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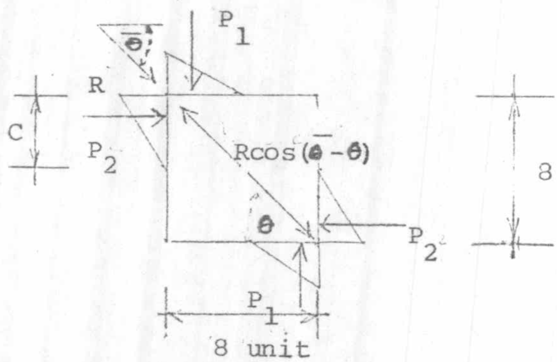
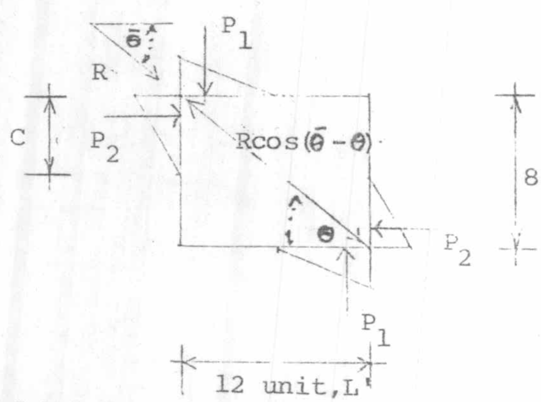
Table 1 Total vertical and horizontal force on infill for L'/h' = 1.0



case 1 L'/h' = 1.0

c/h'	$\bar{\theta}$	R	P_1	P_2	$R\cos(\bar{\theta}-\theta)$	$\cos(\bar{\theta}-\theta)$
1/8	53.97	1000	808.70	599.10	987.0	0.987
1/4	51.34	1000	780.80	624.60	993.0	0.993
3/6	48.36	1000	747.40	664.30	998.0	0.998
1/2	45.00	1000	707.10	707.10	1000.0	1.00

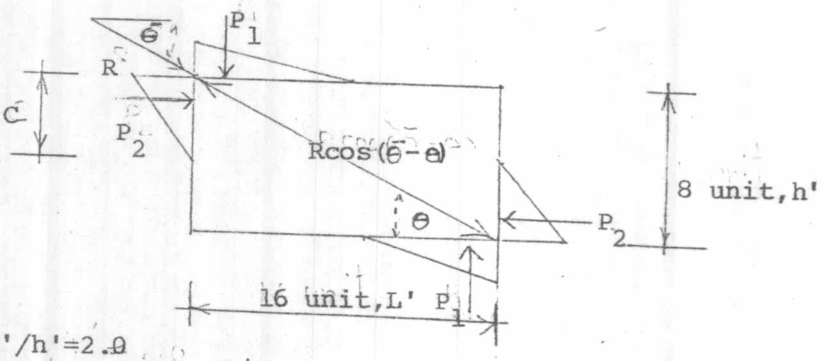
Table 2 Total vertical and horizontal force on infill for L'/h' = 1.5.



case2L'/h'=1.5

C/h'	$\bar{\theta}$	R	P_1	P_2	$R\cos(\bar{\theta}-\theta)$	$\cos(\bar{\theta}-\theta)$
1/8	42.51	1000	677.50	737.10	988.0	0.988
1/4	39.80	1000	640.10	768.20	994.0	0.994
3/8	39.86	1000	600.00	800.00	998.0	0.998
1/2	33.69	1000	554.70	832.00	1000.0	1.00

Table 3 Total vertical and horizontal force on infill for L'/h' = 2.0



case 3 L'/h'=2.0

C/h'	$\bar{\theta}$	R	P_1	P_2	$R\cos(\bar{\theta}-\theta)$	$\cos(\bar{\theta}-\theta)$
1/8	34.50	1000	566.50	824.00	990.0	0.990
1/4	32.00	1000	529.90	847.90	995.0	0.995
3/8	29.35	1000	490.20	871.0	998.0	0.998
1/2	26.56	1000	447.20	894.40	1000	1.000

Table 4—Displacement at load corner

C/h'	x displacement	y displacement	θ'	θ	x^2+y^2	Remark
1/8	-0.0958	0.6232	8.7392	26.56505°	0.63052	L'/h' = 2.0
1/4	-0.04848	0.48761	5.6778	26.56505°	0.4900	
3/8	-0.01137	0.40029	1.627	26.56505°	0.40106	
1/2	0.01718	0.3386	2.904	26.56505°	0.33903	
1/8	-0.039035	0.505469	4.415	33.6903°	0.506974	L'/h' = 1.5
1/4	-0.0169	0.387878	2.494	33.6903°	0.38824	
3/8	0.035427	0.3066	6.591	33.6903°	0.30863	
1/2	0.06624	0.2462	15.059	33.6903°	0.254955	
1/4	0.3003126	0.06767	12.699	45°	0.30784	L'/h' = 1.0
3/8	0.211441	0.109554	27.3897	45°	0.23814	
1/2	0.1436706	0.1436706	45.0	45°	0.20318	

Table 5 Equivalent width of diagonal strut

Proportion	C/h'	x^2+y^2 (Δw)	$(\theta-\theta')$	$\Delta_e = \Delta_w \cos(\theta-\theta')$	$A = \frac{P_o d}{\Delta_e E_w}$	w/d
L'/h' = 2.0	1/8	0.630	35.304	0.514	0.193d	0.19
	1/4	0.490	32.242	0.414	0.240d	0.24
	3/8	0.401	28.192	0.353	0.282d	0.28
	1/2	0.339	23.661	0.310	0.322d	0.32
L'/h' = 1.5	1/8	0.506	38.105	0.398	0.248d	0.25
	1/4	0.388	36.184	0.313	0.317d	0.31
	3/8	0.308	27.102	0.274	0.363d	0.36
	1/2	0.254	18.631	0.241	0.413d	0.41
L'/h' = 1.0	1/4	0.307	32.301	0.260	0.381d	0.38
	3/8	0.238	17.610	0.226	0.441d	0.44
	1/2	0.203	0	0.203	0.492d	0.49

<u>NOTE</u> $P_o = R\cos(\bar{\theta}-\theta)$

Table 6 Calculated width to diagonal ratio for L'/h' = 2.0

Load distribution		values of w/d		different	Percentage of different
C/h'	β/L'	Smith	Proposed		
1/8	1/2	0.18	0.19	0.01	5.5 %
1/4	1/2	0.23	0.24	0.01	5.5 %
3/8	1/2	0.26	0.28	0.02	7.6 %
1/2	1/2	0.30	0.32	0.02	6.6 %

Table 7 Calculated width to diagonal ratio for L'/h' = 1.5

Load distribution		values of w/d		different	Percentage of different
C/h'	β/L'	Smith	Proposed		
1/8	1/2	0.22	0.25	0.03	13.6 %
1/4	1/2	0.27	0.31	0.04	12.5 %
3/8	1/2	0.32	0.36	0.04	12.5 %
1/2	1/2	0.38	0.41	0.03	7.8 %

Table 8 Calculated width to diagonal ratio for L'/h' = 1.0

distance of load		values of w/d		different	Percentage of different
C/h'	β/L'	Smith	Proposed		
1/8	1/2	0.24	-	-	-
1/4	1/2	0.30	0.38	0.08	21 %
3/8	1/2	0.35	0.44	0.09	20.4 %
1/2	1/2	0.38	0.49	0.11	22.4 %

Table 9 Comparision of lateral stiffness, prediction and experiment (Ref. 24)

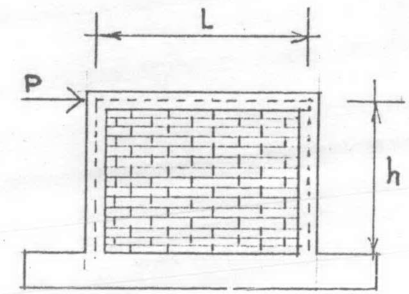
Predicted method	L'/h'=1.0 (FWW 2A)			L'/h'=1.0 (FWW 2B)			L'/h'= 1.5 (FWW 3A)		
	k	Diff.	Expt./Pred.	k	Diff.	Expt./Pred.	k	Diff.	Expt./Pred.
Experiment	36.43	-	-	35.72	-	-	37.50	-	-
Proposed	31.95	+4.47	1.14	35.89	-0.17	0.995	40.92	-3.42	0.916
Holme's	25.27	+11.16	1.44	27.03	+8.69	1.32	33.52	+3.98	1.11
Smith's	26.38	+10.05	1.38	26.34	-2.97	0.92	29.55	+7.95	1.26
Benjamin	27.40	+ 9.03	1.32	32.24	+3.48	1.1	43.53	-6.03	0.86
Wagih, M.	36.74	- 0.31	0.99	43.93	-8.21	0.81	54.12	-16.62	0.69
Meli, R	32.05	+ 4.38	1.12	36.31	-0.59	0.98	47.07	- 9.57	0.79

Note: k are the lateral stiffness in ton per cm.

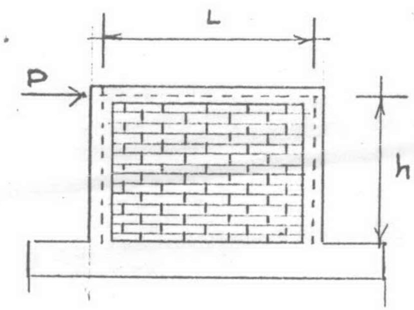
Table 10 Comparision of lateral stiffness , prediction and experiment continue (Ref. 24)

Predicted method	L'/h'=1.0(FWW 4C1)			L'/h'=1.0 (FWW 4C2)		
	k	Diff	Expt./Pred.	k	Diff.	Expt./Pred.
Experiment	17.86	-	-	21.78	-	-
Proposed	17.96	-0.10	0.99	17.78	+4.00	1.22
Holme's	11.62	+6.24	1.53	13.11	+8.67	1.66
Smith's	14.63	+3.23	1.22			
Benjamin	16.12	+1.74	1.1	17.41	+4.37	1.25
Wagih, M	22.84	-4.78	0.78	21.56	+0.22	1.01
Meli, R	19.84	-1.98	0.9	18.06	+3.72	1.20

Detail of speciment



FWW4C1



FWW 4C2

Note: k are the lateral stiffness in ton per cm.

Table 11 Comparision of lateral stiffness, prediction and experiment (Ref. 2)

Predicted method	L'/h' = 1.0 (FW1A)			L'/h' = 1.5 (FW1B)			L'/h' = 2.0 (FW1C)		
	k	Diff.	Expt / Pred.	k	Diff.	Expt. / Pred.	k	Diff.	Expt. / Pred.
Experiment	41	-	-	61	-	-	103	-	-
Proposed	84.81	-43.81	0.48	89.46	-28.49	0.68	102.03	+0.97	1.01
Holme's	64.53	-23.53	0.63	78.62	-17.62	0.77	112.38	-9.38	0.91
Smith's	115.8	-74.80	0.35	78.97	-17.97	0.77	114.50	-11.50	0.89
Benjamin	127.80	-86.80	0.32	162.16	-101.16	0.37	274.75	-171.75	0.37
F.E.M[2]	129.80	-88.8	0.31	167.57	-106.57	0.36	195.51	-92.51	0.57
Wagih, M.	134.20	-93.20	0.30	168.43	-107.43	0.36	280.95	-177.9	0.36

Note : k are the lateral stiffness in ton per cm.

Table 12 - Comparision of lateral stiffness of frame with and without brick infill.

series		L'/h'	series	Experiment		Proposed method	
				k	F	k	F
Reference 24	FWW3A	1.5	infilled frame	37.5	2.66	40.92	2.90
			bare frame[1]	14.09		14.09	
	FWW2A	1.0	infilled frame[1]	36.43	2.84	31.95	2.49
			bare frame[1]	12.8		12.8	
	FWW2B	1.0	infilled frame	35.72	2.61	35.89	2.62
			bare frame[1]	13.69		13.69	
	FWW4C1	1.0	infilled frame	17.86	4.34	17.96	4.36
			bare frame[1]	4.11		4.11	
	FWW4C2	1.0	infilled frame	21.78	4.37	17.78	3.57
			bare frame[1]	4.98		4.98	
Reference 2	FW1A	1.0	infilled fr frame	41.00	5.47	84.81	13.25
			bare frame	7.5		6.40	
	FW1B	1.5	infilled frame	61.00	7.87	89.49	14.27
			bare frame	7.75		6.27	
	FW1C	2.0	infilled frame	103.00	15.15	102.03	16.43
			bare frame	6.8		6.21	

Note k are lateral stiffness in ton per cm.

$$F = \frac{\text{lateral stiffness of infilled frame}}{\text{lateral stiffness of frame only}}$$

bare frame[1] from numerical analysis

Table 13 Ultimate load of infilled frames experiment and prediction (Ref. 24)

Series frames	Experimental. Ult load Pu ton (I)	Prediction			$\frac{Pu_1}{Pu}$	$\frac{Pu_2}{Pu}$	$\frac{Pu_3}{Pu}$
		Proposed Pu_1	Holme's Pu_2	Smith Pu_3			
FWW2	14.40	28.5	23.72	18.18	1.97	1.64	1.26
FWW3	14.59	33.92	29.52	23.27	2.32	2.02	1.59
FWW4	8.72	20.81	17.74	12.91	2.38	2.03	1.47

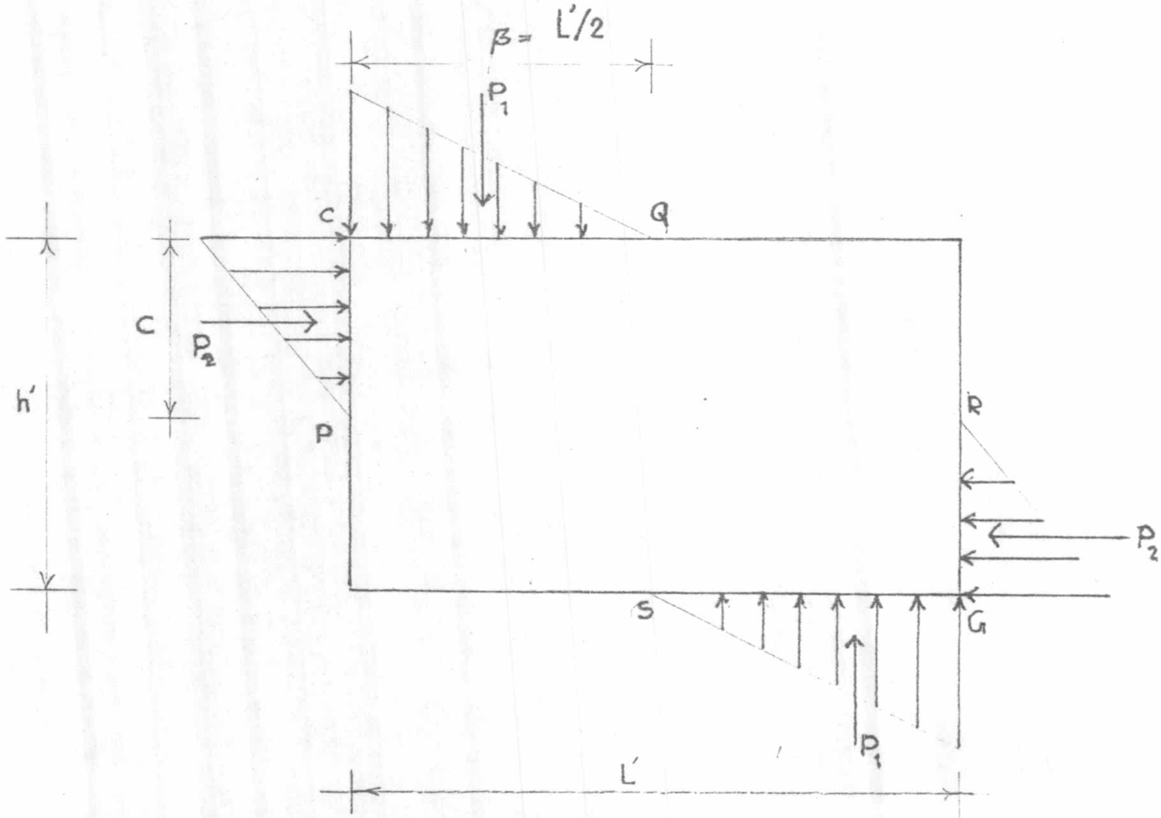


Fig. 1 Assumed load distribution on typical infill

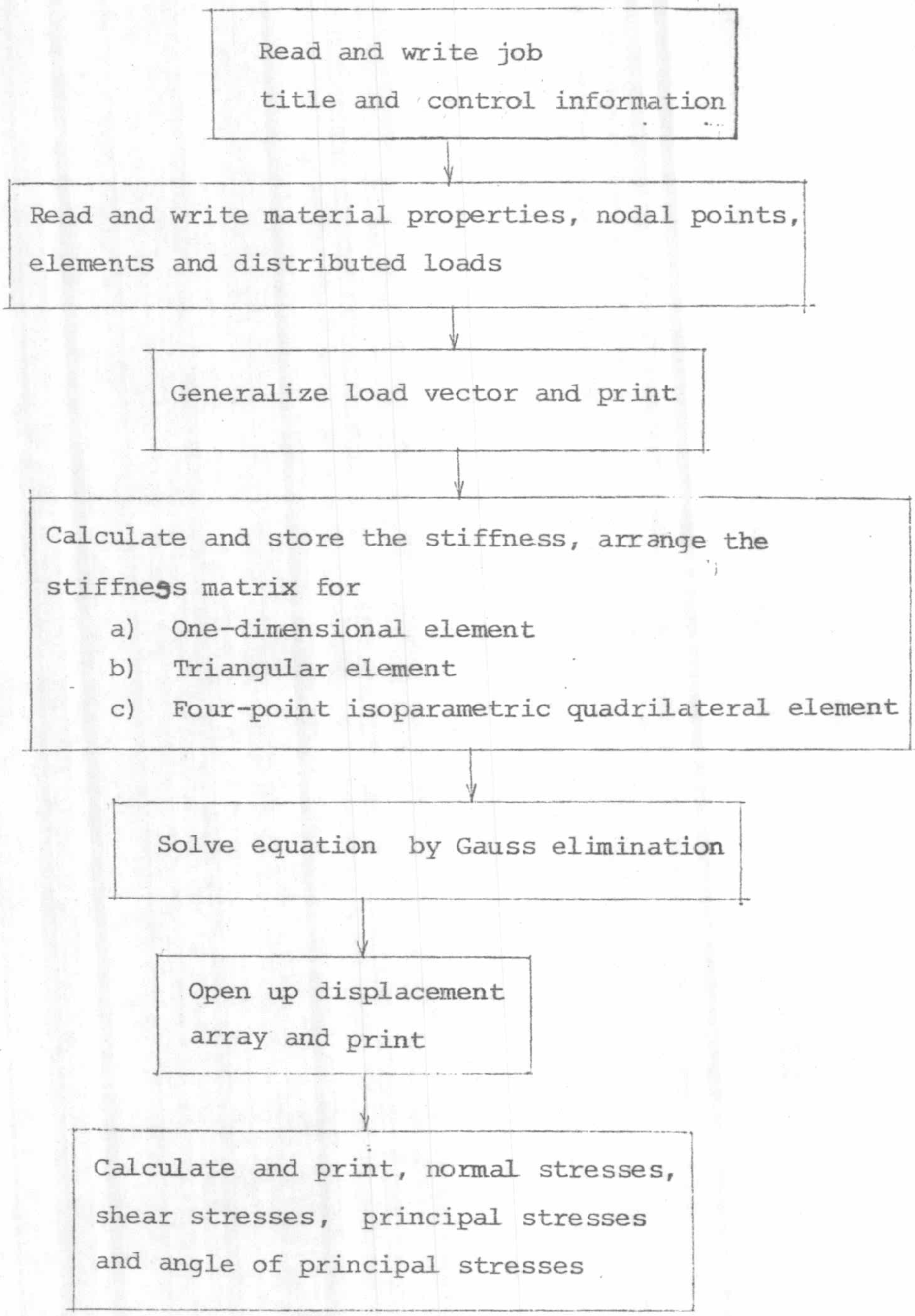


Fig. 2 Calculation procedure for program "PLSTR"

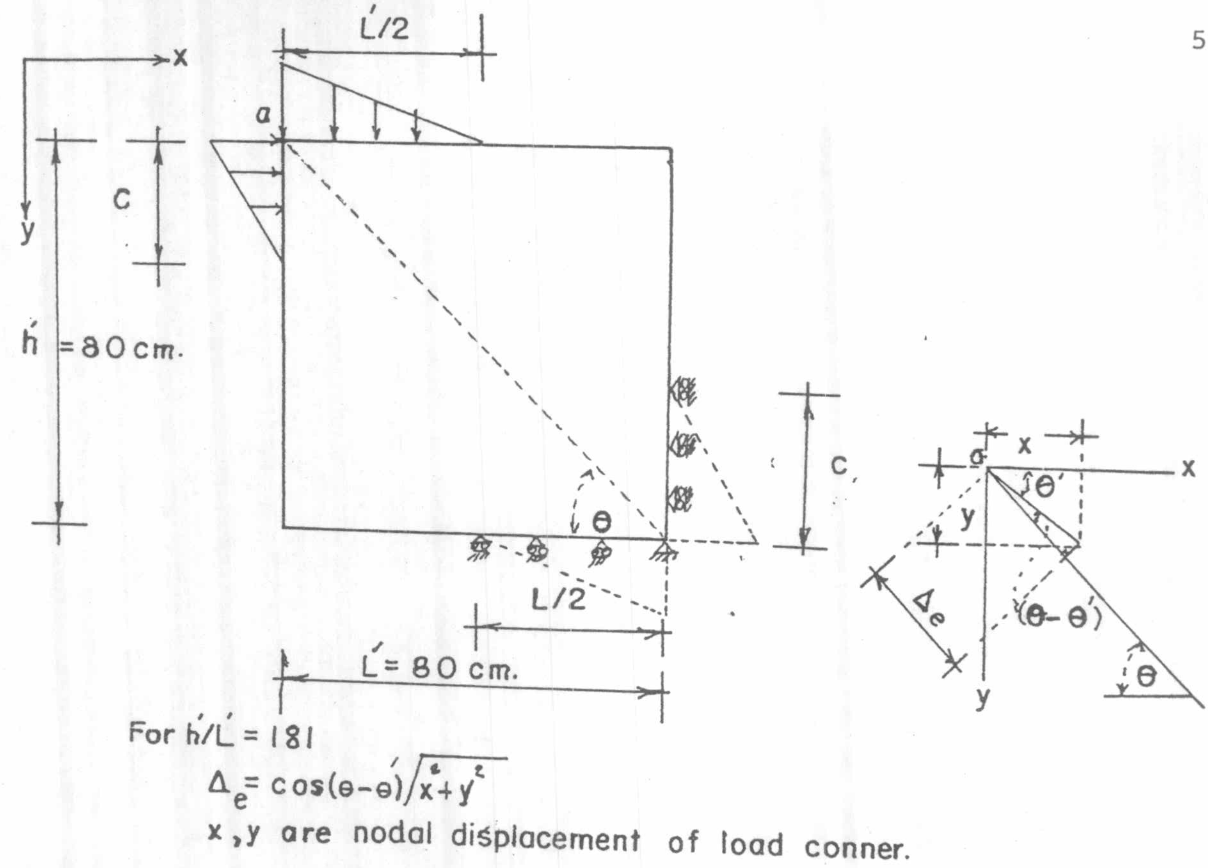


Fig. 3 Boundary condition of an infill for L'/h' = 1.0

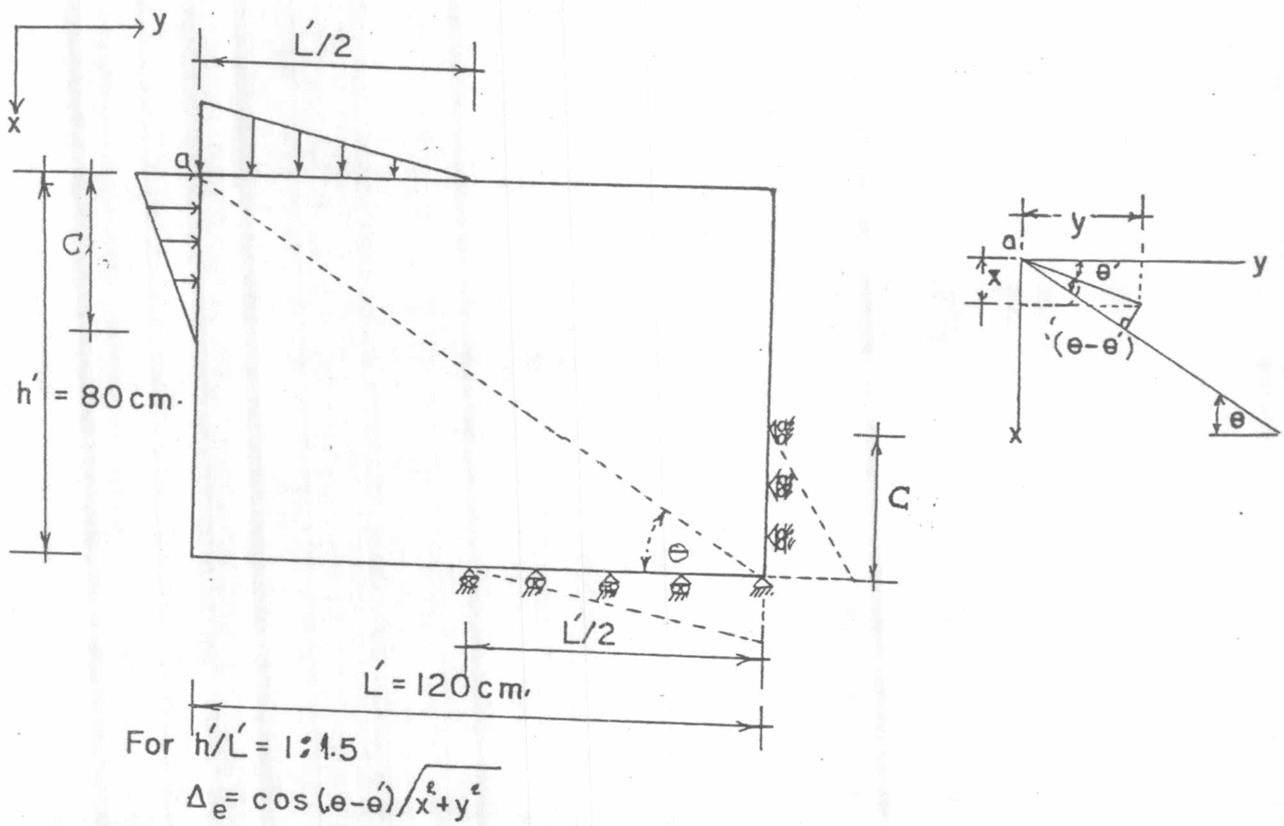


Fig. 4 Boundary condition of an infilled for L'/h' = 1.5

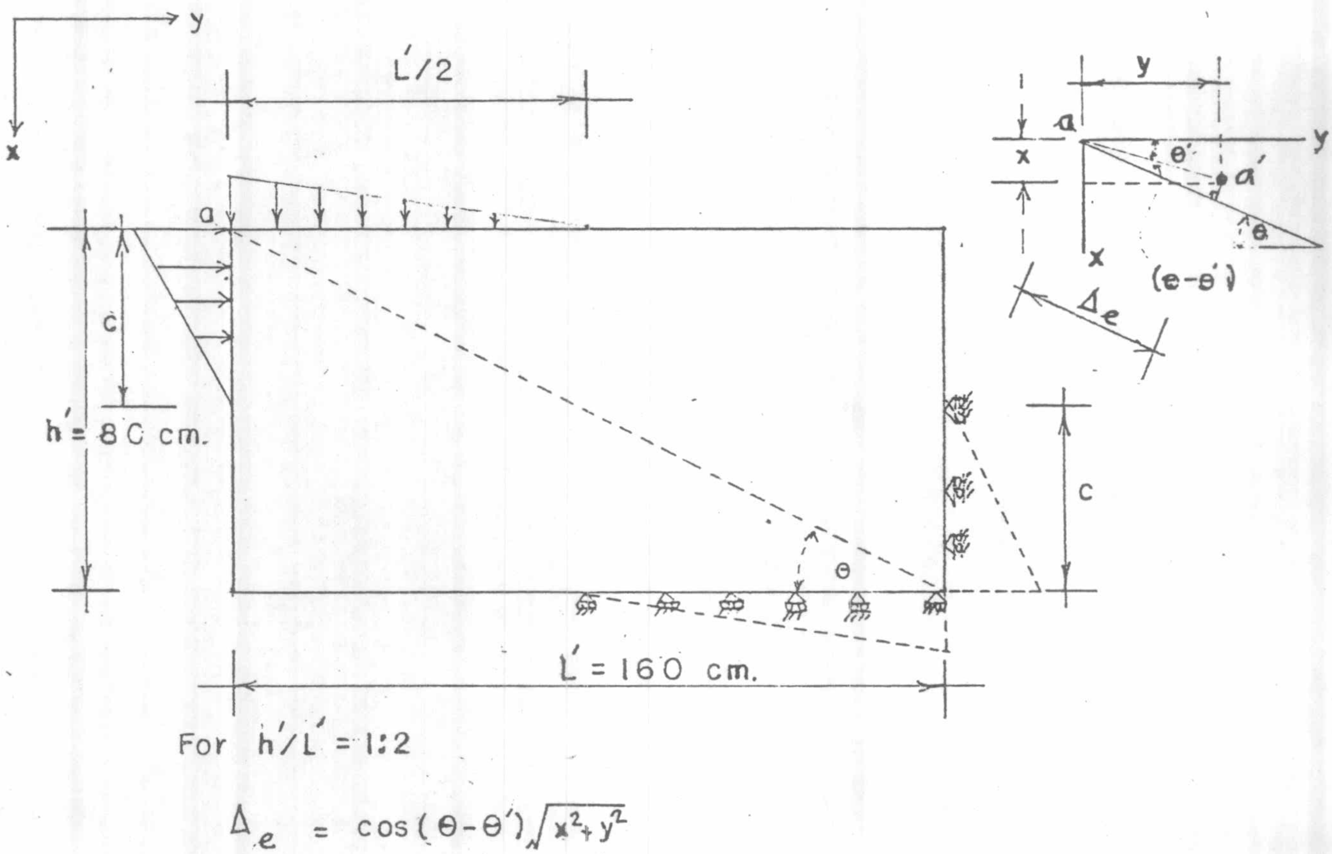


Fig. 5 Boundary condition of an infilled for L'/h' = 2.0

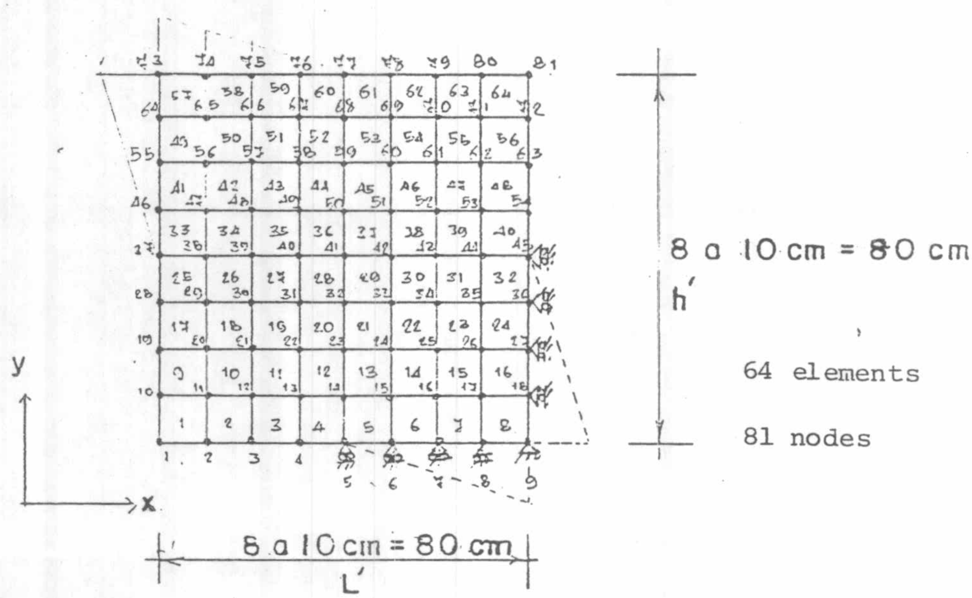


Fig. 6 Element and node number of mesh infill for L'/h' = 1.0

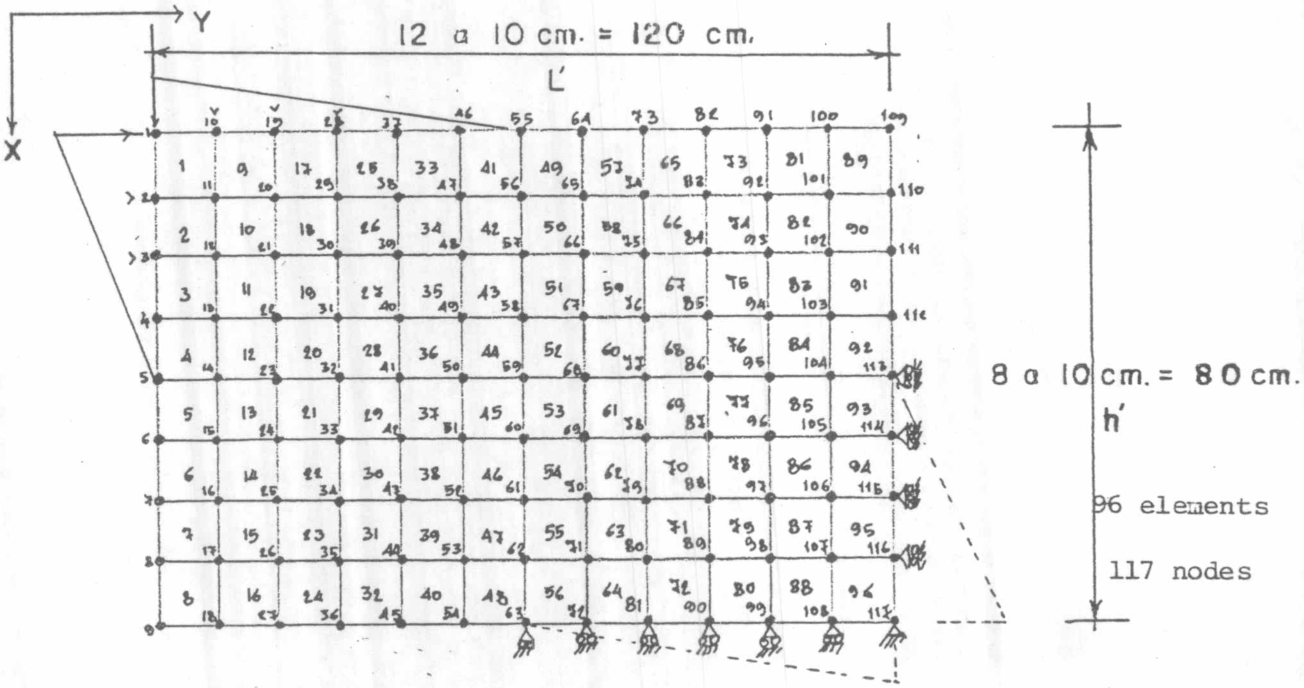


Fig. 7 Element and node number of mesh infill for L'/h' = 1.5

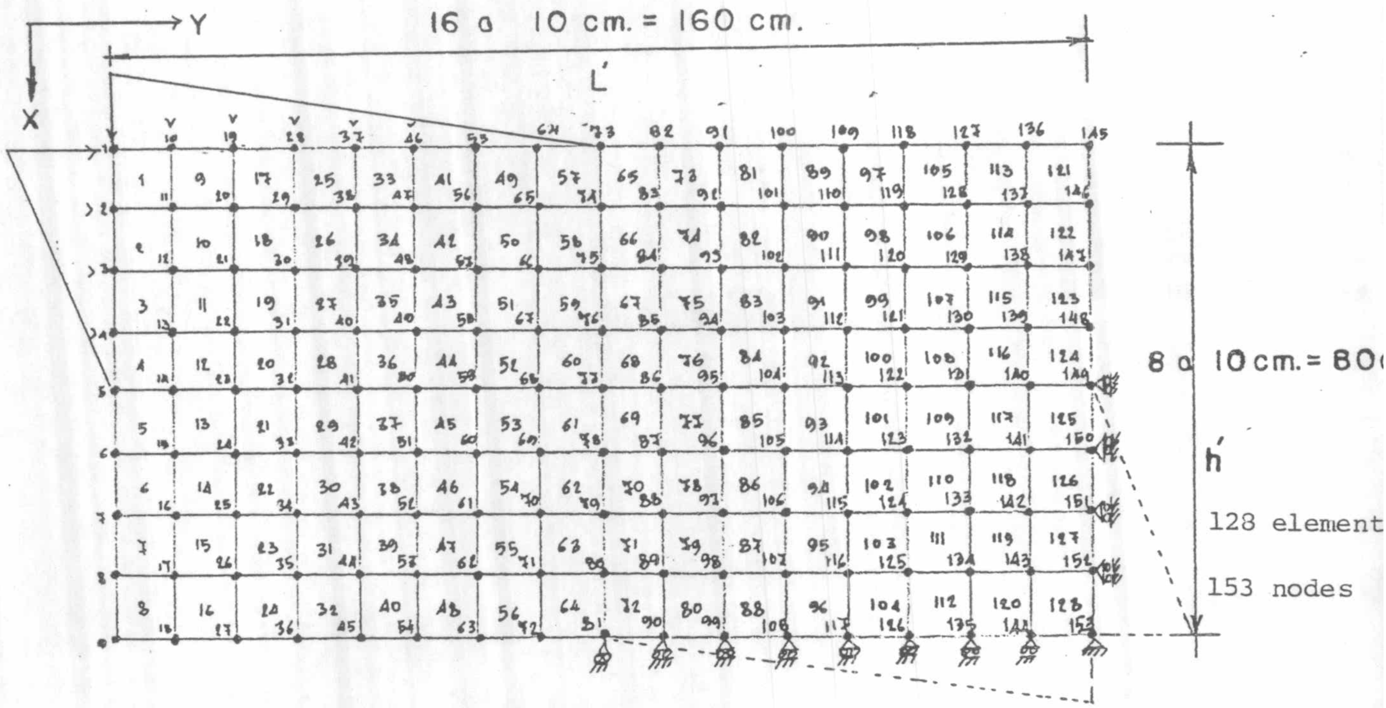
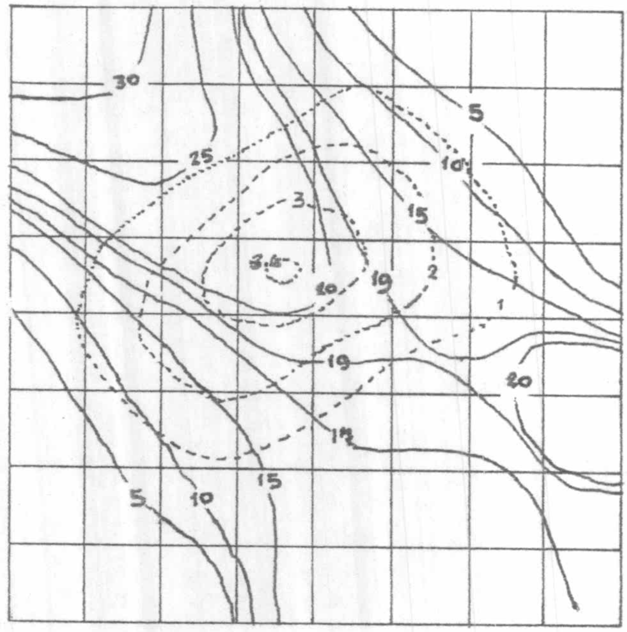
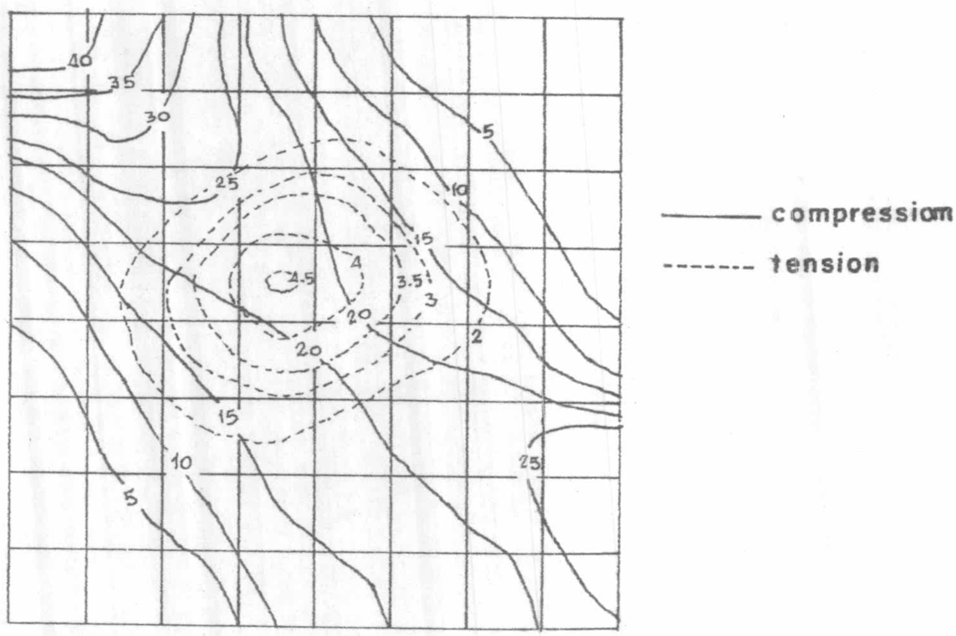


Fig. 8 Element and node number of mesh infill for L'/h' = 2.0

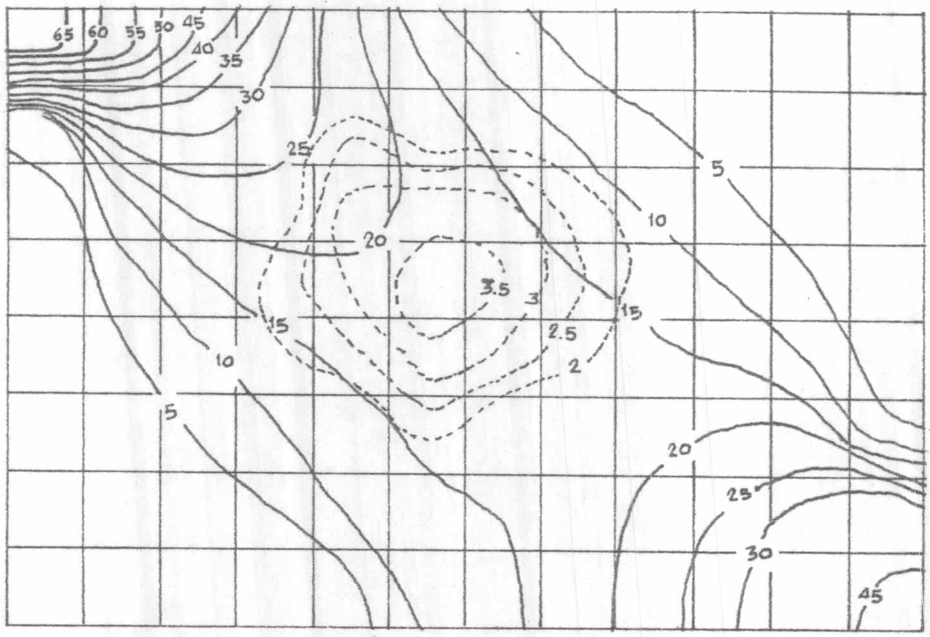


L'/h' = 1.0   c/h' = 3/8

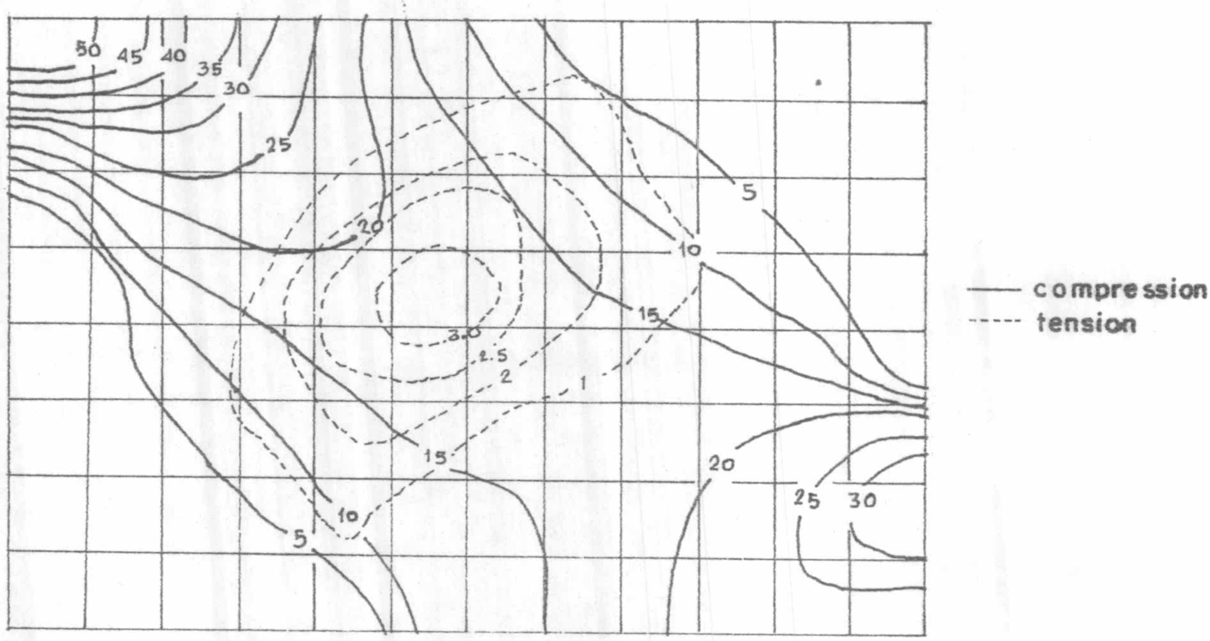


L'/h' = 1.0   c/h' = 1/4

Fig. 9 Contour of principal stress for L'/h' = 1.0

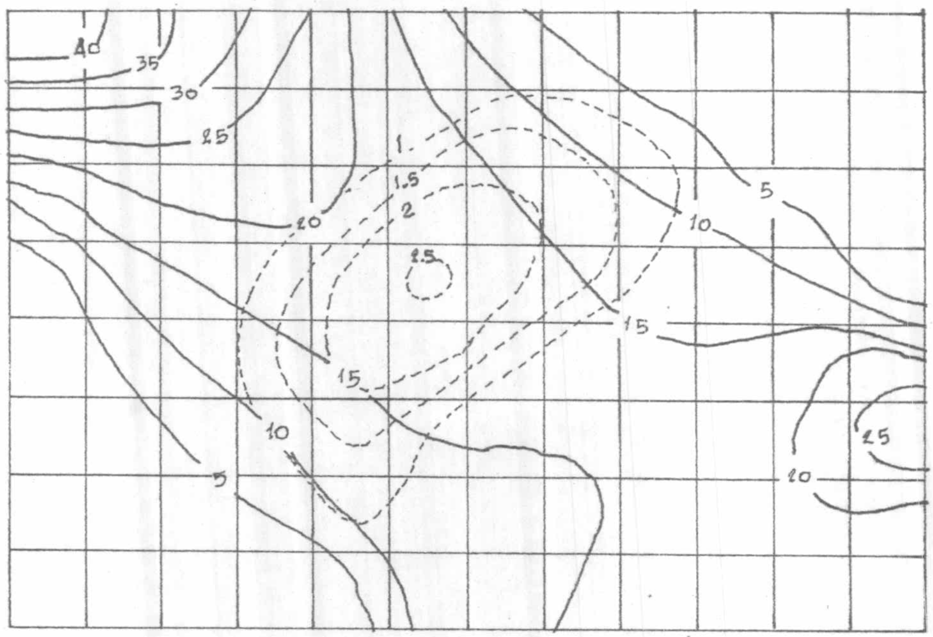


L'/h' = 1.5 C/h' = 1/8

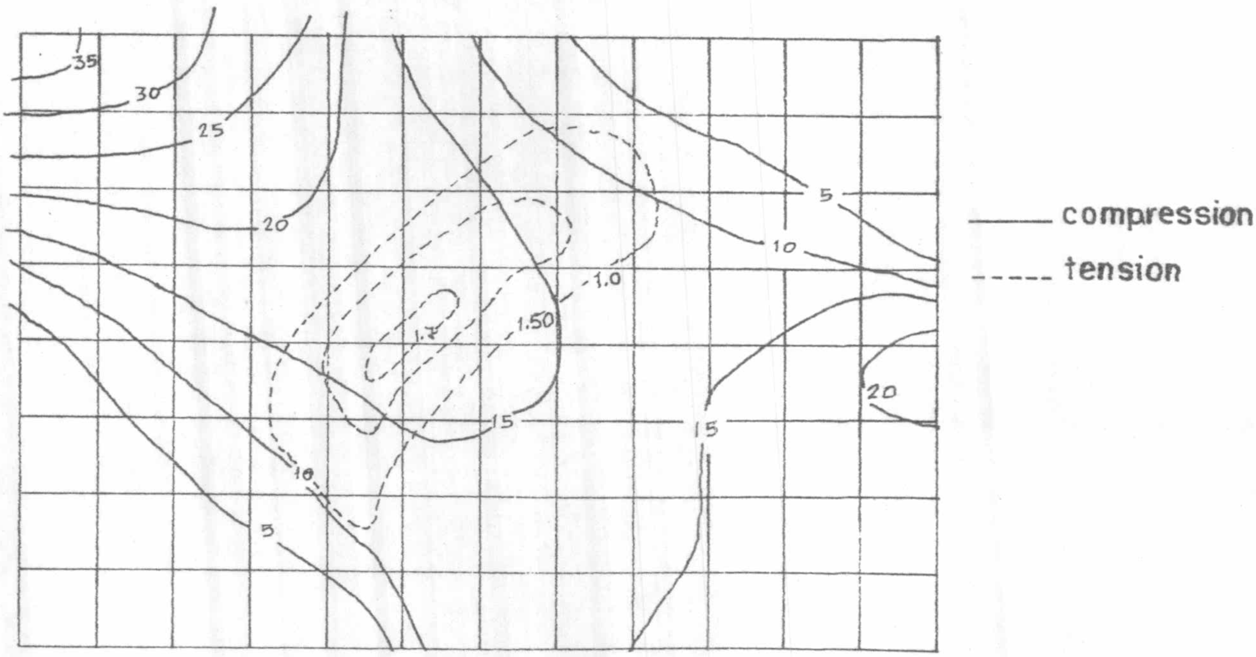


L'/h' = 1.5 C/h' = 1/4

Fig. 10 Contour of principal stress for L'/h' = 1.5

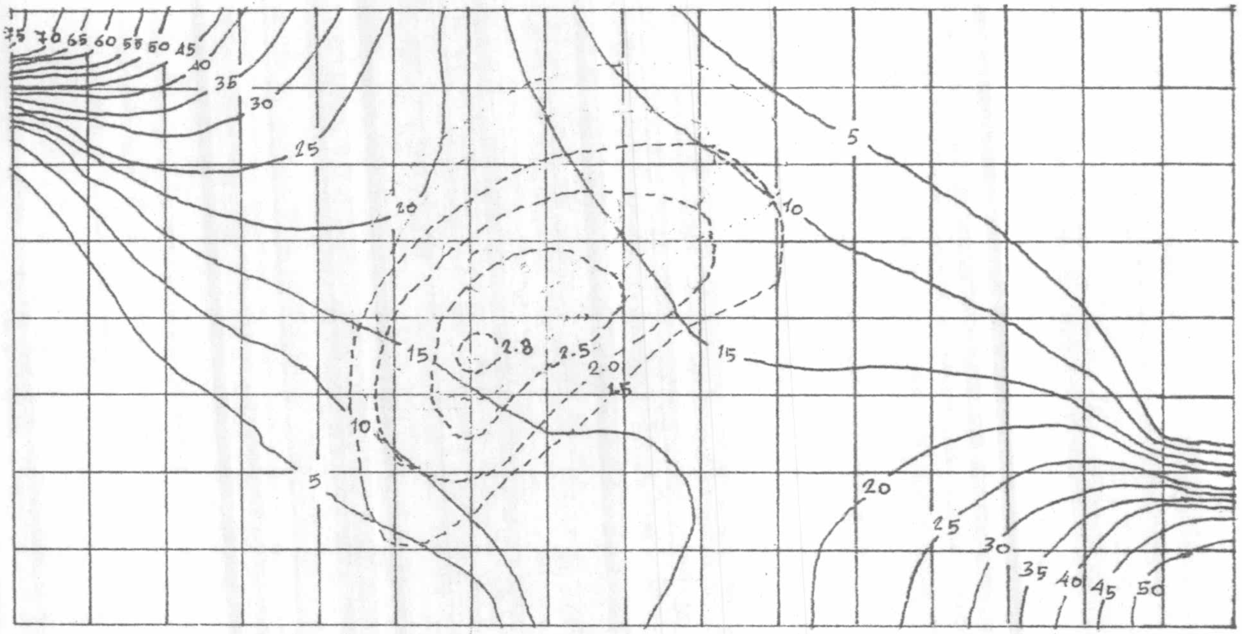


L'/h' = 1.5 , c/h' = 3/8



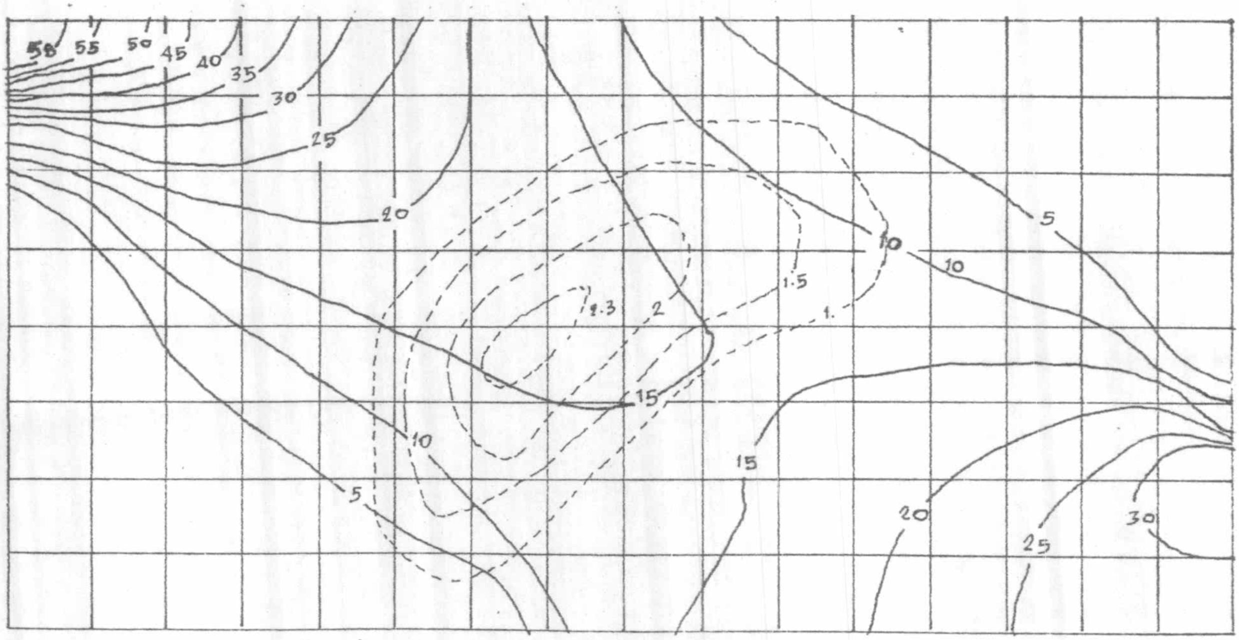
L'/h' = 1.5 , c/h' = 1/2

Fig. 10 (cont.) Contour of principal stress for L'/h' = 1.5



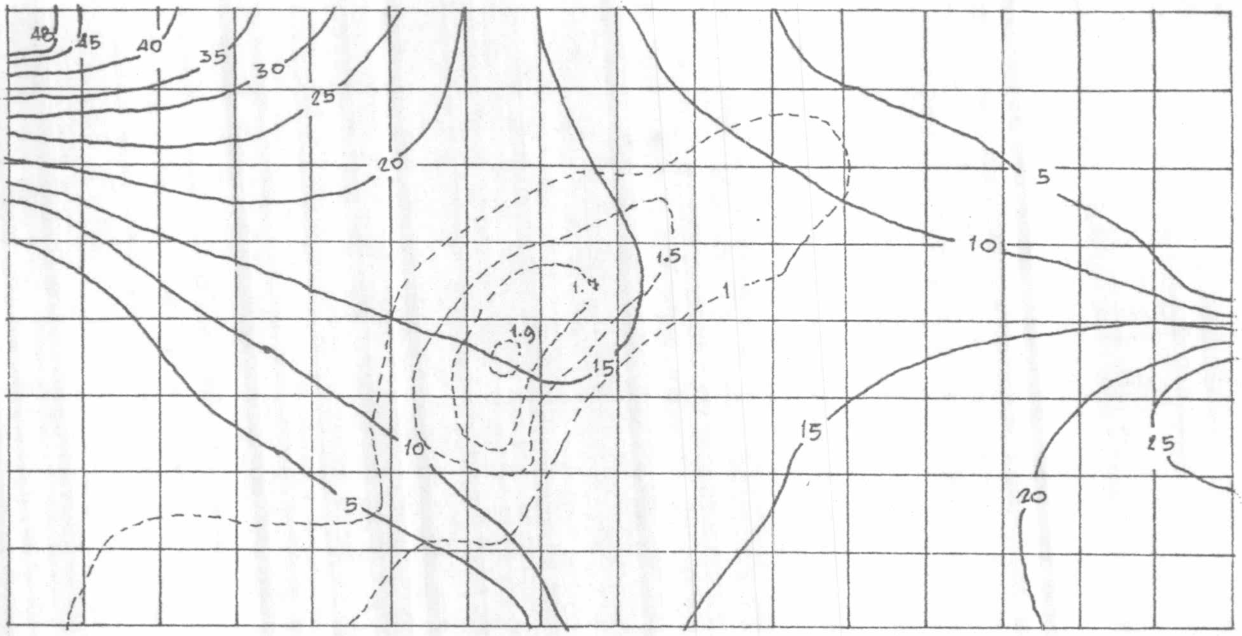
L'/h' = 2.0 , c/h' = 1/8

compression
------ tension



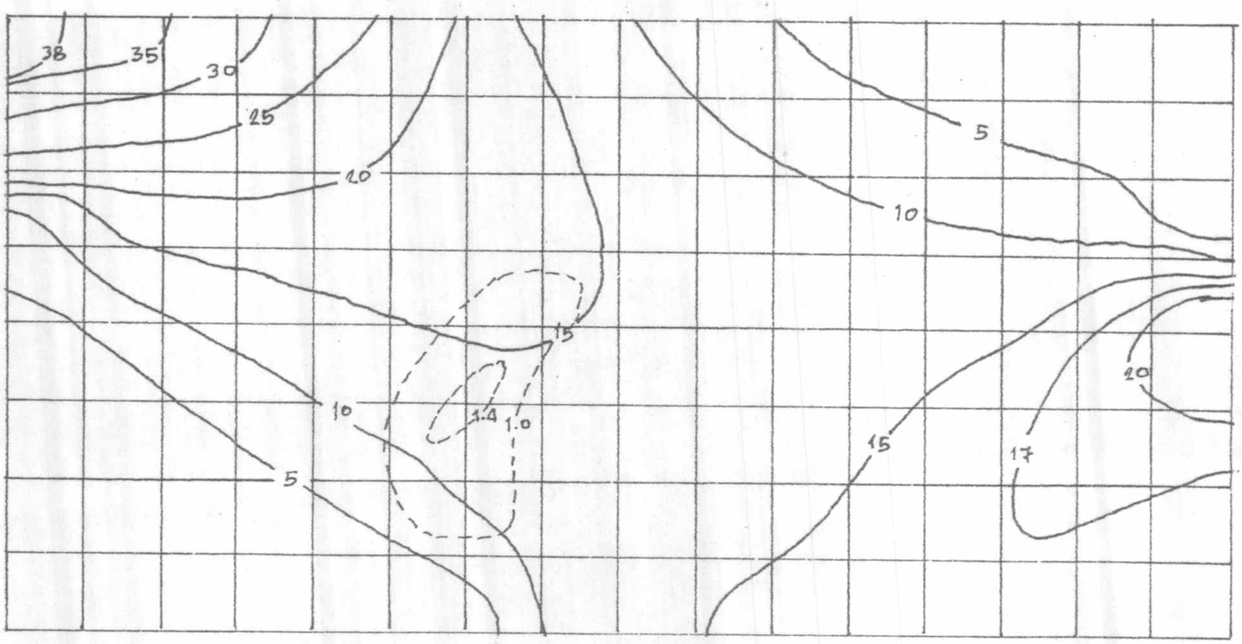
L'/h' = 2.0 c/h' = 1/4

Fig. 11 Contour of principal stress. L'/h' = 2.0



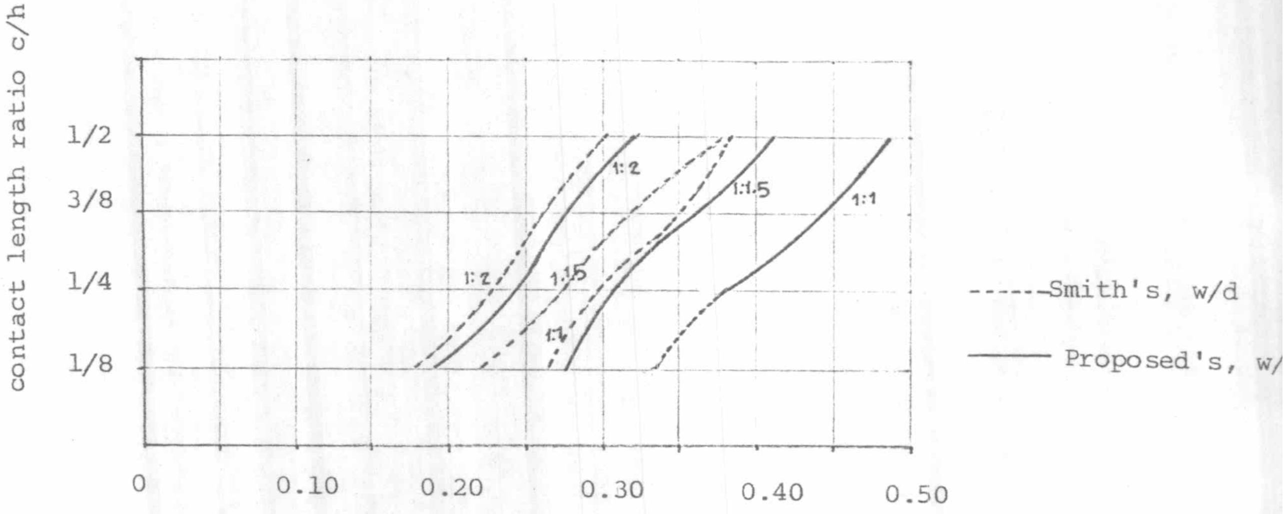
L′/h′ = 2.0 , c/h′ = 3/8

——— compression
- - - - - tension



L′/h′ = 2.0 , c/h′ = 1/2

Fig. 11 (cont.) Contour of principal stress for L′/h′ = 2.0



Effective Width as a function of contact length

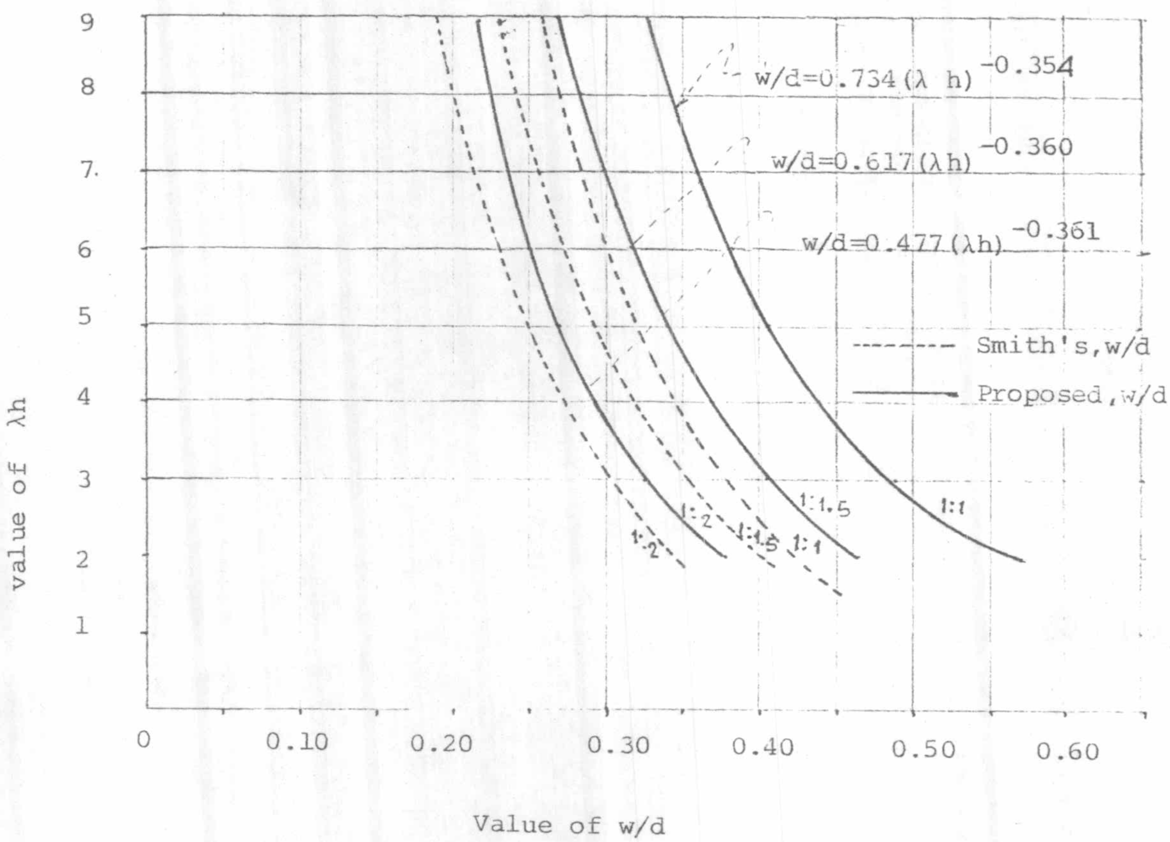


Fig.12 Effective Width as function of λh

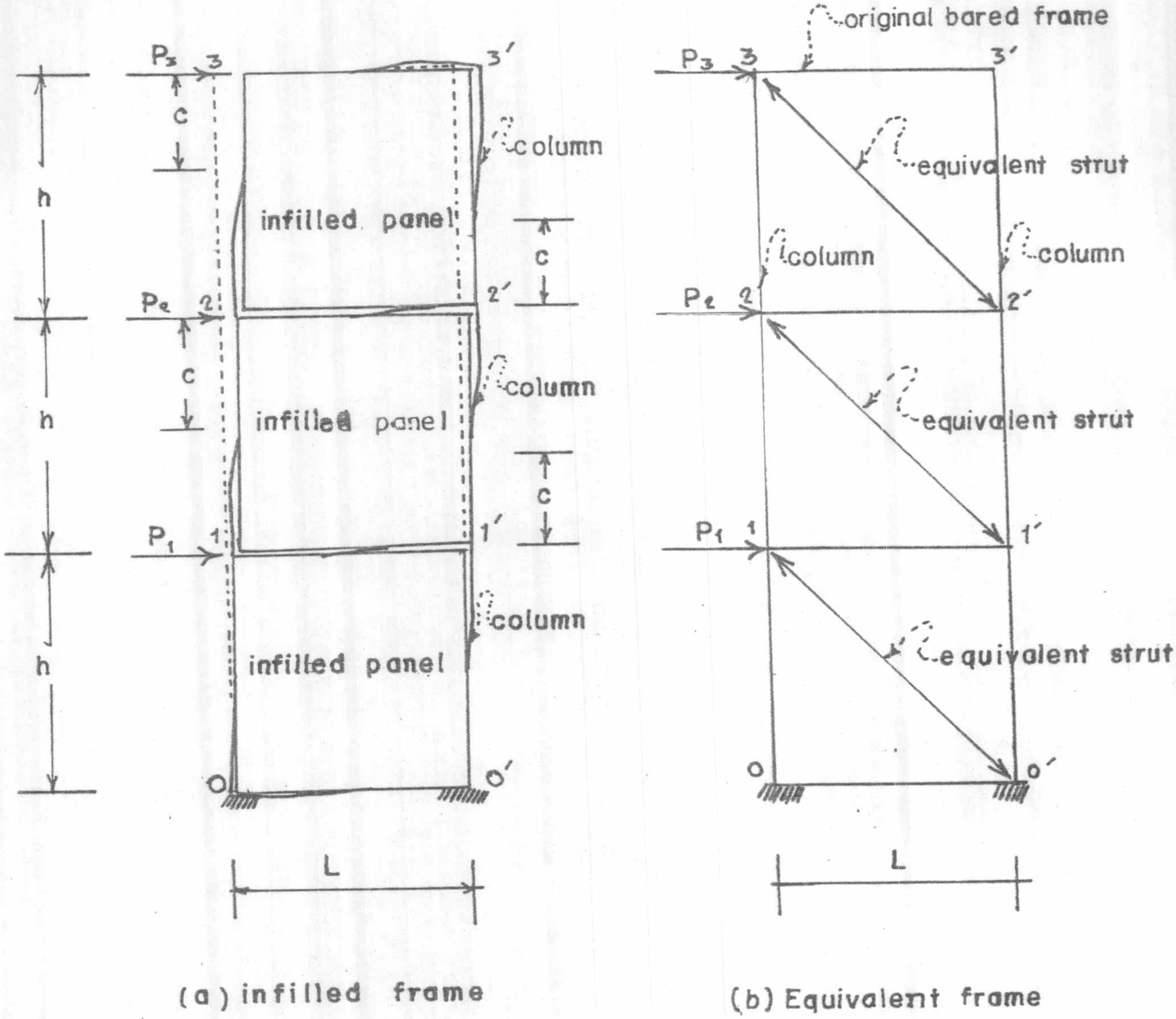
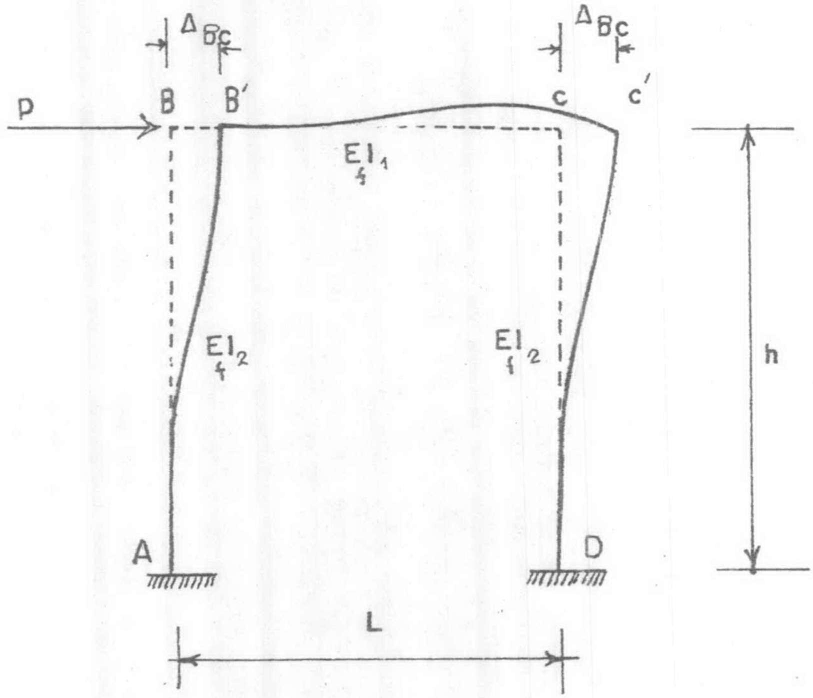
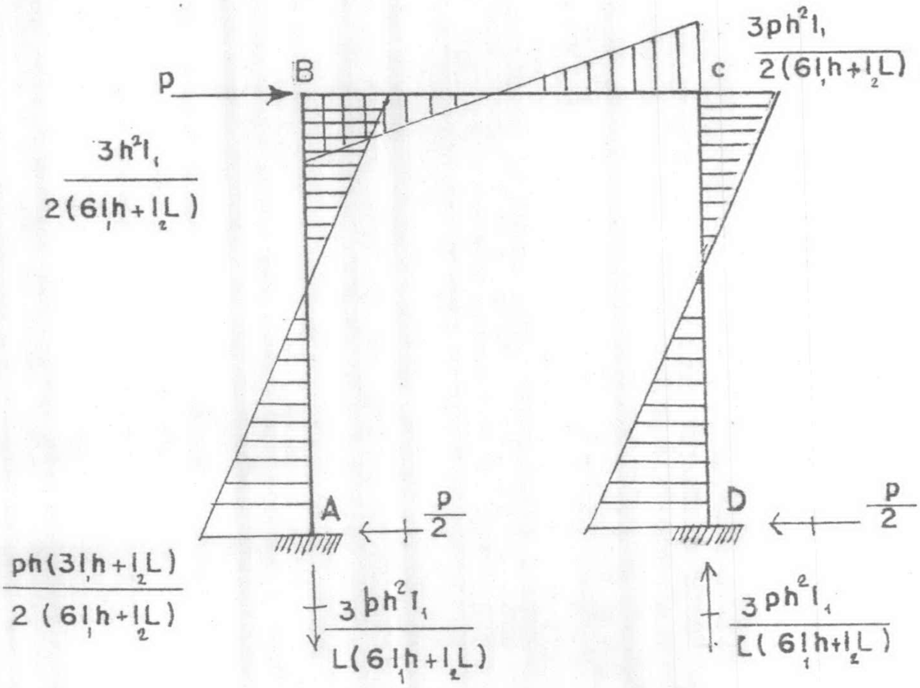


Fig. 13 The infilled frame and the equivalent diagonal strut analogy



(a) Elastic Curve



(b) Raction

Fig.14 Elastic curve and reactions of portal frame

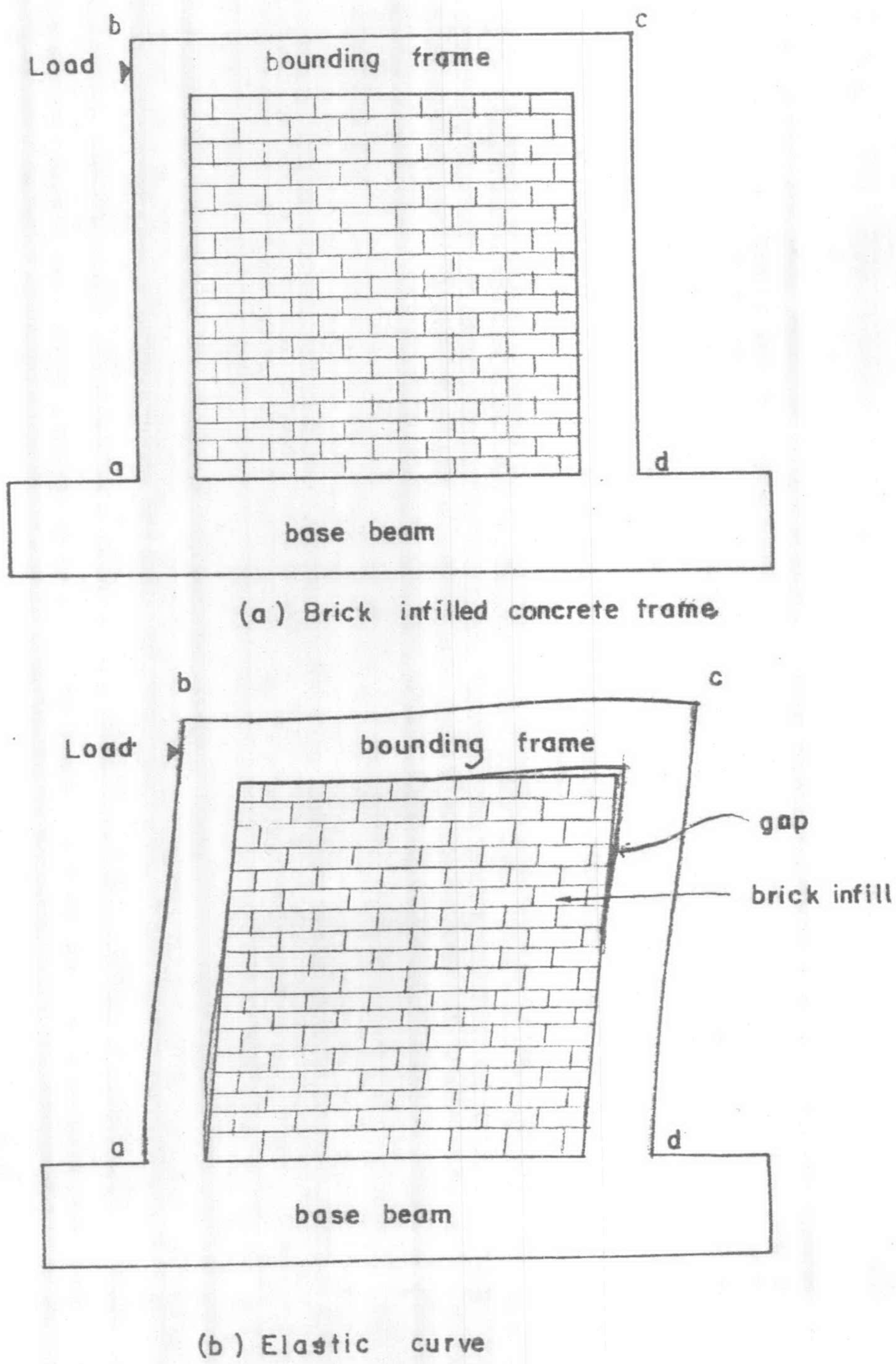


Fig.15 Brick infilled concrete frame and elastic curve

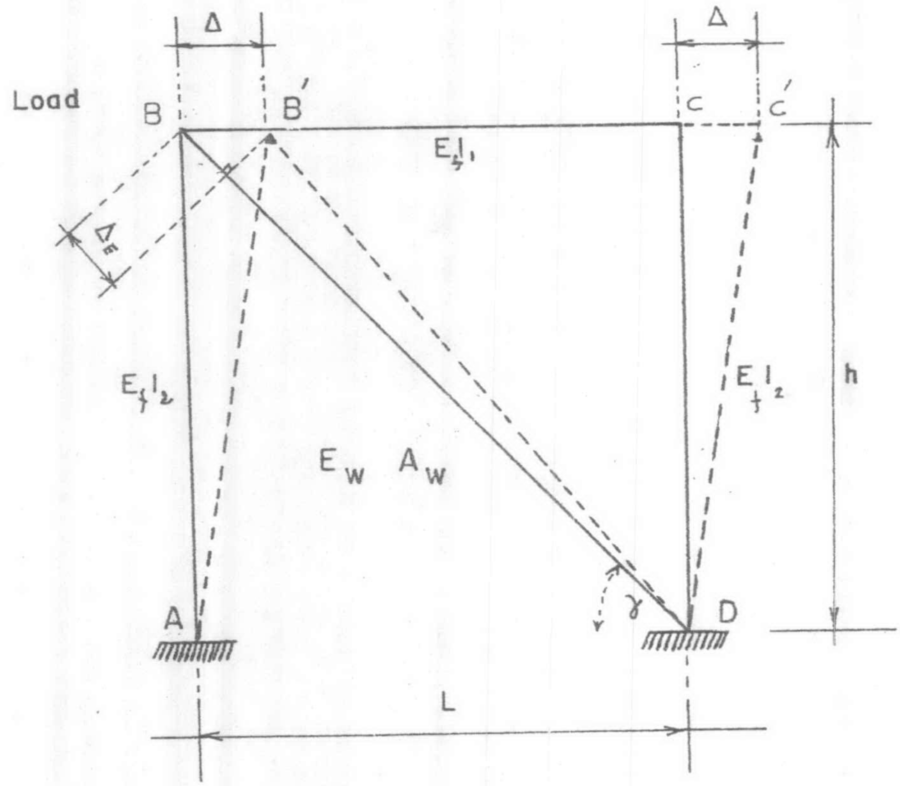


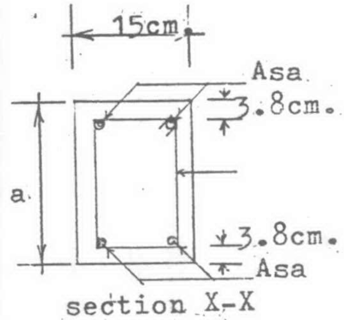
Fig. 16 Equivalent structure

Appendix A

Experiment Data

Ref. (2, 24)

Frame	L' cm.	a cm.	b cm.	Asa	Asb
FWW2A FWW2B	150 60"	22.8 9"	22.8 9"	2¢12mm. 2¢15mm.	2¢12mm. 1¢15mm.
FWW3A FWW3B	225 60"	26.67, 10.5"	22.8 9"	2¢12mm. 2¢15mm.	2¢12mm. 1¢15mm.
FWW4C1 FWW4C2	150 60"	15 6"	15 6"	2¢12mm.	2¢12mm.



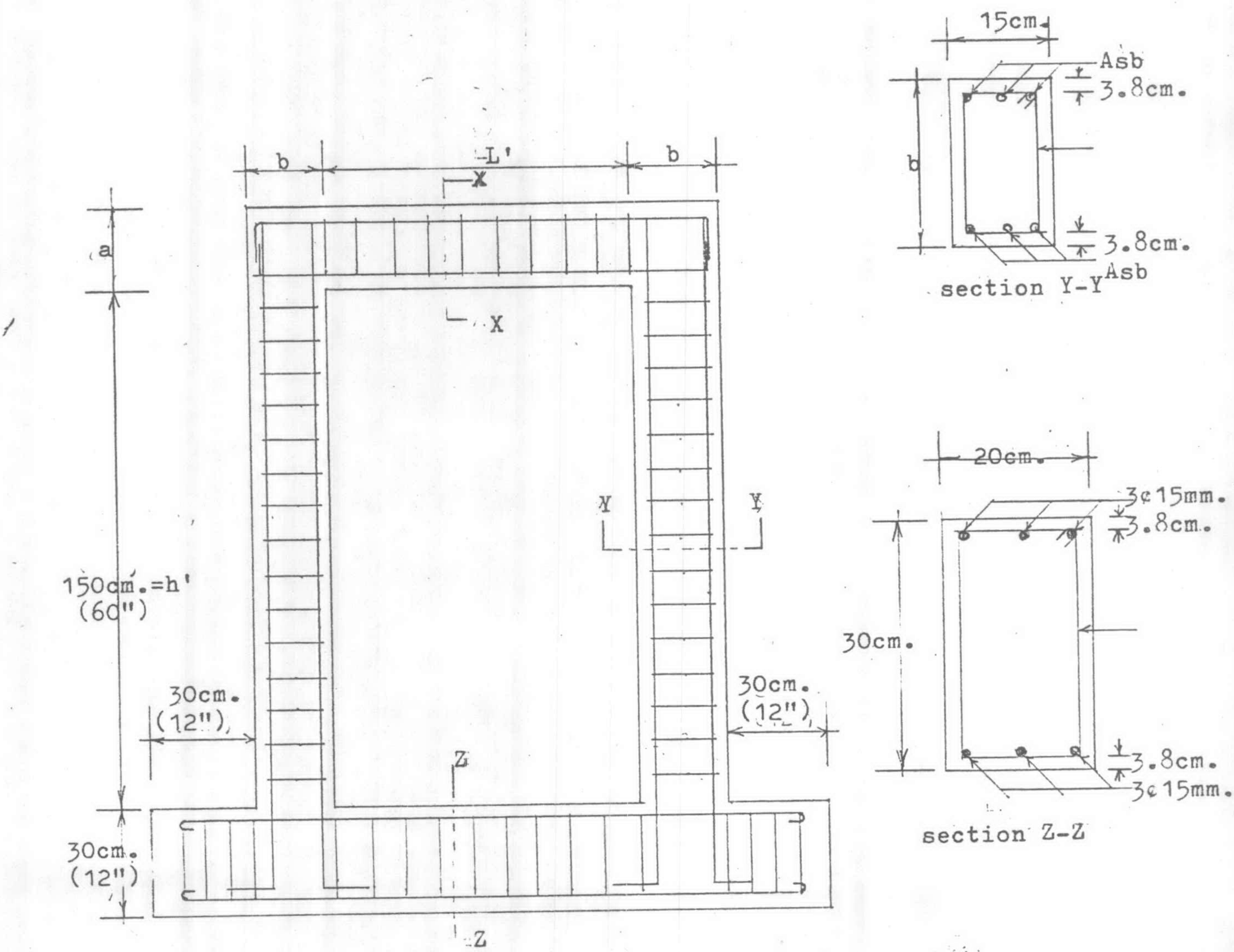


Fig. A-1 Details of reinforcement of tested frames, (Ref. 24)

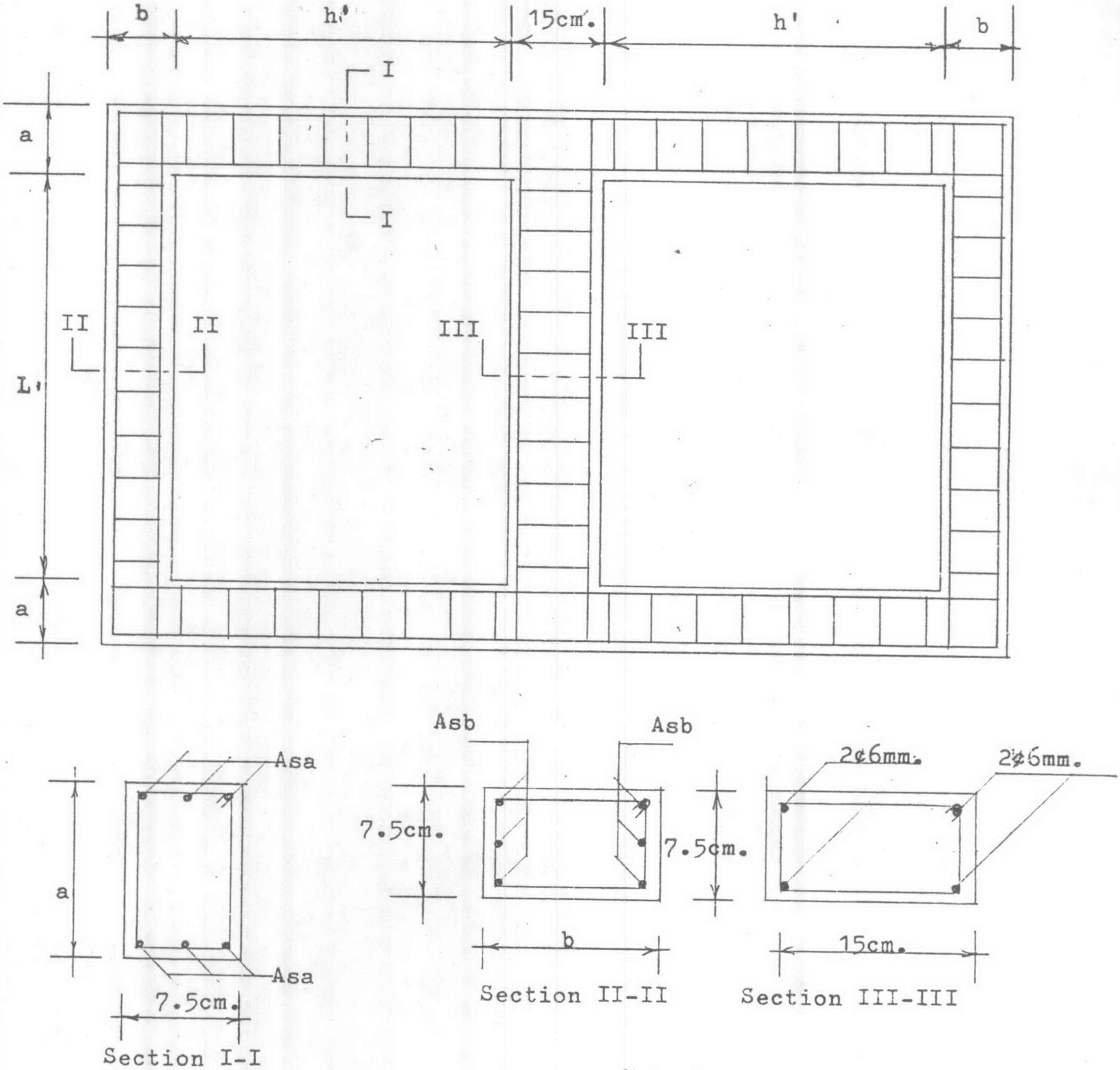


Fig. A-2 Details of reinforcement of tested frame (Ref. 2)

Table A-1 Dimensions and reinforcing steel of tested frame (Ref. 24)

Frame	L' cm.	h' cm.	L'/h' cm./cm/	Column section cm.xcm.	Girder section cm.xcm.	Column steel	Girder steel	Infilling	Remark
FWW2A	150	150	1.0	15x22.8	15x20	2ϕ12 mm.	2-ϕ15mm.	mon brick	
FWW2B	(60")	(60")		(6"x9")	(6"x8")	1ϕ15 mm.			
FWW3A	225	150	1.5	15x22.8	15x26.67	2ϕ12 mm.	2ϕ15 mm.	mon brick	
FWW3B	(90")	(60")		(6"x9")	(6"x10.5")	1ϕ15 mm.	1ϕ12 mm.		
FWW4C1	150	150	1.0	15x15	15x15	2ϕ12 mm.	2ϕ12 mm.	mon brick	
FWW4C2	(60")	(60")		(6"x6")	(6"x6")				

L' = width of the infill

h' = height of the infill

Table A-2 Physical Properties of Mon Bricks (Ref. 24)

Series		Initial Absorption %	Compression Strength kg/cm^2	Modulus of Rupture kg/cm^2	24-Hour Absorption %	Weight kg.	Nominal Size cm.x cm.xcm.
A	Average	12.5	109.68	12.23	22.11	0.59	3x6.7x16.76
	High	13.5	112.49	15.04	23.20	0.50	(1.2"x2.6"x6.6")
FWW2A, FWW3A	Low	10.5	83.31	5.97	19.8	0.65	
	Range as a % of average	24%	26.60%	74.0%	15.4%	26.9%	
B	Average	14.8	102.01	11.81	26.5	0.56	3x6.7x16.76
FWW2B, FWW3B	High	16.5	119.52	13.71	27.8	0.54	(1.2"x2.6"x6.6)
	Low	12.2	79.09	6.89	23.5	0.69	
	Range as a% of average	29.0%	41.4%	57.0%	16.2%	24.8%	
C	Average	11.4	134.15	12.16	21.4	0.65	3x6.7x16.76
	High	12.5	154.68	15.11	22.4	0.55	(1.2"x2.6"x6.6")
FWW4C1, FWW4C2	Low	10.0	125.15	8.50	20.1	0.70	
	Range as a% of average	22.0%	22.0%	71.5%	10.7%	23.1%	

Table A-3 Properties of Test Frames (Ref. 24).

Frame	concrete		Longitudinal reinforcement					
	Unit weight ton/m^3.	28-day cylinder strength kg/cm^2	Bar Size	Yield Pt. ton/cm^2	Modulus of elasticity ton/cm^2	Bar Size	Yield point ton/cm^2	Modulus of elasticity ton/cm^2
FWW2A	2.25	235.53	⌀ 12 mm.	2.99	1898	⌀ 15 mm.	2.84	2179
FWW2B	2.33	242.56	⌀ 12 mm.	2.62	1824	⌀ 15 mm.	2.98	2025
FWW3A	2.38	244.56	⌀ 12 mm.	2.91	1982	⌀ 15 mm.	2.93	2390
FWW3B	2.25	247.49	⌀ 12 mm.	2.45	1821	⌀ 15 mm.	2.98	2109
FWW4C1	2.22	242.59	⌀ 12 mm.	2.59	2200			
FWW4C2	2.43	272.09	⌀ 12 mm.	2.62	2186	⌀ 15 mm.	3.02	2095

Table A-4 Mechanical properties of brick panels (Ref. 24)

Series	Frame	Weight kg.	Compressive Strenght kg./cm^2	Compressive Strain	Modulus of Elasticity ton/cm.^{2}
A	FWW2A	1.07	38.31	0.004	11.95
	FWW2A	1.15	40.99	0.006	7.73
	FWW3A	1.19	36.63	0.005	8.08
	FWW3A	1.09	32.97	0.004	12.65
Average		1.14	38.45	0.004	12.02
B	FWW2B	1.11	45.98	0.005	10.19
	FWW2B	1.17	45.70	0.003	14.06
	FWW3B	1.18	45.98	0.004	10.89
	FWW3B	1.15	44.29	0.006	8.78
Average		1.11	43.87	0.004	11.39
C	FWW4C1	1.11	37.12	0.006	7.03
	FWW4C1	1.18	44.99	0.005	8.43
	FWW4C2	1.26	47.81	0.007	7.59
	FWW4C2	1.05	36.27	0.007	5.48
Average		1.15	41.55	0.006	7.05

Table A-5 Test Results of Infilled Frames (Ref. 24)

Series	Frame	Pu (Ultimate Load) ton	Stiffness ton/cm.
A	FWW2A	14.0	36.43
	FWW3A	15.54	37.50
B	FWW2B	14.81	35.72
	FWW3B	13.63	32.14
C	FWW4C1	8.5	17.86
	FWW4C2	9.0	9.82

Table A-6 Data of Experimental Models (Ref. 2)

	FW1A	FW2A	FW1B	FW2B	FW1C	FW2C
L(cm)	86.36	86.36	124.46	124.46	162.56	162.56
h(cm	81.28	81.28	81.28	81.28	82.50	82.50
E_f(kg/cm^2)	307000	302000	339500	311000	242500	351000
t_f(cm)	7.62	7.62	7.62	7.62	7.62	7.62
a(cm)	10.16	10.16	10.16	10.16	10.16	10.16
b(cm)	10.16	10.16	10.16	10.16	12.70	12.70
u_f	.21	.19	.27	.19	.18	.33
E_w(kg/cm^2)	95000		87050		112500	
t_w(cm)	3.81		3.81		3.81	
L'(cm)	76.20		114.30		152.40	
h'(cm)	76.20		76.20		76.20	
u_w	.18		.17		.30	

Table A-7 Comparision of Stiffness (ton/cm) (2.) (Ref. 2)

series	$\frac{L}{h}$	$\frac{L'}{h'}$	Experimental	Theoretical Finite Element	$\frac{\text{Thrtcl}}{\text{Exptl}}$
FW1A	1.06	1.00	41.00	129.80	3.170
FW2A			7.50	12.41	1.655
FW1B	1.53	1.50	61.00	167.57	2.747
FW2B			7.75	12.78	1.649
FW1C	1.97	2.00	103.00	195.51	1.898
FW2C			6.80	15.04	2.265

Table A-8 Dimensions and Reinforcements of test frames (Re.f 2)

Frame	$\frac{L'}{h'}$	h'(cm)	a(cm)	b(cm)	L'(cm)	x(cm)	A_{sa}	A_{sb}
FW1A FW2A	1.00	76.2	10	10	76.2	5	3⌀6 mm.	3⌀6 mm.
FW1B FW2B	1.50	76.2	10	10	114.3	5	3⌀6 mm.	3⌀6 mm.
FW1C FW2C	2.00	76.2	10	12.7	152.4	5	3⌀6 mm.	3⌀6 mm.