significant enough to show up the limitation of this relatively simple elastic analysis.

COMPARISON WITH ESTIMATES OF EFFECTIVE WIDTH

Based on the analyses of Khan and Sbarounis (1), Sharan(7) and Allen and Darvall (8) the relevant effective widths for Models 1 and 3 have been calculated and these are presented in Table 3. It is evident that all of these methods and the recommendations of ACI(1971) (3) and CP110 (2) overestimate the proportion of the slab width which is effective and some by substantial amounts. The design charts of Khan and Sbarounis (1) which probably have been widely used in practice would appear to give the best correlation for these two models.

The main reason for the differences which exist between test and theory would appear to be that circumferential cracks around the column significantly reduce the stiffness of the connection in the model tests. One other possible cause which is not taken account of in any of the above analyses is the influence of gravity loading.

To determine whether it was the extent of cracking caused by gravity loading or the magnitude of this loading which was causing this reduced stiffness one additional test was carried out on Model 3. This involved the reapplication of the lateral loading after the gravity loading had been increased to DL + LL. The resulting load deflection curve given in Fig. 5 would suggest that the level of gravity loading does not significantly influence the lateral stiffness.

One other suggested approach which would appear to have some logic is to reduce the slab stiffness for lateral loading analysis in the same proportion as the column stiffness is reduced for gravity loading analysis. Thus corresponding to the dimensions of the slab column connections in the models the reduction factors were calculated using the recommended procedure in ACI318-71(3) and the values of the reduced effective widths are included under the heading "INVERSE" in Table 3. It is evident from the trend of results that this approach is not worthy of further consideration.

COMPARISON WITH OTHER TEST RESULTS

It would appear that the only other lateral load tests on reinforced concrete slabs are those reported by Beresford (11). Since slender steel columns were used the information obtained was of little value to an equivalent structure with much stiffer concrete columns. However, some relevant unpublished results have been obtained from a thesis (12) by the first author.

A number of tests were carried out on $\frac{1}{4}$ scale reinforced concrete slab-internal column models with boundary conditions similar to those of Long and Masterson(9). Different levels of gravity loading were applied in each case and then lateral loading was applied incrementally until punching failure occurred. From the initial part of the horizontal load/lateral deflection curves of these models (Fig. 8) the lateral stiffness of the system can be assessed and the corresponding effective widths calculated (Table 4).

The very low values of effective widths obtained would indicate that the extensive cracking and perhaps some localised yielding of the slab reinforcement, associated with the high gravity loading, has greatly reduced the lateral stiffness of the connection. As a consequence of this finding the effective widths predicted by existing methods may well be very optimistic if the slab at some stage in its design life is subjected to floor overload.

CONCLUSIONS AND RECOMMENDATIONS

On the basis of an examination of the limited number of test results reported in this paper the following conclusions have been reached.

(1) The use of an effective width of approximately 0.3 has been found to yield realistic estimates of the lateral stiffness of slab-column systems with $\frac{c}{L}$ values of 0.08 and 0.12.

(2) The lateral stiffness is reduced significantly by the development of cracks induced by design levels of gravity loading. As a consequence elastic plate bending finite element analyses will tend to yield optimistic estimates of effective widths.

(3) Cracking associated with gravity overloading markedly reduces the lateral stiffness of a framework.

In view of the lack of experimental data in this area and of the findings in this paper that existing analytical techniques are largely inadequate it is recommended that further tests be carried out to determine:

(1) The influence of a range of $\frac{\ell_1}{\ell_2}$ ratios.

(2) The influence of cracking caused by different levels of gravity loading.

It is essential that these tests are carried out on reinforced concrete models with realistic boundary conditions and levels of reinforcement similar to those used in engineering practice. Results from these tests could act as the basis for the formulation of a satisfactory equivalent frame model.

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Model Number	Average cylinder compressive strength psi (MPa)	Average split cylinder tensile strength psi (MPa)
1	3980 (27.4)	483 (3.33)
2	3720 (25.6)	479 (3.30)
3	3080 (21.2)	377 (2.60)

Table 1. Concrete strengths for test specimens

Model Number		1		2		3	
Column Location		Interior	Edge	Interior	Edge	Interior	Edge
Measured column moments (kN. m)		3.27	1.71	4.18	2.76	4.17	2.12
Column moments predicted by Frame Analysis (kN. m)	Effective width						
	0.25	2.83	1.34	3.56	2.54	3.36	1.96
	0.30	3.33	1.58	4.19	2.87	4.00	2.36
	0.35	3.81	1.81	4.80	3.20	4.65	2.75
	0.40	4.27	2.04	5.39	3.50	5.29	3.12
	0.50	5.15	2.48	6.50	4.11	6.55	3.87
	1.00	8.75	4.27	10.98	6.63	12.60	7.48

Table 2. Comparison of Measured and Predicted Column Moments.

Source	Column Location	Predicted Effective Width	
		Model 1	Model 3
Khan et al[1]	Internal	0.39	0.43
Pecknold[6]	Internal	0.70 (Rigid) 0.42 (Flexible)	0.90 (Rigid) 0.54 (Flexible)
Sharan[7]	Edge	0.38	0.47
	Internal	0.62	0.72
Allen and Darvall[8]	Internal	0.57	0.65
"Inverse"	Edge	0.23	0.09
	Internal	0.17	0.06

Table 3. Predicted effective widths from various sources.

Model No.	Estimated effective width	Gravity Loading Applied
3A	0.13	2.7 (LL + DL)
4A	0.17	1.8 (DL + LL)
RMC Tests	0.30	1.0 (DL + LL)

Table 4. Comparison with results obtained from Long [12]

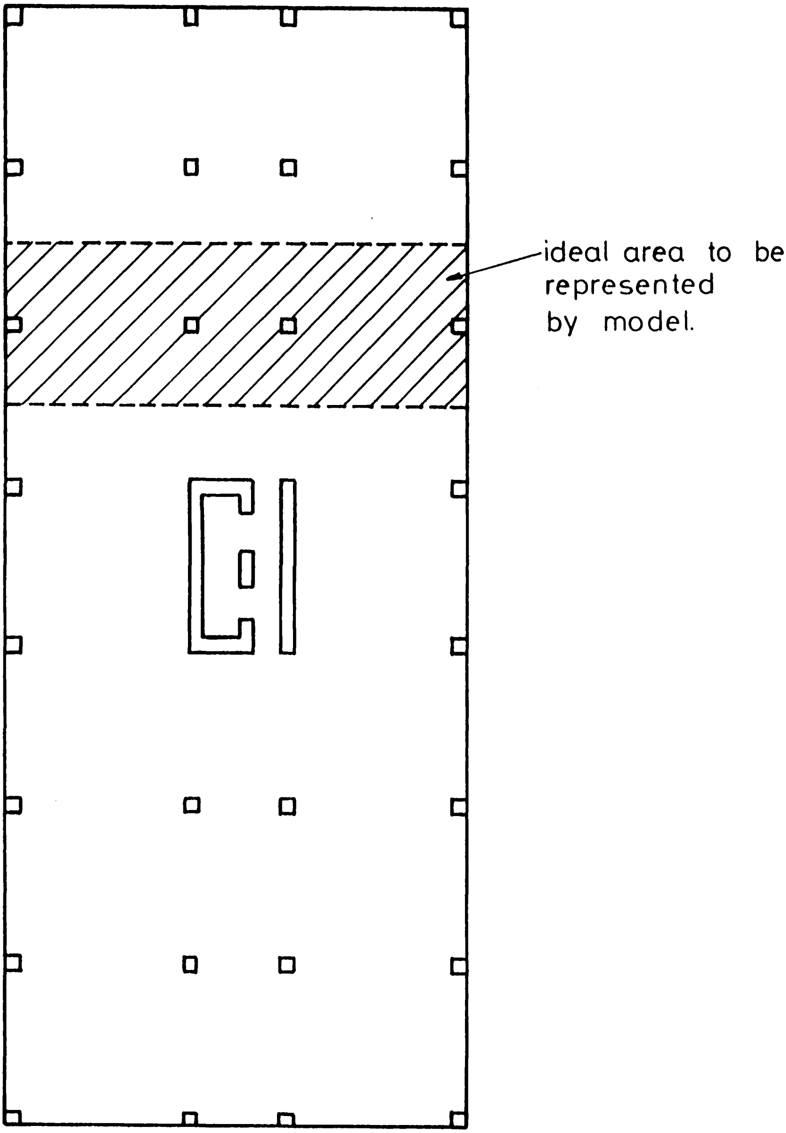

Fig. 1--Typical floor plan of a slab/column structure