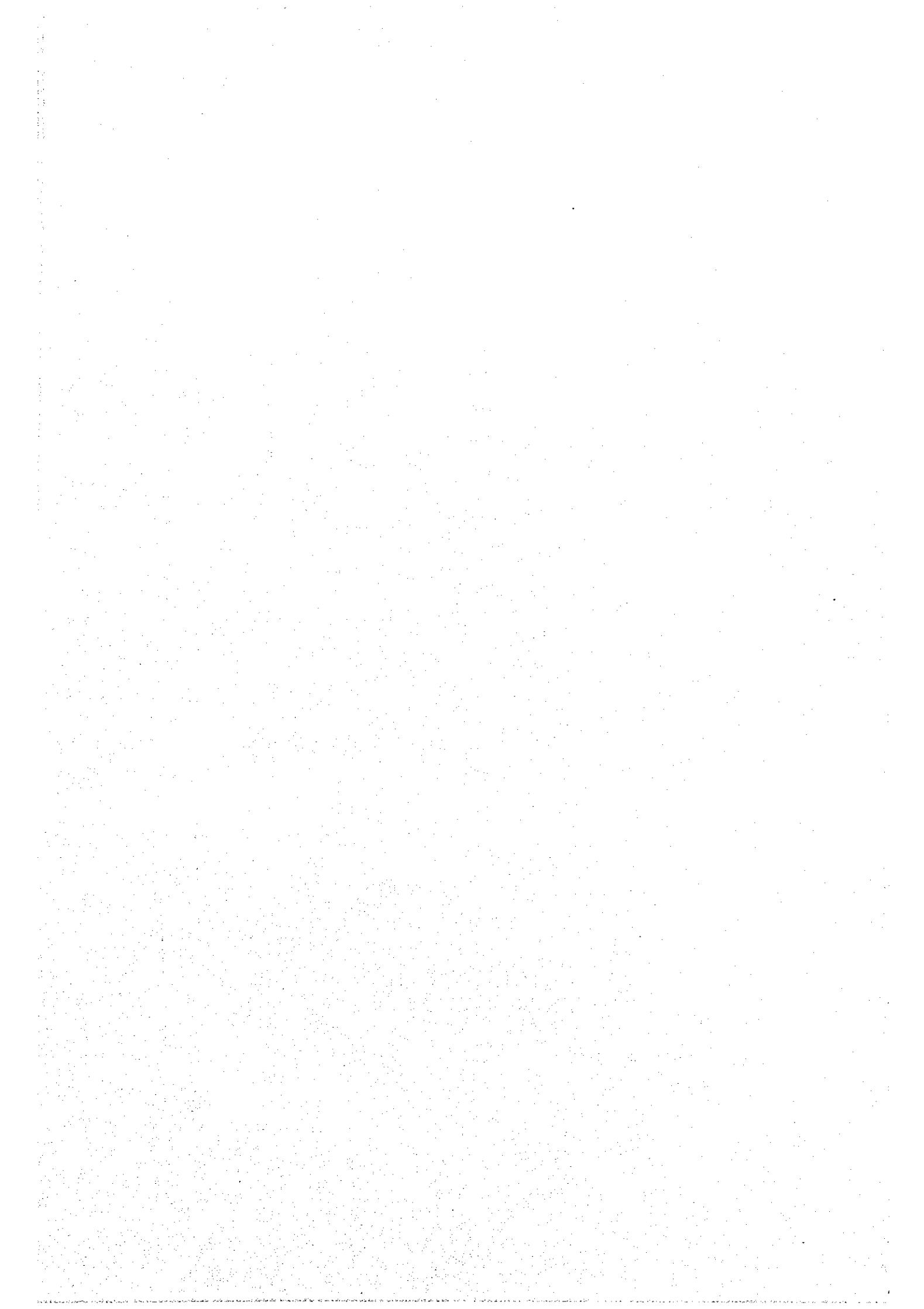


## 2.2 Asin Bridges

## **2.2 Asin Bridges**

### **2.2.1 Structural Calculation**



## ASIN No.1 BRIDGE

				SUBSTRUCTURE DESIGN RECORD ABUTMENT				NAME		ASIN No.1BRIDGE	
SUBSTRUCTURE No.				MEMBERS&POSITION	LOAD	FORCES		BAR ARRANGEMENT		STRESS (kg/cm²)	REMARKS
COEFFICIENT OF EARTH PRESSURE	NORMAL	0.308	SEISMIC	0.433		M(lf m)	74.252				
FIGURE	DIMENSION			PARAPET (BACK)	NORMAL	S(lf)	63.746	10   40	FRONT BACK	0.02bd As As = 158.880 cm² D16-125 ctc	34.975 1292.6 1800 1.56 2.2
		93.60						50			
					SEISMIC	M(lf m)					
						S(lf)					
				BODY (FOOT)	NORMAL	M(lf m)	329.913	10   As	FRONT BACK	0.0015A As As = cm² D - ctc	19.37 75 406.99 1800 1.01 2.2
		250	143			N(lf)	482.406	133   As			
					SEISMIC	S(lf)	136.353	143	FRONT BACK	As=158.880 cm² D 16 - 125 ctc	
		650				M(lf m)	635.988	10   As		0.0015A As 0.008A As	43.69 112.5
						N(lf)	385.406	133   As			2066.23 2700
				FOOTING (BACK)	SEISMIC	S(lf)	243.588	143	FRONT BACK	As=158.880 cm² D 16 - 125 ctc	1.80 2.6
						M(lf m)	403.378	10   10		0.002bd As 0.02bd As	37.47 112.5
					SEISMIC	S(lf)		110   120			2460.60 2700
								650		As=158.88 cm² D16-125ctc	
FIGURE	BAR ARRANGEMENT			FOOTING (FRONT )	SEISMIC	M(lf m)	-624.416	105   120		0.002bd As 0.02bd As	47.71 112.5
						S(lf)		650		As=309.68 cm² D22-125ctc	2098.19 2700
					SEISMIC						=309.68
					SEISMIC						

ASIN No.2 BRIDGE

ASIN PUMP BRIDGE

		SUBSTRUCTURE DESIGN RECORD PC PILES						NAME	ASIN No.18RIDGE
SUBSTRUCTURE No.		ASIN1 A1	ASIN1 A2	ASIN2 A1	ASIN2 A2	ASINPUMP A1	ASINPUMP		
PILES TYPE		PC DRIVEN PILES							
DIAMETERS mm		500	500	500	500	500	500	500	500
LENGTH OF PILES		18m							
NUMBER OF PILES		35	35	30	30	25	25		
JOIN METHOD		TYPE A <input checked="" type="radio"/> TYPE B <input type="radio"/>	TYPE A <input checked="" type="radio"/> TYPE B <input type="radio"/>	TYPE A <input checked="" type="radio"/> TYPE B <input type="radio"/>	TYPE A <input checked="" type="radio"/> TYPE B <input type="radio"/>	TYPE A <input checked="" type="radio"/> TYPE B <input type="radio"/>	TYPE A <input checked="" type="radio"/> TYPE B <input type="radio"/>	TYPE A <input checked="" type="radio"/> TYPE B <input type="radio"/>	TYPE A <input checked="" type="radio"/> TYPE B <input type="radio"/>
FACTOR OF LIQUEFACTION D <sub>E</sub>		0 1/3 2/3 1 <input checked="" type="radio"/>	0 1/3 2/3 1 <input type="radio"/>	0 1/3 2/3 1 <input type="radio"/>	0 1/3 2/3 1 <input type="radio"/>	0 1/3 2/3 1 <input type="radio"/>	0 1/3 2/3 1 <input type="radio"/>	0 1/3 2/3 1 <input type="radio"/>	0 1/3 2/3 1 <input type="radio"/>
SECTION OF LIQUEFACTION m		WEAK CLAY SECTION	.....	.....	.....	.....	.....	.....	.....
HORIZONTAL REFLECT FACTOR OF GROUND K <sub>H</sub> (/ SECTION)		.....	.....	.....	.....	.....	.....	.....	.....
DECIDED FACTOR OF PILES NUMBER		B D S O	B D S O	B D S O	B D S O	B D S O	B D S O	B D S O	B D S O
F O R C E	DECIDED CASE		NORMAL CASE						
	BEND MOMENT t f m		-6.247	-6.247	-6.025	-6.025	-5.384	-5.384	
	VERTICAL FORCE t		35.092	35.092	35.047	35.047	28.315	28.315	
	HORIZONTAL FORCE t		.....	.....	.....	.....	.....	.....	.....
S T R E S S	c <sub>a</sub> c <sub>a</sub>	kgf/cm <sup>2</sup>	167 170	167 170	165.6 170	165.6 170	154.1 170	154.1 170	
	t <sub>1</sub> t <sub>a</sub>	kgf/cm <sup>2</sup>	8214.9 8700	8214.9 8700	8202.7 8700	8202.7 8700	8205.3 8700	8205.3 8700	
	, t <sub>a</sub>	kgf/cm <sup>2</sup>	.....	.....	.....	.....	.....	.....	
R E S U L T S	M <sub>0</sub>		6.247	6.247	6.025	6.025	5.384	5.384	
	M <sub>m</sub>		.....	.....	.....	.....	.....	.....	
	M <sub>1/2</sub>		3.1235	3.1235	3.0125	3.0125	2.692	2.692	
	L <sub>1/2</sub>		3.705	3.705	3.685	3.685	3.725	3.725	
	L <sub>min</sub>		6.427	6.427	6.434	6.434	6.408	6.408	
	L <sub>1</sub>		6.427	6.427	6.434	6.434	6.408	6.408	
	L <sub>2</sub>		.....	.....	.....	.....	.....	.....	
	L <sub>3</sub>		.....	.....	.....	.....	.....	.....	
	D1 or t1		500	500	500	500	500	500	500
	D2 or t2		.....	.....	.....	.....	.....	.....	.....
Note D1 D3:Bar arrangement of cast-in-place piles									
t1 t3:The thickness of steel tube, express by the types of piles									
A <sub>min</sub>									
EMARK									

## **2.3 Asin Box Culvert**

## **2.3 Asin Box Culvert**

### **2.3.1 Hydraulic Calculation**

David Pollock  
Geophysical Institute

Name of Structure	Asin Box Culvert	Category of calculation	Hydrological / Hydraulic	Page	1 / 3
<b>1) Design Peak Discharge</b>					
<b>Conditions of Calculation</b>					
Catchment Area (see Fig.-1):			0.135 km <sup>2</sup>		
Max. Length of channel to the culvert inlet:			1,100 m		
Assumed flow velocity:			1.5 m/sec		
Time of inlet:			15 min.		
Run-off coefficient:			0.650 m		
<b>Time of Flood Concentration</b>					
$T = 15 + 1100 / 1.5 / 60 = 27.22 \rightarrow 27 \text{ min.}$					
<b>Rainfall Intensity</b>					
$r = 1272 / (T + 6.95)^{0.64} = 133.3 \text{ mm/hr}$					
<b>Design Peak Discharge</b>					
$Q = 1/3.6 \times F \times r \times A \times C = 1/3.6 \times 0.65 \times 133.3 \times 0.135 \times 0.8 \\ = 2.599 \text{ m}^3/\text{sec} \rightarrow 3 \text{ m}^3/\text{sec} : \text{Design Peak Discharge}$					
Where Q: peak discharge (m <sup>3</sup> /sec) F: run-off coefficient r: rainfall intensity (mm/hr) A: catchment area (km <sup>2</sup> ) C: coefficient (0.8)					
<b>2) Interior Dimension of Box Culvert</b>					
<b>Width</b>					
The width of channel connected to the upstream end of box culvert is about 3.5 m. Therefore, the width of box culvert set as a same width of the channel to keep water flowing smoothly.					
<b>Height</b>					
To have enough space for maintenance, height of the box culvert is set 2.0 m.					
<b>3) Design Bed Slope</b>					
<b>Max. Slope</b>					
The elevation of invert at the upstream end is assumed as EL.-3.1 m. The lowest river bed of Asin river is EL.-3.7 m. Therefore, max. slope of the culvert is 1/333 (= 0.6/200).					
<b>Design Slope</b>					
With consideration of small amount of discharge volume and to avoid over excavation, design bed slope of the culvert is set as 1/2000.					
<b>4) Check of Flow Capacity</b>					
Flow capacity is checked under following three cases.					
<b>1- Normal (water level of Asin river = El.-2.5 m)</b>					
In this case, it is assumed that uniform flow:					
$v = 1/n \times R^{2/3} \times I^{1/2} = 1/0.015 \times (3.15/5.3)^{2/3} \times (1/2000)^{1/2} = 1.05 \text{ m/sec}$					
$Q = v \times A = 1.05 \times 3.15 = 3.308 \text{ m}^3/\text{sec} \rightarrow \text{OK}$					
where v: flow velocity (m/sec) n: roughness coefficient (0.015:SSUDP standard) R: hydraulic radius					

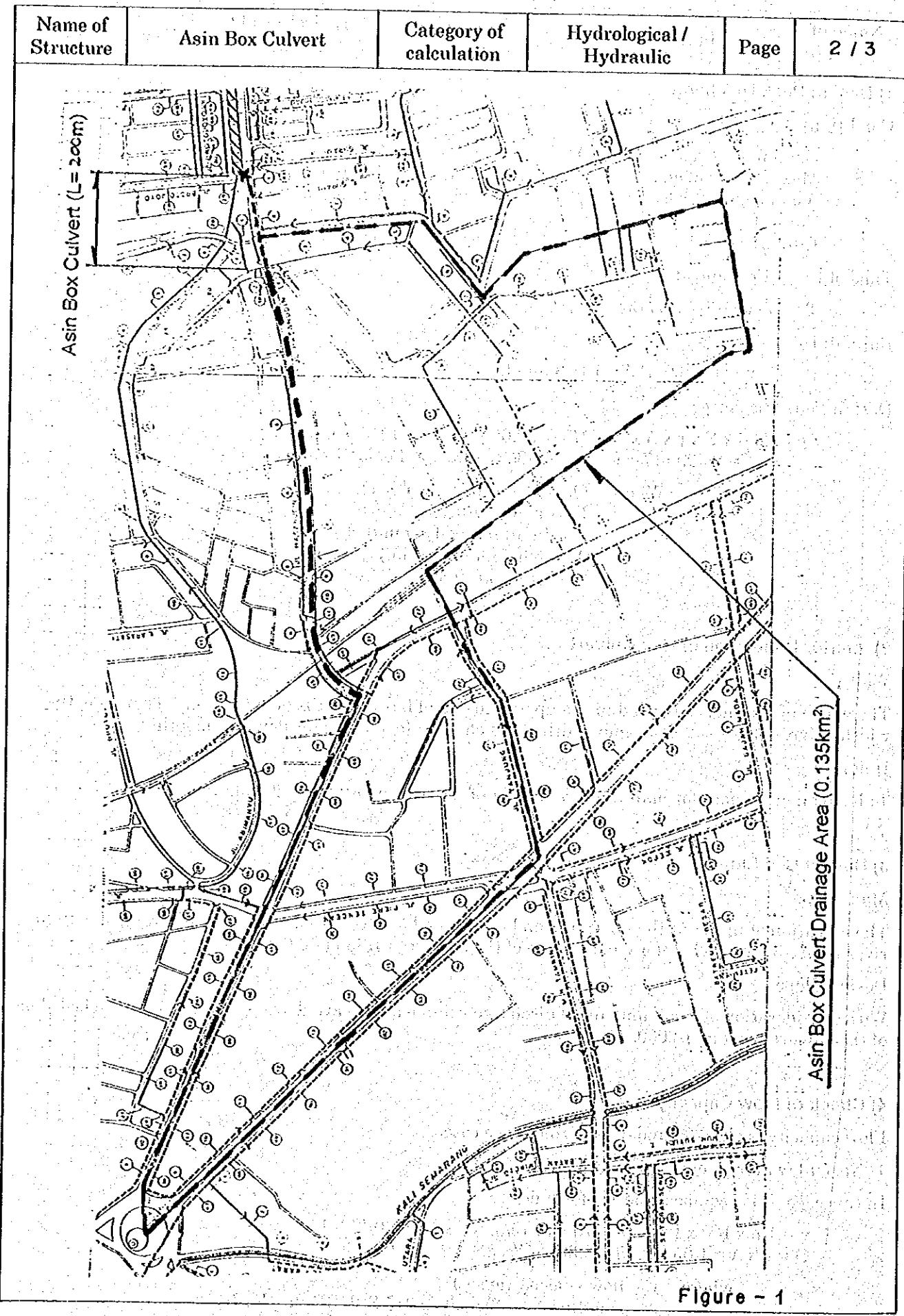


Figure - 1

Name of Structure	Asin Box Culvert	Category of calculation	Hydrological / Hydraulic	Page	3 / 3
	<p>I: channel slope  Q: flow capacity (<math>m^3/sec</math>)  A: flow area (<math>m^2/sec</math>)</p> <p><b>2- Flood (1) (water level of Asin river &lt; El. of soffit of culvert)</b></p> <p>Water level of Asin river up to the El. of soffit of culvert, flow is assumed that the non-pressured flow.</p> $v = 1/n \times R^{2/3} \times I^{1/2} = 1/0.015 \times (7/11)^{2/3} \times (1/2000)^{1/2} = 1.10 \text{ m/sec}$ $Q = v \times A = 1.10 \times 7.0 = 7.70 \text{ m}^3/\text{sec} \rightarrow \text{OK}$ <p><b>3- Flood (2) (water level of Asin river = El. - 0.417 m = HWL)</b></p> <p>In this case, flow is assumed that pressured flow</p> $H_1 = H_2 + v^2/2g + h_e$ <p>where    H1: water level of upstream  H2: water level of downstream  g: acceleration of gravity  he: friction loss (<math>= 1 \times (n^{1/2}/R^{2/3}) \times v^2 = 0.082 \times v^2</math>)</p> $-0.15 = -0.417 + v^2/2g + 0.082 v^2$ $v = 1.42 \text{ m/sec}$ $Q = v \times A = 1.42 \times 7.0 = 9.94 \text{ m}^3/\text{sec} \rightarrow \text{OK}$				

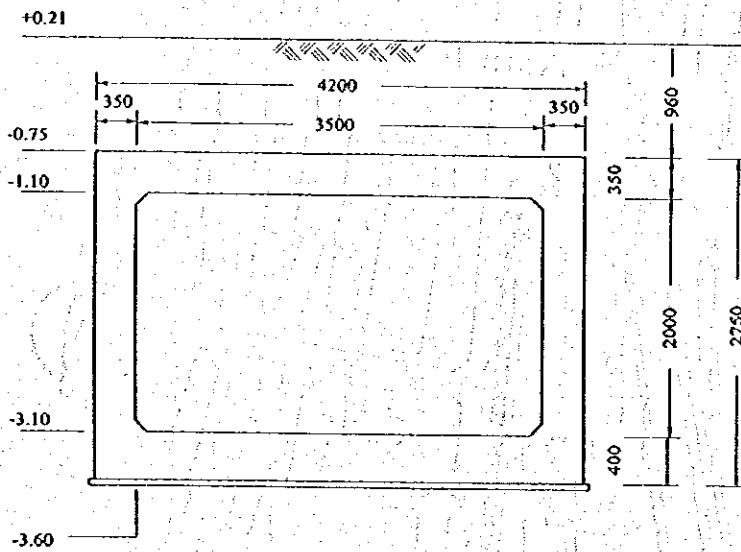
## **2.3 Asin Box Culvert**

### **2.3.2 Structural Calculation**

Name of Structure	ASIN BOX CULVERT	Category of calculation	STRUCTURAL CALCULATION	Page	1/16
<p>The map illustrates the location of the Asin Box Culvert. It shows a network of streets and houses. A thick black line traces the path of the culvert, which starts near the top left, crosses several streets, and ends at a rectangular structure labeled "Box Culvert for Asin River". The culvert's path is marked with dimensions: 0.4, 0.6, 0.5, 0.5, 0.3, 0.6, 0.3, 0.3, 0.4, 0.3, 0.3, 0.2, and 0.6. A north arrow is located in the upper right quadrant of the map area.</p>					

LOCATION MAP  
OF ASIN BOX CULVERT

Name of Structure	ASIN BOX CULVERT	CATEGORY Calculation	Structural Calculation	Page	2/16
<b>DESIGN SECTION</b>					



## DESIGN SECTION

### 1. STRUCTURAL DESIGN CALCULATION

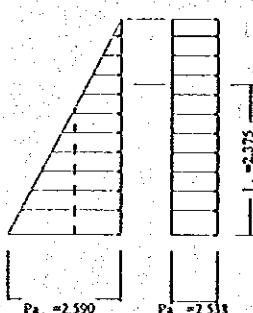
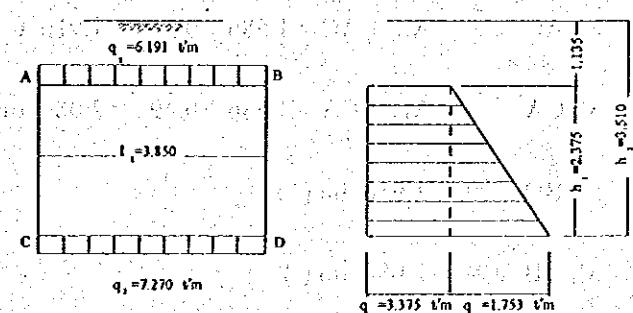
As the barrel are rigid, they should designed as the continues structural every maximum 30 m length. The calculation to be adopted per meter length to longitudinal section direction and by using standard Design of Ministry of Construction Japan, the thickness of frame are :

$$\begin{aligned} \text{Top Slab} &= 35 \text{ cm} \\ \text{Side walls} &= 35 \text{ cm} \\ \text{Bottom Slab} &= 40 \text{ cm} \end{aligned}$$

1. The acting forces, in case under construction when vehicle pass over the barrel and the barrel are empty / no water.
2. The soil data, there are no data from laboratory test. According the Design Criteria, the soil data will be assumed soft clay.
  - Unit Weight, the soil to be compacted and wet condition unit weight  $\gamma_s = 1.80t / m^3$ .

Name of Structure	ASIN BOX CULVERT	CATEGORY Calculation	Structural Calculation	Page	3/16
<ul style="list-style-type: none"> <li>- Cohesion, to be estimated by using "N" value,  <math>C = \frac{N}{8} \approx \frac{N}{11}</math>      (N for soft clay, N &lt; 10)</li> <li>- Internal Friction Angle  <math>\phi = 15 + \sqrt{15N} \leq 45^\circ</math>      (for N &gt; 5)  <math>\phi = 15 + \sqrt{15 \times 7.50} = 25.60^\circ \approx 25^\circ</math></li> </ul> <p>3. Loading</p> <p>a. Vertical loading</p> <ul style="list-style-type: none"> <li>* Weight of a saturated soil = <math>q_s = 0.96 \times 1.80 = 1.728 \text{ t/m}^2</math></li> <li>* The vehicle pass over the barrel</li> </ul> <p>Diagram showing a truck loading a culvert. The truck has a rear wheel load <math>P = 10 \text{ t}</math>, a width <math>B = 3.80 \text{ m}</math>, and a height <math>h = 0.95 \text{ m}</math> above the ground. The culvert has a total width <math>a = 2.75 \text{ m}</math> and a height of <math>0.30 \text{ m}</math> above the top slab. The impact coefficient <math>i = 0.392</math>.</p> $W_e = \frac{2P(1.0 + i)}{a} \times \frac{2B - b}{B^2} \quad \text{for } B > b$ <p>Where, <math>W_e</math> = Distributed load (<math>\text{t/m}^2</math>)  <math>a</math> = width of truck (m), <math>a = 2.75 \text{ m}</math>  <math>a</math> = width of distributed load to longitudinal direction (m),  <math>a = 2h + (1.75 + 0.30)</math>  <math>B</math> = width of structure  <math>P</math> = rear wheel load of vehicle (t), <math>P = 10 \text{ t}</math>  <math>h</math> = height of earth covering above top slab (m)  <math>i</math> = impact coefficient, determined as follows</p>					

Name of Structure	ASIN BOX CULVERT	CATEGORY Calculation	Structural Calculation	Page	4/16
		$i = 0.30 \text{ for } h \leq 3,50 \text{ m}$ $i = 0.00 \text{ for } h > 3,50 \text{ m}$  $W_e = \frac{2 \times 10(1 + 0.30)}{2.75} \times \frac{2 \times 3.80 - 2.12}{3.80^2} = 3.588 \text{ t/m}^2$  <b>Loading over top slab</b> $= q t_s = q_s + W_e = 1.728 + 3.588 = 5.316 \text{ t/m}^2$  <b>Weight of top slab</b> $= W T_s = 0.35 \times 2.5 = 0.875 \text{ t/m}^2$  <b>Total Loading of top slab</b> $= q_1 = q t_s + W T_s = 5.316 + 0.875 = 6.191 \text{ t/m}^2$  <b>Weight of barrel per meter of length</b> $W_{b_R}$  $W_{b_R} = \{(2 \times 0.35 \times 2.75) + (0.35 \times 3.50) + (0.40 \times 3.50)\} \times 2.50 + 0.10 \times 4.40 \times 2.35$ $= 12.409 \text{ t}$  <b>Total load of barrel per meter of length</b> $= W_{tot} = W_{b_R} + q t_s \times 4.20$  $W_{tot} = 12.409 + 5.316 \times 4.20 = 34.736 \text{ t.}$  <b>Uplift per meter of length</b> $= q_u = (3.60 - 0.75) \times 4.20 \times 1.00 = 11.970 \text{ t.}$  $W_{tot} = 34.736 \text{ t} > q_u = 11.970 \text{ t} \rightarrow \text{no buoyancy (OK)}$  <b>Pressure to base slab</b> $= q_2 = \frac{W_{tot}}{4.20} - (0.4 \times 2.5) = \frac{34.736}{4.20} - 1.0 = 7.270 \text{ t/m}^2$  <b>b. Horizontal loading</b>  <b>Active earth pressure by clayey soil</b>  $P_a = K_a \cdot \gamma_s \cdot h - 2C\sqrt{K_a + K_a \cdot q}$ C value not include calculated, more save $P_a = K_a \cdot \gamma_s \cdot h + K_a \cdot q$ <b>Active earth pressure coefficient <math>K_a</math></b>			

Name of Structure	ASIN BOX CULVERT	CATEGORY Calculation	Structural Calculation	Page	5/16
	$K_a = \frac{\cos^2(\phi - \theta)}{\cos^2 \theta \cdot \cos(\theta + \delta) \left[ 1 - \sqrt{\frac{\sin(\phi - \delta) \cdot \sin(\phi - \alpha)}{\cos(\theta + \delta) \cdot \cos(\theta - \alpha)}} \right]^2}$ for $\theta, \delta, \alpha = 0^\circ$ $K_a = \frac{\cos^2 \phi}{(1 + \sin \phi)^2} = \frac{\cos^2 25^\circ}{(1 + \sin 25^\circ)^2} = 0.41$ $P_{a1} = K_a \cdot \gamma_s \cdot h_2 = 0.41 \times 1.80 \times 3.510 = 2.590 \text{ t/m}$ $P_{a2} = K_a \cdot q_1 = 0.41 \times 6.191 = 2.538 \text{ t/m}$ $q_3 = 2.538 + \frac{1.135}{3.510} \times 2.590 = 3.375 \text{ t/m}$ $q_4 = \left(1 - \frac{1.135}{3.510}\right) \times 2.590 = 1.753 \text{ t/m}$  				

#### 4. Moment Calculation (With Hardy Cross Method)

Fixing moment

$$M_f AB = \frac{q_1 \ell_1^2}{12} = \frac{6.191 \times 3.85^2}{12} = 7.647 \text{ tm.(+)}$$

$$M_f BA = 7.647 \text{ tm.(-)}$$

Name of Structure	ASIN BOX CULVERT	CATEGORY Calculation	Structural Calculation	Page	6/16
$M_f CD$	$= \frac{q_2 \ell_1^2}{12} = \frac{7.270 \times 3.85^2}{12} = 8.980 \text{ tm.(-)}$				
$M_f DC$	$= 8.980 \text{ tm.(+)}$				
	<u>on span AC</u>				
Rectangular load, $M_R$	$= \frac{q_3 \times \ell_2^2}{12} = \frac{3.375 \times 2.375^2}{12} = 1.586 \text{ tm}$				
	<u>Triangular load</u>				
AC	$= \frac{q_4 \times \ell_2^2}{30} = \frac{1.753 \times 2.375^2}{30} = 0.330 \text{ tm}$				
CA	$= \frac{q_4 \times \ell_2^2}{20} = \frac{1.753 \times 2.375^2}{20} = 0.494 \text{ tm}$				
$M_f AC$	$= M_R + AC = 1.586 + 0.330 = 1.916 \text{ tm (-)}$				
$M_f CA$	$= M_R + CA = 1.586 + 0.494 = 2.080 \text{ tm (+)}$				
$M_f BD$	$= 1.916 \text{ tm (+)}$				
$M_f DB$	$= 2.080 \text{ tm (-)}$				
* Moment distribution factors					
$\mu = \frac{4EI}{\ell}$					
- joint A					
$\mu_{ab} : \mu_{ac} = \frac{4(EI)ab}{\ell_1} : \frac{4(EI)ac}{\ell_2} = \frac{1}{3.85} : \frac{1}{2.375} = 0.260 : 0.421$					
$\mu_{ab} = \frac{0.260}{0.260 + 0.421} = 0.382$					

Name of Structure

ASIN  
BOX CULVERT

CATEGORY  
Calculation

Structural  
Calculation

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$$\mu_{ac} = \frac{0.421}{0.260 + 0.421} = 0.618$$

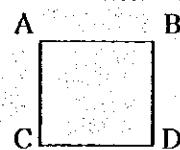
joint C

$$\begin{aligned}\mu_{cd} : \mu_{ca} &= \frac{4(EI)cd}{\ell_1} : \frac{4(EI)ca}{\ell_2} = \frac{(hcd)^4}{\ell_1} : \frac{(hca)^4}{\ell_2} \\ &= \frac{(0.4)^4}{3.85} : \frac{(0.35)^4}{2.375} = 0.665 : 0.632\end{aligned}$$

$$\mu_{cd} = \frac{0.665}{0.665 + 0.632} = 0.513$$

$$\mu_{ca} = \frac{0.632}{0.665 + 0.632} = 0.487$$

\* Distribution moment



Joint	C		A		B		D	
Member	CD	CA	AC	AB	BA	BD	DB	DC
$\mu$	0.513	0.487	0.618	0.382	0.382	0.618	0.487	0.513
Mf	-8.980	+2.080	-1.916	+7.647	-7.647	+1.916	-2.080	+8.980
M0	-6.900		+5.731		-5.731		+6.900	
	+3.540	+3.360	-3.542	-2.189	+2.189	+3.542	-3.360	-3.540
	-1.770	-1.771	+1.680	+1.095	-1.095	-1.680	+1.771	+1.770
	+1.817	+1.724	-1.715	-1.060	+1.060	+1.715	-1.724	-1.817
	-0.909	-0.858	+0.862	+0.530	-0.530	-0.862	+0.858	+0.909
	+0.906	+0.861	-0.860	-0.532	+0.532	+0.860	-0.861	-0.906
	-0.453	-0.430	+0.431	+0.266	-0.266	-0.431	+0.430	+0.453
	+0.453	+0.430	-0.431	-0.266	+0.266	+0.431	-0.430	-0.453
	-5.396	+5.396	-5.491	+5.491	-5.491	+5.491	-5.396	+5.396
	⊖	⊕	⊖	⊕	⊖	⊕	⊖	⊕

Name of Structure	ASIN BOX CULVERT	CATEGORY Calculation	Structural Calculation	Page	8/16
<b>* Shear force (SF) and Normal Force (NF)</b>					
			<b>For free body :</b> $M_{CD} = 5.396 \text{ tm } \curvearrowleft$ $M_{CA} = 5.396 \text{ tm } \curvearrowright$ $M_{AC} = 5.491 \text{ tm } \curvearrowleft$ $M_{AB} = 5.491 \text{ tm } \curvearrowright$ $M_{BA} = 5.491 \text{ tm } \curvearrowleft$ $M_{BD} = 5.491 \text{ tm } \curvearrowright$ $M_{DB} = 5.396 \text{ tm } \curvearrowleft$ $M_{DC} = 5.396 \text{ tm } \curvearrowright$		

Free body for member A - B

$$\Sigma MA = 0 \rightarrow V_B \times \ell_1 - \frac{1}{2} q_1 \ell_1^2 - M_{BA} + M_{AB} = 0$$

$$VB = \frac{1}{2} \times 6.191 \times 3.85 + \frac{5.491 - 5.491}{3.85} = 11.918 \text{ t}$$

$$\Sigma MB = 0 \rightarrow V_A \times \ell_1 - \frac{1}{2} q_1 \ell_1^2 - M_{AB} + M_{BA} = 0$$

$$VA = \frac{1}{2} \times 6.191 \times 3.85 + \frac{5.491 - 5.491}{3.85} = 11.918 \text{ t}$$

Free body for member C - D

$$\Sigma MC = 0 \rightarrow V_D \times \ell_1 - \frac{1}{2} q_2 \ell_1^2 - M_{DC} + M_{CD} = 0$$

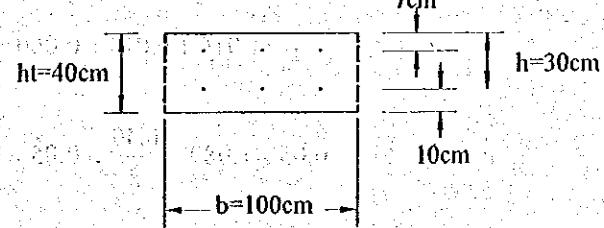
$$VD = \frac{1}{2} \times 7.270 \times 3.85 + \frac{5.396 - 5.396}{3.85} = 13.995 \text{ t}$$

Name of Structure	ASIN BOX CULVERT	CATEGORY Calculation	Structural Calculation	Page	9/16																																				
$\Sigma MD = 0 \rightarrow V_C \times l_1 - \frac{1}{2} q_2 l_1^2 - M_{CD} + M_{DC} = 0$																																									
	$V_C = \frac{1}{2} \times 2.270 \times 3.85 + \frac{5.396 - 5.396}{3.85} = 13.995 \text{ t}$																																								
	<u>Free body for member C - A</u>																																								
$\Sigma MC = 0 \rightarrow H_A \times l_2 - \frac{1}{2} q_3 l_2^2 - \frac{1}{6} q_4 l_2^2 - M_{AC} + M_{CA} = 0$																																									
	$H_A = \frac{1}{2} \times 3.375 \times 2.375 + \frac{1}{6} \times 1.753 \times 2.375 + \frac{5.491 - 5.396}{2.375}$																																								
	$= 4.008 + 0.694 + 0.040 = 4.742 \text{ t}$																																								
$\Sigma MA = 0 \rightarrow H_C \times l_2 - \frac{1}{2} q_3 l_2^2 - \frac{1}{3} q_4 l_2^2 - M_{CA} + M_{AC}$																																									
	$H_C = \frac{1}{2} \times 3.375 \times 2.375 + \frac{1}{3} \times 1.753 \times 2.375 + \frac{5.443 - 5.485}{2.375}$																																								
	$= 4.008 + 1.388 - 0.018 = 5.378 \text{ t}$																																								
	<b>SUMMARY OF FORCES</b>																																								
	<table border="1"> <thead> <tr> <th></th> <th>CD</th> <th>CA</th> <th>AC</th> <th>AB</th> <th>BA</th> <th>BD</th> <th>DB</th> <th>DC</th> </tr> </thead> <tbody> <tr> <td>M (kg m)</td> <td>5396</td> <td>5396</td> <td>5491</td> <td>5491</td> <td>5491</td> <td>5491</td> <td>5396</td> <td>5396</td> </tr> <tr> <td>NF (kg)</td> <td>5378</td> <td>13995</td> <td>11918</td> <td>4742</td> <td>4742</td> <td>11918</td> <td>13995</td> <td>5378</td> </tr> <tr> <td>SF (kg)</td> <td>13995</td> <td>5378</td> <td>4742</td> <td>11918</td> <td>11918</td> <td>4742</td> <td>5378</td> <td>13995</td> </tr> </tbody> </table>		CD	CA	AC	AB	BA	BD	DB	DC	M (kg m)	5396	5396	5491	5491	5491	5491	5396	5396	NF (kg)	5378	13995	11918	4742	4742	11918	13995	5378	SF (kg)	13995	5378	4742	11918	11918	4742	5378	13995				
	CD	CA	AC	AB	BA	BD	DB	DC																																	
M (kg m)	5396	5396	5491	5491	5491	5491	5396	5396																																	
NF (kg)	5378	13995	11918	4742	4742	11918	13995	5378																																	
SF (kg)	13995	5378	4742	11918	11918	4742	5378	13995																																	

## 5. Reinforcing Calculation

### (a) Member CD

$$\begin{aligned}
 M &= 5396 \text{ kgm} \\
 NF &= 5378 \text{ kg} \\
 SF &= 13995 \text{ kg} \\
 ht &= 40 \text{ cm} \\
 h &= 30 \text{ cm} \\
 b &= 100 \text{ cm} \\
 lt &= 3.85 \text{ m}
 \end{aligned}$$



Name of Structure	ASIN BOX CULVERT	CATEGORY Calculation	Structural Calculation	Page	10/16
	$\begin{aligned} lk &= 0.70 \times lt \\ &= 0.70 \times 3.85 \\ &= 2.695 \text{ m} \end{aligned}$ <p>According to design criteria as follows :</p> <p>concrete K<sub>225</sub> → <math>\bar{\sigma}_b = 75 \text{ kg/cm}^2</math>; <math>\bar{\tau}_b = 6.50 \text{ kg/cm}^2</math></p> <p>Steel U<sub>24</sub> → <math>\bar{\sigma} = 1400 \text{ kg/cm}^2</math></p> <p>Ratio of Young's modulus, assume n = 15</p> $\phi_0 = \frac{\bar{\sigma}_a}{n\bar{\sigma}_b} = \frac{1400}{15 \times 75} = 1.244$ $e_{0_1} = \frac{M}{NF} = \frac{5396}{5378} = 1.003 \text{ m}$ $e_{0_2} = \frac{1}{30} ht = \frac{0.40}{30} = 0.013 \text{ m}$ $e_0 = e_{0_1} + e_{0_2} = 1.003 + 0.013 = 1.016 \text{ m}$ $\frac{e_0}{ht} = \frac{1.016}{0.40} = 2.54 > 1 \rightarrow C = 7$ $e_1 = C \left( \frac{lk}{100ht} \right)^2 \times ht = 7 \left( \frac{2.695}{100 \times 0.40} \right)^2 \times 0.40 = 0.013 \text{ m}$ $e_2 = 0.15 ht = 0.15 \times 0.40 = 0.060 \text{ m}$ $e_a = e_0 + e_1 + e_2 = 1.016 + 0.013 + 0.060 = 1.089 \text{ m}$ $e_a = e + \frac{1}{2} ht - 0.05 = 1.089 + \frac{0.40}{2} - 0.05 = 1.239 \text{ m}$ $NF \times e_a = 5378 \times 1.239 = 6663 \text{ kg m}$				

Name of Structure	ASIN BOX CULVERT	CATEGORY Calculation	Structural Calculation	Page	11/16																		
	$C_a = \frac{h}{\sqrt{\frac{n \times NF \cdot e_a}{b \times \bar{\sigma}_a}}} = \frac{30}{\sqrt{\frac{15 \times 6663}{1 \times 1400}}} = 3.551$ $\delta = 1 - \frac{7}{8} \times \frac{h}{e_a} = 1 - \frac{7}{8} \times \frac{0.30}{1.239} = 0.788 \sim 0.80$ $\left. \begin{array}{l} \delta = 0.80 \\ C_a = 3.551 \end{array} \right\} \quad \left. \begin{array}{l} \phi = 2.226 > \phi_0 \ 1.244 \rightarrow \text{ok} \\ \xi = 0.897 \\ n\omega = 0.09205 \end{array} \right.$ $\left. \begin{array}{l} \frac{e_a}{h} = \frac{1.2391}{0.30} = 4.13 \\ \xi = 0.897 \end{array} \right\} \quad i = 1.29$ $iA = \omega bh = \frac{0.09205}{15} \times 100 \times 30 = 18.41 \text{ cm}^2$ $A = \frac{iA}{i} = \frac{18.41}{1.29} = 14.271 \text{ cm}^2$ $A' = \delta \times iA = 0.788 \times 18.41 = 14.507 \text{ cm}^2 \sim A$ <p>to be used D<sub>16</sub>@12.50 cm (A = 16.08 cm<sup>2</sup>)</p> <p>shear strength check:</p> $\tau_b = \frac{SF}{\frac{7}{8} \times b \times h} = \frac{13775}{\frac{7}{8} \times 100 \times 30} = 5.331 \text{ kg/cm}^2 < \bar{\tau}_b = 6.50 \text{ cm}^2 \rightarrow \text{ok}$ <p>(b) Member CA</p> <table> <tr> <td>M = 5396 kgm</td> <td>ht=35cm</td> <td>7cm</td> </tr> <tr> <td>NF = 13995 kg</td> <td></td> <td>h=28cm</td> </tr> <tr> <td>SF = 5378 kg</td> <td></td> <td>7cm</td> </tr> <tr> <td>ht = 35 cm</td> <td>b=100cm</td> <td></td> </tr> <tr> <td>h = 35 - = 28 cm</td> <td></td> <td></td> </tr> <tr> <td>lt = 2.375 m</td> <td></td> <td></td> </tr> </table>	M = 5396 kgm	ht=35cm	7cm	NF = 13995 kg		h=28cm	SF = 5378 kg		7cm	ht = 35 cm	b=100cm		h = 35 - = 28 cm			lt = 2.375 m						
M = 5396 kgm	ht=35cm	7cm																					
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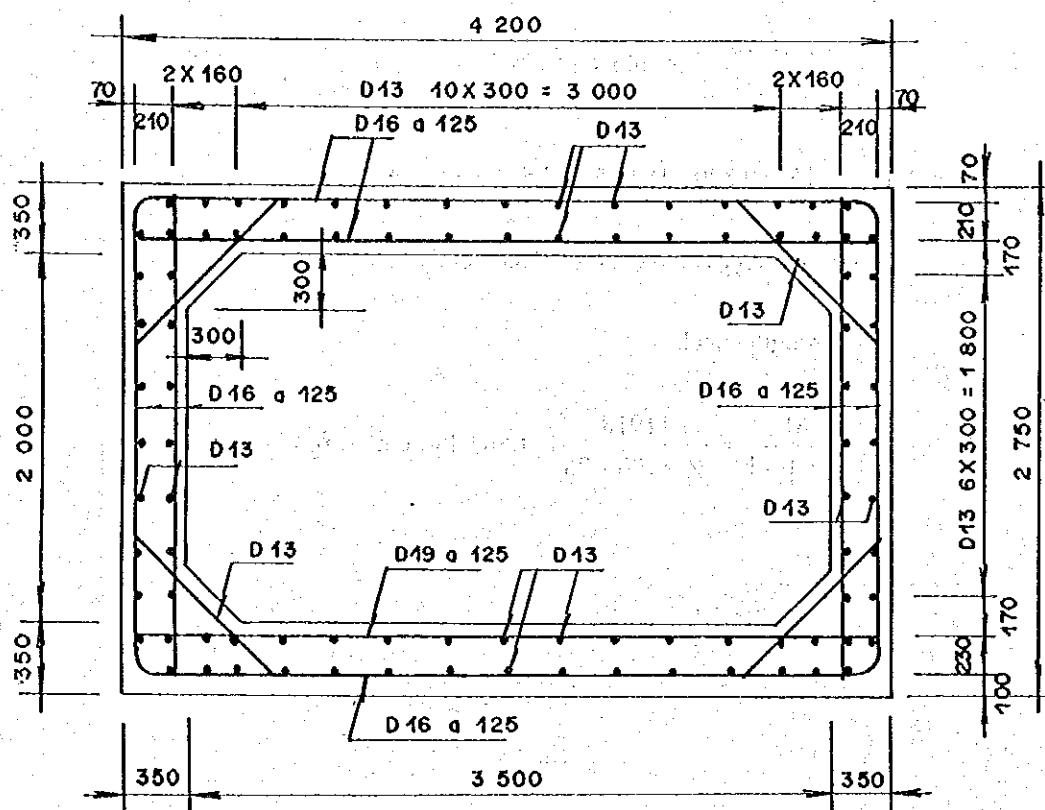
Name of Structure	ASIN BOX CULVERT	CATEGORY Calculation	Structural Calculation	Page	12/16
	$lk = 0.70 \times lt$ $= 0.70 \times 2.375$ $= 1.663 \text{ m}$  $e_{0_1} = \frac{M}{NF} = \frac{5396}{13995} = 0.386 \text{ m}$  $e_{0_2} = \frac{1}{30} ht = \frac{0.35}{30} = 0.012 \text{ m}$  $e_0 = e_{0_1} + e_{0_2} = 0.386 + 0.012 = 0.398 \text{ m}$  $\frac{e_0}{ht} = \frac{0.398}{0.35} = 1.137 > 1 \rightarrow C = 7$  $e_1 = C \left( \frac{lk}{100ht} \right)^2 \times ht = 7 \left( \frac{1.663}{100 \times 0.35} \right)^2 \times 0.35 = 0.006 \text{ m}$  $e_2 = 0.15 ht = 0.15 \times 0.35 = 0.053 \text{ m}$  $e = e_0 + e_1 + e_2 = 0.398 + 0.006 + 0.053 = 0.457 \text{ m}$  $e_a = e + \frac{1}{2} ht - 0.05 = 0.457 + \frac{0.35}{2} - 0.05 = 0.582 \text{ m}$  $NF \times e_a = 3995 \times 0.582 = 8145 \text{ kg m}$  $C_a = \frac{h}{\sqrt{\frac{n \times NF \cdot e_a}{b \times \bar{\sigma}_a}}} = \frac{28}{\sqrt{\frac{15 \times 8145}{1.0 \times 1400}}} = 2.997$  $\delta = 1 - \frac{1}{8} \times \frac{h}{e_a} = 1 - \frac{1}{8} \times \frac{0.28}{0.582} = 0.579 \sim 0.60$				

Name of Structure	ASIN BOX CULVERT	CATEGORY Calculation	Structural Calculation	Page	13/16
$\delta = 0.60$	$\left. \begin{array}{l} \phi = 1.817 > \phi_0 \ 1.244 \rightarrow \text{ok} \\ \xi = 0.886 \end{array} \right\}$				
$C_a = 2.997$	$n\omega = 0.1281$				
$\frac{e_a}{h} = \frac{0.582}{0.28} = 2.079$	$\left. \begin{array}{l} i = 1.72 \\ \xi = 0.886 \end{array} \right\}$				
$iA = \omega b h = \frac{0.1281}{15} \times 100 \times 28 = 23.912 \text{ cm}^2$					
$A = \frac{iA}{i} = \frac{23.912}{1.72} = 13.902 \text{ cm}^2$					
$A' = \delta \times iA = 0.579 \times 23.912 = 13.845 \text{ cm}^2 \sim A$					
to be used D <sub>16</sub> @12.50 cm (A = 16.08 cm <sup>2</sup> )					
shear strength check,					
$\tau_b = \frac{SF}{\frac{1}{8} \times b \times h} = \frac{5378}{\frac{1}{8} \times 100 \times 28} = 2.195 \text{ kg/cm}^2 < \bar{\tau}_b = 6.50 \text{ cm}^2 \rightarrow \text{ok}$					
(c) Member AB					
M = 5491	kNm				
NF = 4742	kg				
SF = 11918	kg				
ht = 35	cm				
h = 35 - 7 = 28	cm				
lt = 3.85	m				
lk = 0.70 x lt					
= 0.70 x 3.85					
= 2.695 m					

Name of Structure	ASIN BOX CULVERT	CATEGORY Calculation	Structural Calculation	Page	14/16
	$e_{0_1} = \frac{M}{NF} = \frac{4591}{4742} = 1.158 \text{ m}$				
	$e_{0_2} = \frac{1}{30} ht = \frac{0.35}{30} = 0.012 \text{ m}$				
	$e_0 = e_{0_1} + e_{0_2} = 1.158 + 0.012 = 1.170 \text{ m}$				
	$\frac{e_0}{ht} = \frac{1.170}{0.35} = 3.343 > 1 \rightarrow C = 7$				
	$e_1 = C \left( \frac{lk}{100ht} \right)^2 \times ht = 7 \left( \frac{2.695}{100 \times 0.35} \right)^2 \times 0.35 = 0.015 \text{ m}$				
	$e_2 = 0.15 ht = 0.15 \times 0.35 = 0.053 \text{ m}$				
	$e = e_0 + e_1 + e_2 = 1.170 + 0.015 + 0.053 = 1.238 \text{ m}$				
	$e_a = e + \frac{1}{2} ht - 0.05 = 1.238 + \frac{0.35}{2} - 0.05 = 1.363 \text{ m}$				
	$NF \times e_a = 4742 \times 1.363 = 6463 \text{ kg m}$				
	$C_a = \frac{h}{\sqrt{\frac{n \times NF \cdot e_a}{b \times \bar{\sigma}_a}}} = \frac{28}{\sqrt{\frac{15 \times 6463}{1.0 \times 1400}}} = 3.365$				
	$\delta = 1 - \frac{7}{8} \times \frac{h}{e_a} = 1 - \frac{7}{8} \times \frac{0.28}{1.363} = 0.820 \sim 0.80$				
$\delta = 0.80$ $C_a = 3.365$	$\left. \begin{array}{l} \phi = 2.125 > \phi_0 1.244 \rightarrow \text{ok} \\ \xi = 0.895 \\ n\omega = 0.1016 \end{array} \right\}$				
$\frac{e_a}{h} = \frac{1.363}{0.28} = 4.868$ $\xi = 0.895$	$\left. \begin{array}{l} \\ \\ i = 1.22 \end{array} \right\}$				

Name of Structure	ASIN BOX CULVERT	CATEGORY Calculation	Structural Calculation	Page	15/16
			$iA = \omega bh = \frac{0.1016}{15} \times 100 \times 28 = 18.965 \text{ cm}^2$ $A = \frac{iA}{i} = \frac{18.965}{1.22} = 15.545 \text{ cm}^2$ $A' = \delta \times iA = 0.820 \times 18.965 = 15.551 \text{ cm}^2 \sim A$ to be used D <sub>16</sub> @12.50 cm (A = 16.08 cm <sup>2</sup> ) shear strength check. $\tau_b = \frac{SF}{\frac{1}{8} \times b \times h} = \frac{11918}{\frac{1}{8} \times 100 \times 28} = 4.864 \text{ kg/cm}^2 < \bar{\tau}_b = 6.50 \text{ cm}^2 \rightarrow \text{ok}$		

Name of Structure	ASIN BOX CULVERT	Category of calculation	STRUCTURAL CALCULATION	Page	16/16
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REINFORCING BAR ARRANGEMENT

## 2.4 Pump Control Building

## 2.4 Pump Control Building

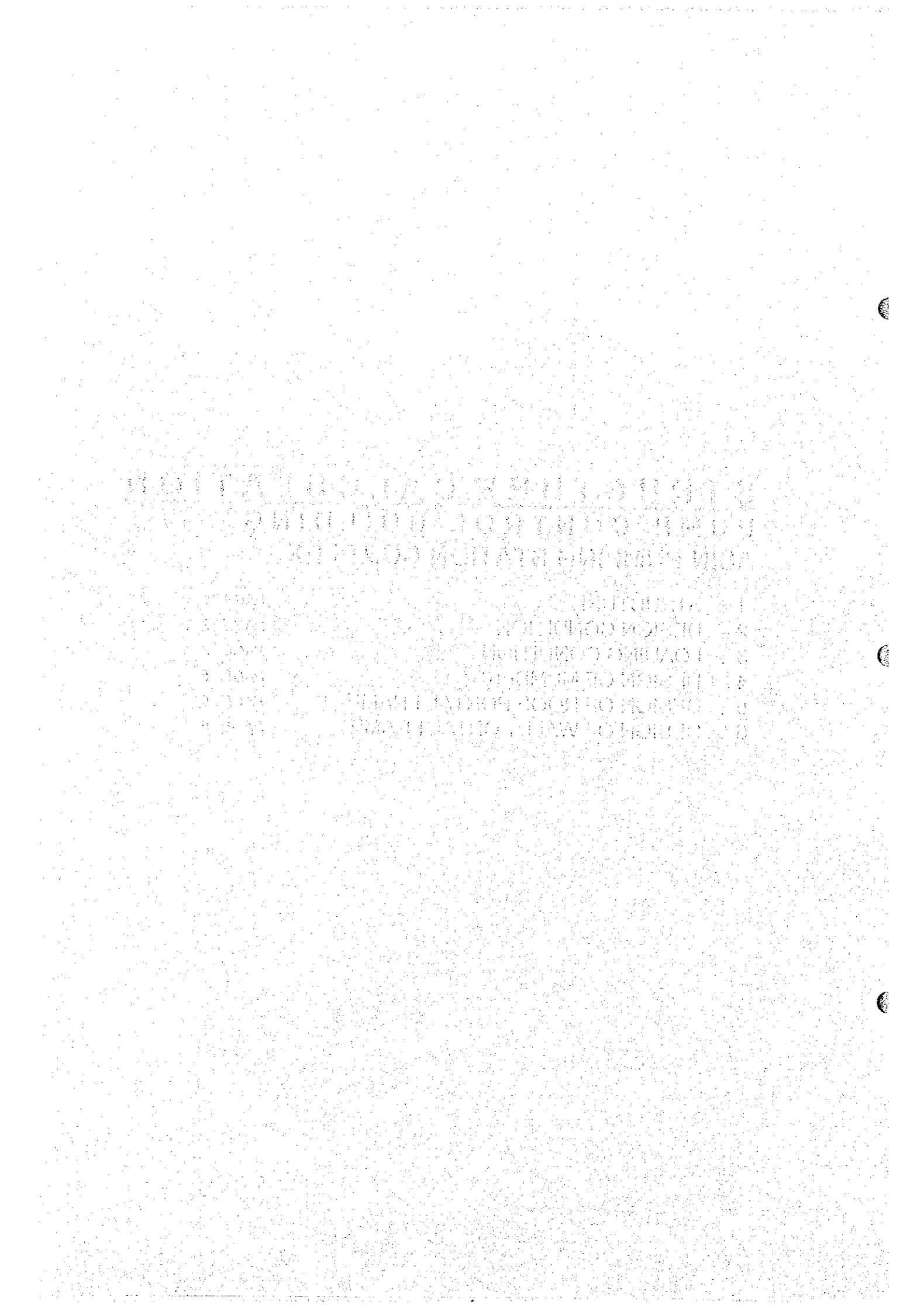
### 2.4.1 Structural Calculation

# **STRUCTURE CALCULATION**

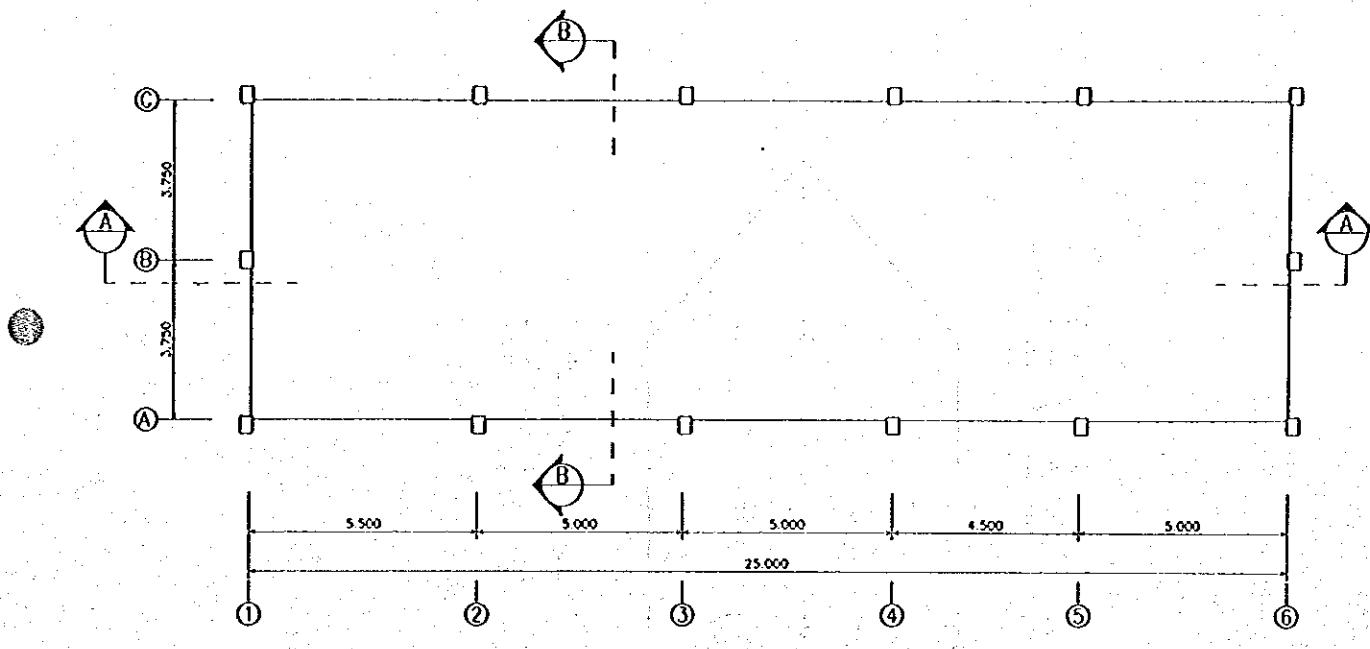
## **PUMP CONTROL BUILDING**

### **ASIN PUMPING STATION COMPLEX**

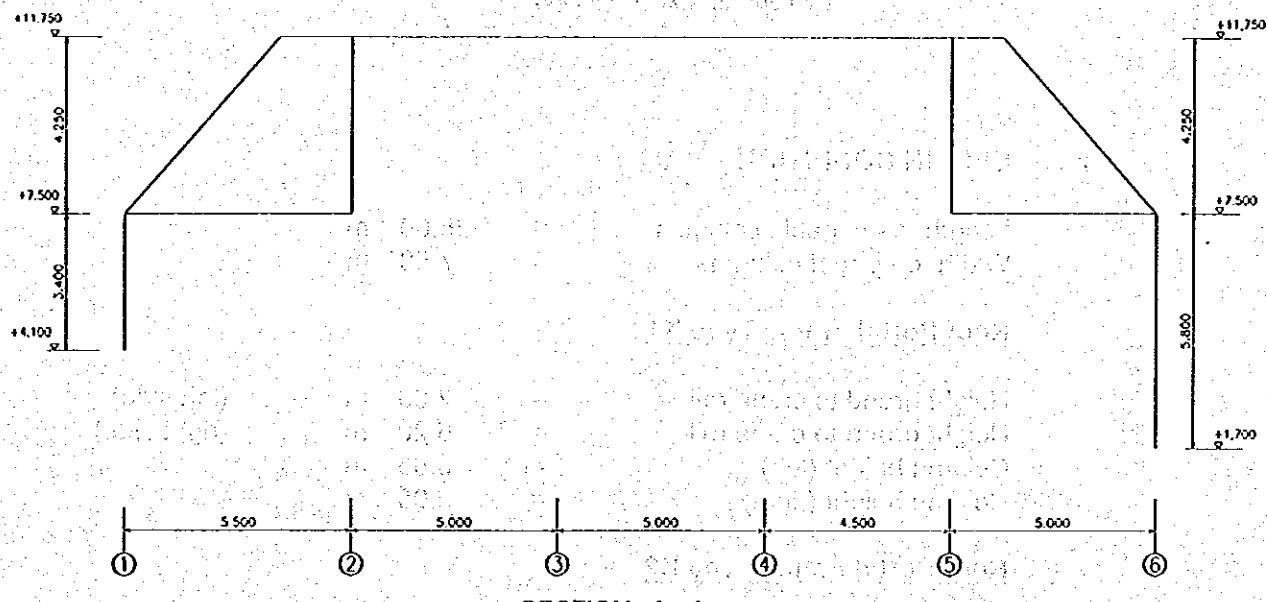
1 . STRUCTURE	PAGE 1
2 . DESIGN CONDITION	PAGE 2
3 . LOADING CONDITION	PAGE 3
4 . DESIGN OF MEMBERS	PAGE 5
5 . DESIGN OF ROOF PORTAL FRAME	PAGE 6
6 . DESIGN OF WALL PORTAL FRAME	PAGE 9



## 1. STRUCTURE

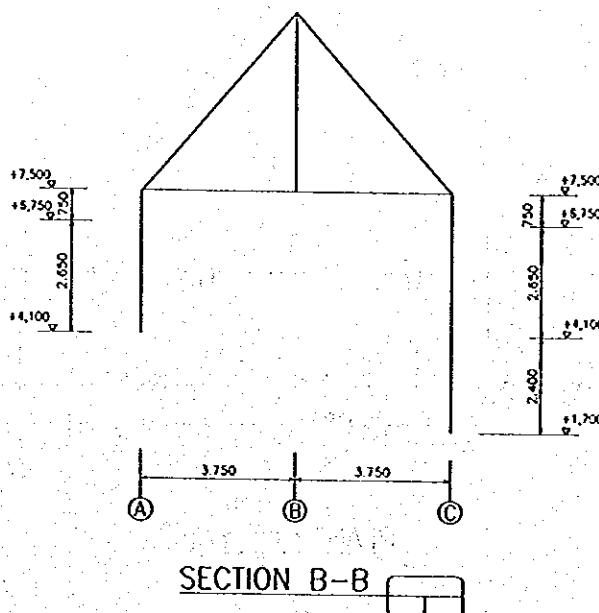


PLAN



SECTION A-A

PUMP CONTROL BUILDING  
ASIN PUMPING STATION COMPLEX



**PUMP CONTROL BUILDING**  
ASIN PUMPING STATION COMPLEX

## 2. DESIGN CONDITION

Length c - c gable columns = 25.00 m  
Width c - c roof columns = 7.50 m

### Roof Portal Frame Type K1

Height grond to crane rail	=	2.80 m	(left side)
Height grond to crane rail	=	5.20 m	(right side)
Column height (left)	=	3.65 m	
Column height (right)	=	6.05 m	

### Roof Portal Frame Type K2

Height grond to crane rail	=	5.20 m	(left side)
Height grond to crane rail	=	5.20 m	(right side)
Column height (left)	=	3.65 m	
Column height (right)	=	6.05 m	

Roof covering	=	Ceramic roof tile
Crane span	=	6.70 m
End clearance	=	0.10 m
Weight of crane without carb	=	2.00 Ton
Weight of carb	=	0.80 Ton

### 3. Loading Condition

#### a. Dead load

- Roof cover (ceramic tile + timber rafter) =  $70 \text{ kg/m}^2$
- Ceiling (fiber cement) =  $10 \text{ kg/m}^2$
- Reinforced concrete =  $2,400 \text{ kg/m}^3$
- Brick wall 0.15 m thick =  $250 \text{ kg/m}^2$
- Weight of a worker as point load =  $100 \text{ kg}$

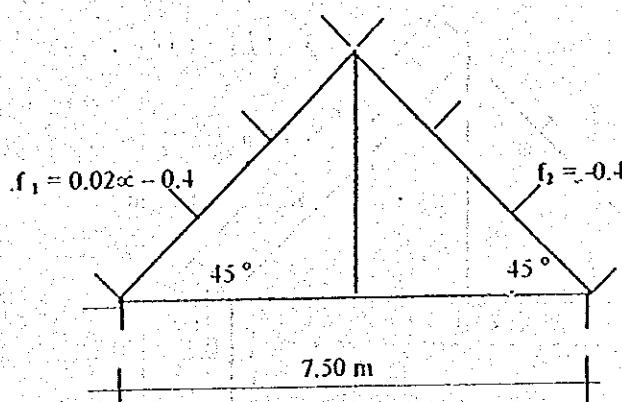
#### b. Wind Load

- Wind pressure at coastal up to 5 km far =  $40 \text{ kg/m}^2$
- Pressure coefficient ( $f$ )
  - Windward  $f = 0.02 \times \alpha - 0.5$   
 $\alpha = (\text{angle of roof slope}) \leq 65^\circ$
  - Leeward  $f = -0.4$

#### c. Live Load :

- Point load at center point of purlin span when a worker is setting up the roof cover (rafter and ceramic tile)

$$P = 100 \text{ kg} \quad P_1 = P_2 = P \cos 45^\circ = 71 \text{ kg}$$

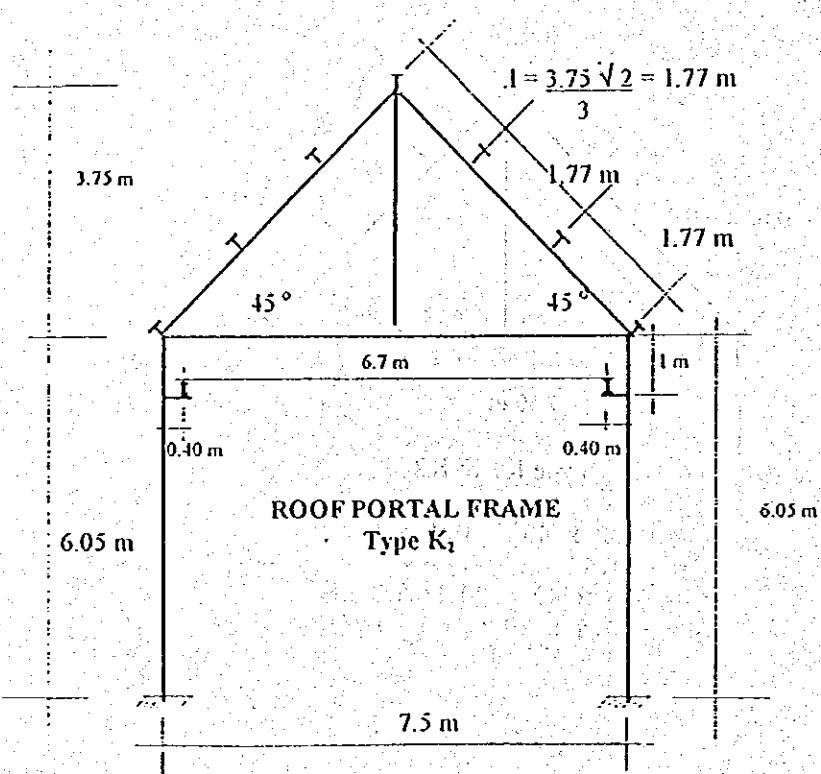
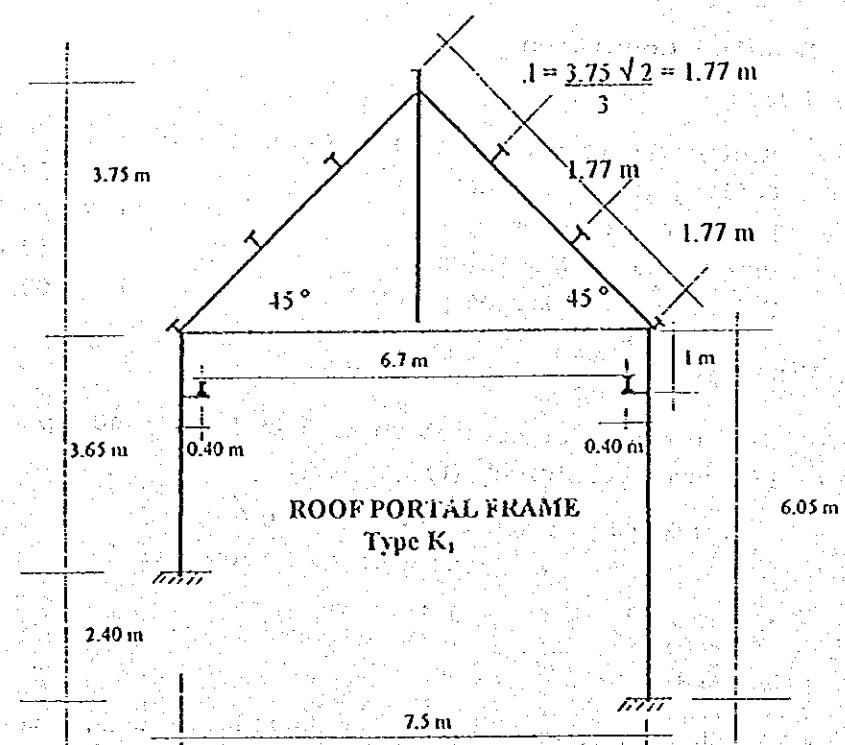


$$f_1 = 0.02 \times 45^\circ - 0.4 = 0.5$$

$$f_2 = -0.4$$

$$w_1 = 0.5 \times 40 = 20 \text{ kg/m}^2$$

$$w_2 = -0.4 \times 40 = -16 \text{ kg/m}^2$$



4. Design of members

Purlins 5 m span ; 1.77 m centers

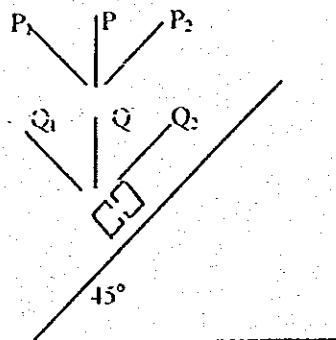
Dead load :

- Roof cover (ceramic tile) + timber rafter	= 70 kg/m <sup>2</sup>
- Ceiling (fiber cement)	= 10 kg/m <sup>2</sup>
	= 80 kg/m <sup>2</sup>

$$q_1 = 1.77 \times 80 = 141.6 \approx 142 \text{ kg/m}^2$$

$$\text{Purlin self weight (q_2)} \text{ say } = 15 \text{ kg/m}^2$$

$$Q = 157 \text{ kg/m}^2$$



$$Q_1 = Q_2 = Q \cos 45^\circ$$

$$= 157 \cos 45^\circ$$

$$= 111 \text{ kg/m}^2$$

- Try purlin of Lip Channel type :



$$150 \times 130 \times 20 \times 3.2$$

$$I_x = 664 \text{ cm}^4; W_x = 88.6 \text{ cm}^3$$

$$I_y = 476 \text{ cm}^4; W_y = 73.2 \text{ cm}^3$$

- Bending Moment at center point of purlin span :

$$M_x = \frac{1}{8} \times 111 \times 5^2 + 1 \times 71 \times 5 = 435.625 \text{ kgm}$$

$$M_y = M_x = 435.625 \text{ kgm} \approx 43,563 \text{ kg cm}$$

Stress :

$$\sigma = \sigma_x + \sigma_y$$

$$= \frac{M_x}{W_x} + \frac{M_y}{W_y}$$

$$= \frac{43.563}{88.6} + \frac{43.563}{73.2}$$

$$= \sigma 1,087 \text{ kg/cm}^2 < \bar{\sigma}_{\text{allowable}} = 1,400 \text{ kg/cm}^2 (\text{OK!})$$

Deflection

$$f_x = \frac{5}{384} \times \frac{111}{100} \times \frac{500^4}{2.1E6 \times 664} + \frac{1}{48} \times \frac{71}{500^3}{\frac{500^3}{2.1E6 \times 664}}$$

$$= 0.64 \text{ cm} + 0.13 \text{ cm}$$

$$= 0.77 \text{ cm}$$

$$f_y = 0.90 + 0.18$$

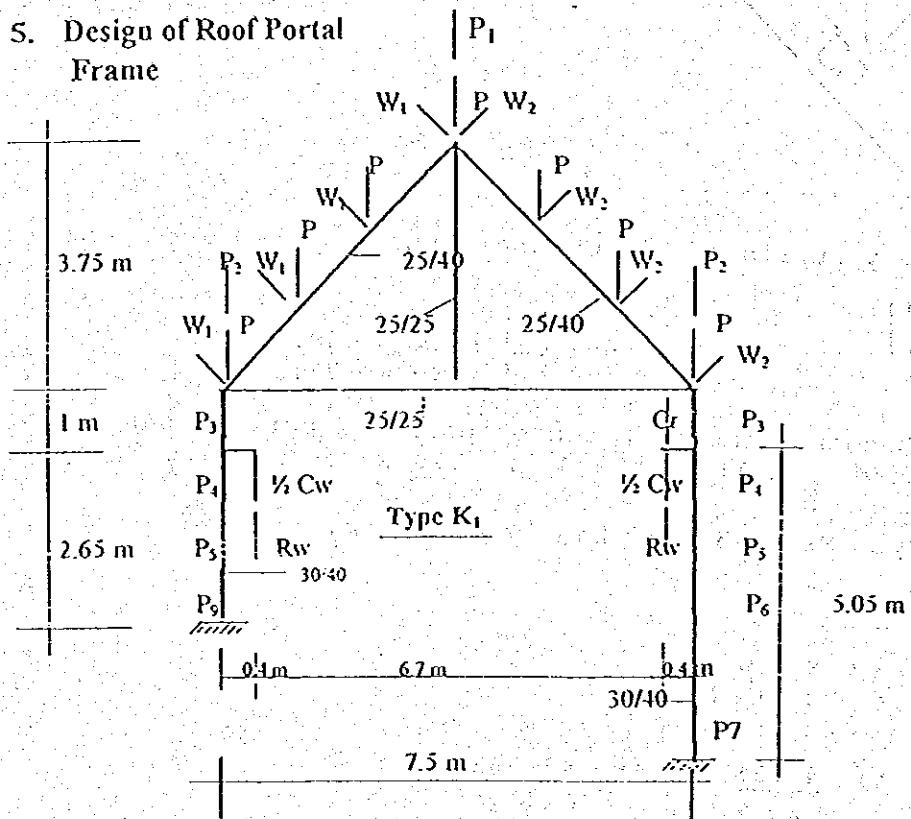
$$= 1.08$$

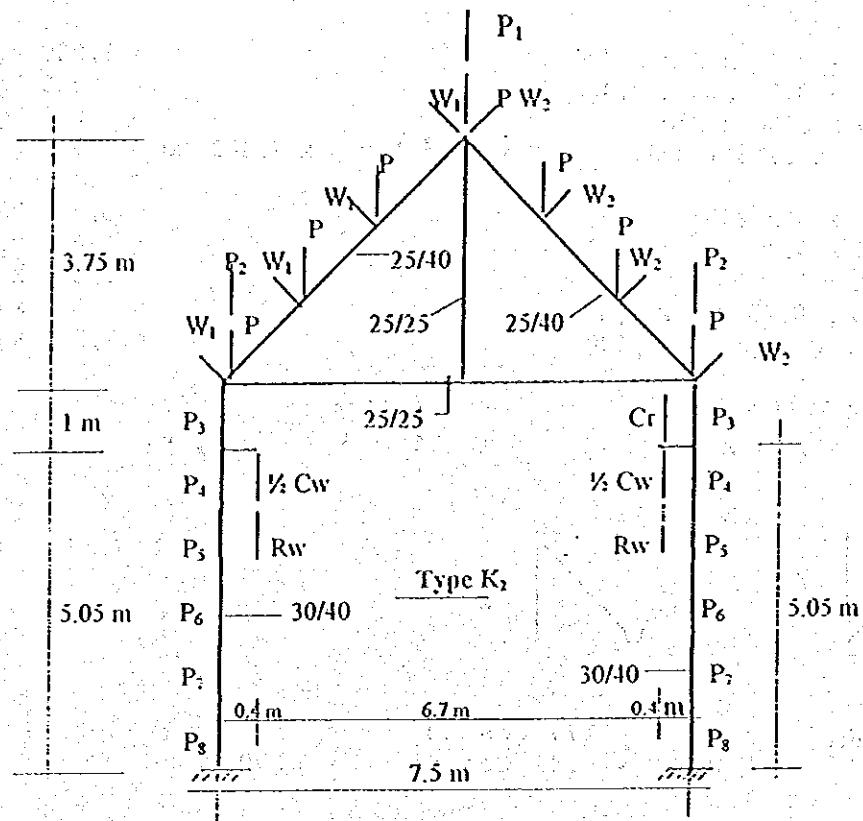
$$f = (\sqrt{0.77^2 + 1.08^2})^{1/2} = 1.3 \text{ cm}$$

$$\bar{f}_{\text{allow}} = \frac{1}{360} L = \frac{500}{360} = 1.4 \text{ cm}$$

$f < \bar{f}_{\text{allow}}$  (OK !)

**5. Design of Roof Portal Frame**





**Loads**

$C_r$  = Crane Weight = 2 Tons (alternate on right side)

$C_w$  = Carb Weight = 0.8 Ton

$\frac{1}{2} C_w$  = 0.4 ton

$R_w$  = Rail Weight =  $22.9 \times 5 \approx 115$  kg

$P$  = Roof Cover weight (include purlin self weight)

$P_1$  = Ridge reinforcement concrete (r.c.) beam 25/40

$P_2$  = Ring r.c. beam 15/20

$P_3$  = Brick wall weight

$P_4$  = Crane rail supported r.c. beam

$P_5$  = Brick wall weight

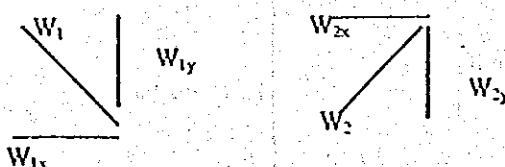
$P_6$  = Bracing r.c. beam

$P_7$  = Brick wall weight

$P_8$  = Tied beam weight (20/25)

$P_9$  = Tied beam weight (25/40)

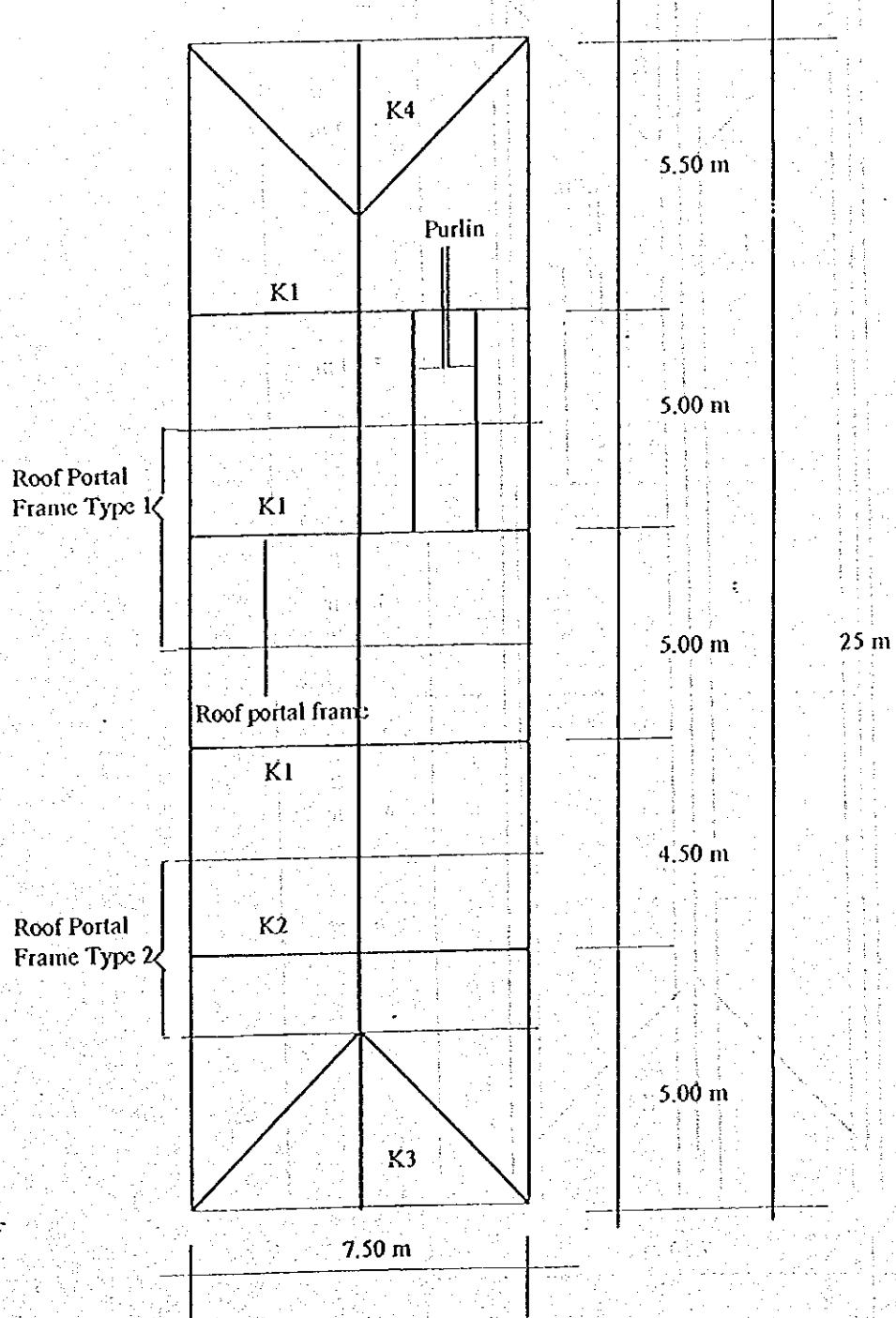
$P = 157 \times 5$	= 785 kg
$P_1 = 0.25 \times 0.40 \times 5 \times 2,400$	= 1,200 kg
$P_2 = 0.15 \times 0.20 \times 5 \times 2,400$	= 360 kg
$P_3 = 0.55 \times 5.00 \times 250$	= 688 kg
$P_4 = (0.55 \times 0.35 + 0.55 + 0.40 \times 0.15) \times 5 \times 2,400 \text{ kg} = 855 \text{ kg}$	
$P_5 = 2.65 \times 5 \times 250$	= 3,313 kg
$P_6 = 0.20 \times 0.25 \times 5 \times 2,400$	= 600 kg
$P_7 = 2.40 \times 5 \times 250$	= 3,000 kg
$P_8 = 0.20 \times 0.25 \times 5 \times 2,400$	= 600 kg
$P_9 = 0.25 \times 0.40 \times 5 \times 2,400$	= 1,200 kg
$W_1 = 20 \times 1.77 \times 5$	= 177 kg
$W_2 = -16 \times 1.77 \times 5$	= -141.6 kg $\approx$ -142 kg

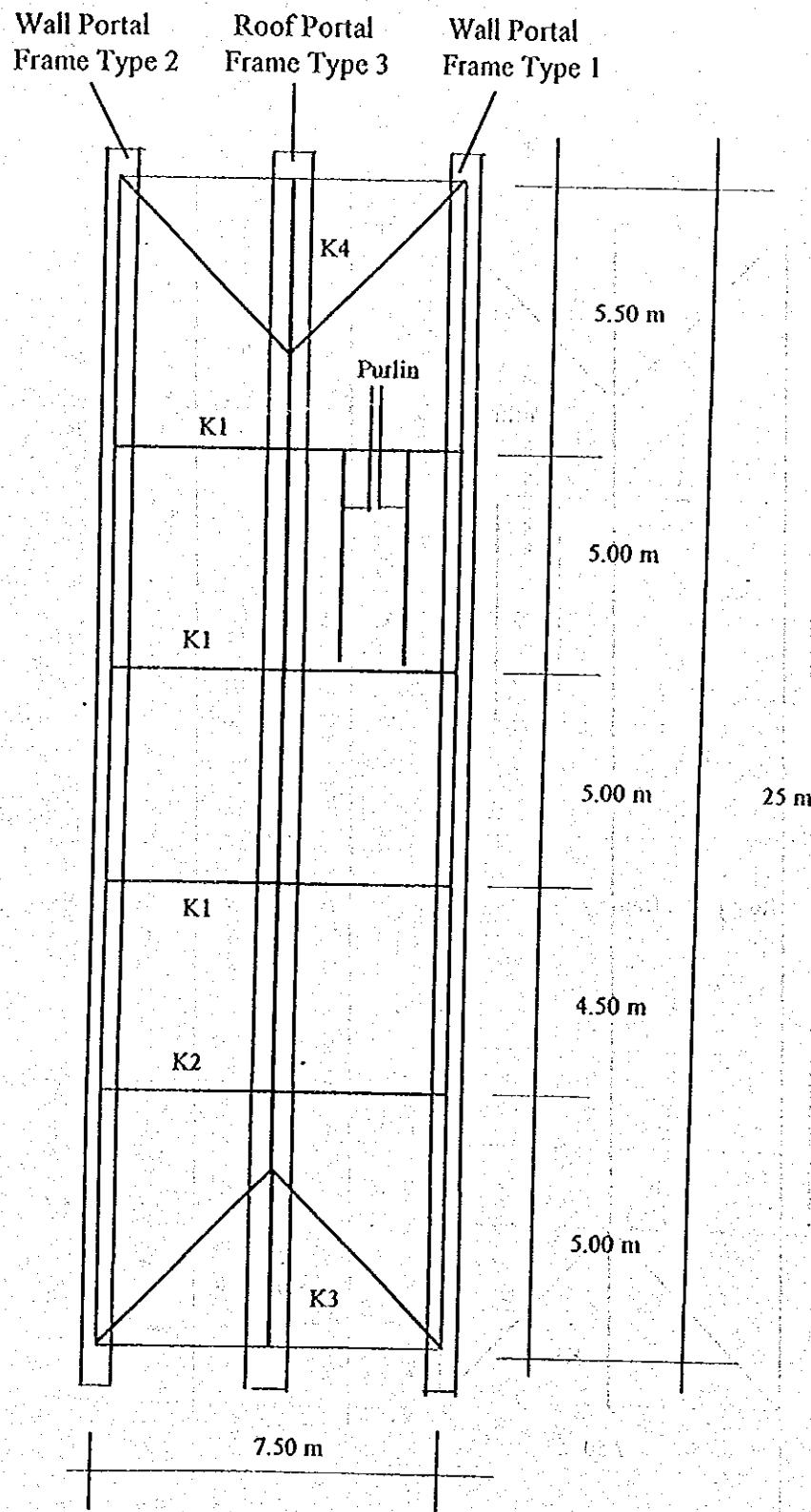


$$\begin{aligned} W_{1x} &= W_{1y} = 177 \cos 45^\circ = 125 \text{ kg} \\ W_{2x} &= W_{2y} = -142 \cos 45^\circ = -100 \text{ kg} \end{aligned}$$

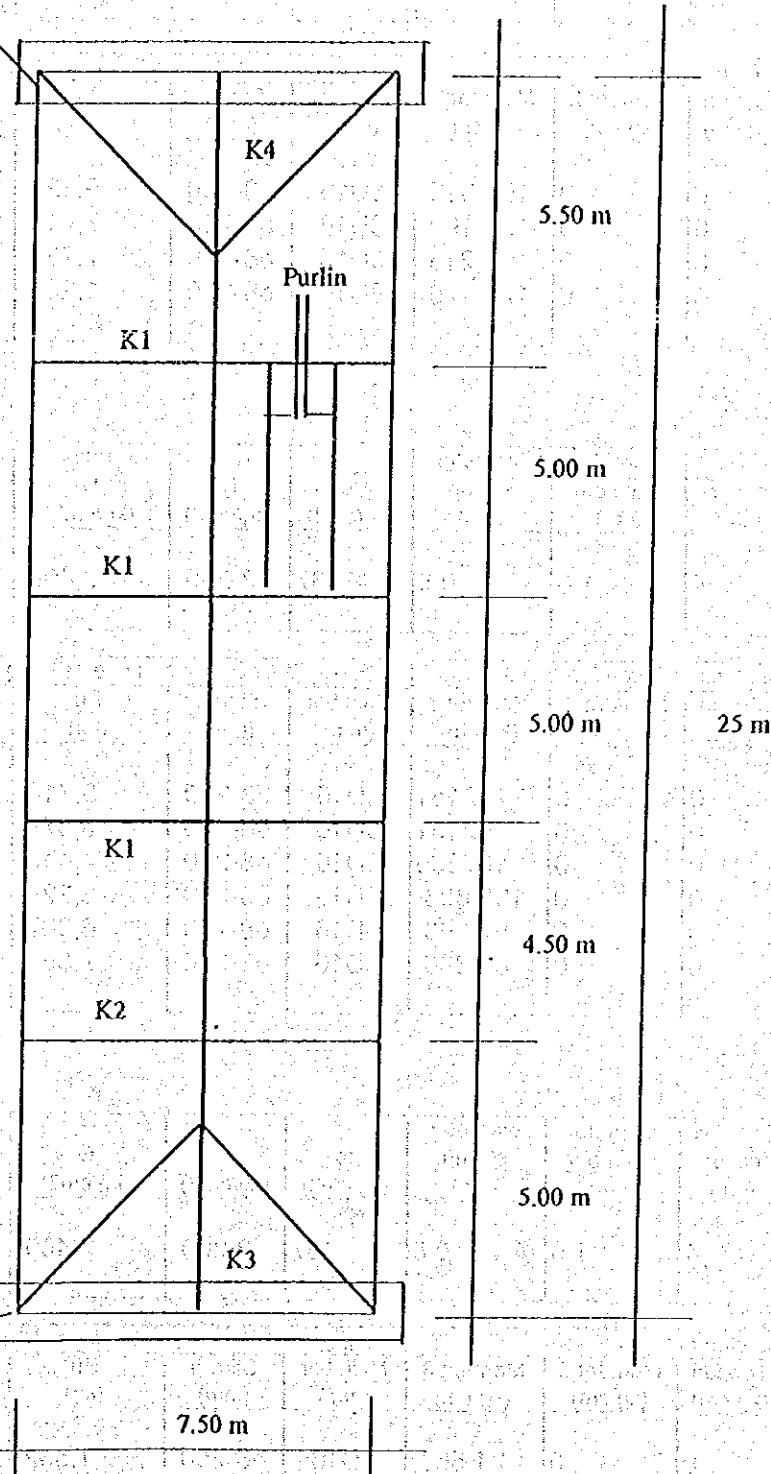
- Further structure calculation, a part of loads can be simplified as :
  - a. Roof Portal Frame Type K<sub>1</sub>
    - Left Side :  $P_A = P_2 + P_3 + P_4 + P_5 = 5,216 \text{ kg}$
    - Right Side :  $P_B = P_1 + P_3 + P_4 + P_5 + P_6 + P_7 + P_8 = 10,016 \text{ kg}$
  - b. Roof Portal Frame Type K<sub>2</sub>
    - Right Side :  $P_A = P_2 + P_3 + P_4 + P_5 + P_6 + P_7 + P_8 = 9,416 \text{ kg}$
    - Left Side :  $P_B = P_A = 9,416 \text{ kg}$
- Structure Calculation of Roof Portal Frame by using computer programming, including self weight of structure. The software is Structure Analysis and Design System (SANS/89) Version 3.5 (1994), Engineering Software Research, Indonesia.

## 6. DESIGN OF WALL PORTAL FRAME





Wall Portal  
Frame Type 3



Wall Portal  
Frame Type 4