THE RESPONSE OF REINFORCED CONCRETE PLATE-COLUMN ASSEMBLIES SUBJECTED TO HORIZONTAL LOADING

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SUMMARY

This paper covers experimental work done on flat reinforced concrete plate-column assemblies at the University of Illinois, Urbana. In all, nine specimens were tested, 5 statically and 4 dynamically subjected to horizontal load. This parallel testing made possible the comparison of statically with dynamically tested specimens. Other variables considered, in these approximately third scale specimens, were reinforcement ratio and vertical load. Funding was provided by the U.S. National Science Foundation.

OBJECT AND SCOPE

The main thrust of the investigation is to obtain dynamic response characteristics of reinforced concrete flat plate-column assemblies. It is intended to simulate the performance of an interior connection.

The work spans three stages: a pilot dynamic test, a series of cyclic static tests, and a series of dynamic tests.

Certain properties are common to all the specimens. Plate dimensions were not altered, and measured 1.829 m by 1.829 m. Following the philosophy of protecting the columns of a structure, the column is very rigid in comparison to the slab. The slab has a thickness of 76 mm while the column has a square cross section of 305 mm by 305 mm. Irrespective of the actual reinforcement ratio, the reinforcing was placed uniformly in both directions as well as in the top and bottom of the slab. (See Fig. 1)

DESCRIPTION OF TESTS

Static Tests. In this series the horizontal load was applied to the column stub by a hydraulic reversible jack. The load was monotonically increased in a cyclic fashion. In the first of the five assemblies tested, the reinforcement ratio was varied from .65% to .98% to 1.31%. The last two specimens of the static series both had a reinforcement ratio of .98%, but had vertically applied load that resulted in a column reaction of 1.31 kN and 28.6 kN respectively. The latter case was tantamount to a superimposed dead load by partitions and the like of about 1.92 kN/m^2 (40 lb/ft^2).

Dynamic Tests. This series was done on the University of Illinois earthquake simulator. These specimens were subjected to three types of motion: free vibrations, steady state and the NS component of the 1940 El Centro record. The three specimens were constructed with the same variation in

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reinforcement ratio as the static tests, i.e. .65%, .98%, and 1.31%. The horizontal inertial force was obtained by placing a mass on either side of the column.

OBSERVATIONS AND CONCLUSIONS

Differences Between Static and Dynamic Tests. When comparing the lightly reinforced slab tested statically, S1, with its correspondingly reinforced dynamically tested specimen, D1, no significant difference in behavior is observed. The obtained ultimate strength and stiffness of the specimens are essentially the same. However, for the two compared pairs S2 and D2, corresponding to a .98% reinforcement ratio, and S3 and D3, corresponding to a 1.31% reinforcement ratio, considerable differences are apparent. In both comparisons, the increase in strength of the dynamically tested specimens over the statically tested is in excess of 25%. A further trend is the relatively small increase in strength of specimens with a 1.31% reinforcement ratio to those with a .98% reinforcement ratio as compared to the increase from ".65%" to ".98%" specimens. (Refer to Fig. 2)

Stiffnesses. The overriding impression gained from the experiments with respect to stiffness is the relative flexibility of the specimens in comparison to other structural systems. Table 1 indicates effective width factors obtained during the dynamic tests if due consideration is given to the connection dimensions (1). Furthermore, a study of the hysteresis obtained during dynamic tests indicates that significant energy dissipation did not take place before excessive column rotations (more than 1% to 2%) were achieved. It would appear that serviceability criteria may be decisive , therefore. (See Fig. 3)

Strength. In comparing the observed specimen strengths with strengths calculated from a number of references, a large variation is clear. The various values compared are listed in Table 2, and indicate that the equivalent beam approach by Park and Islam (2) is the only method that predicts a consistently conservative strength. These strength comparisons cover the equivalent beam approach (2) and (3), the direct method assuming a linear stress distribution across the column face by the ACI (318-77) Building Code (4), and a yield line approach using parallel yield lines across the width of the plate running past the front and back faces of the column (2).

Strain Rate Effects. It would appear that to attribute the increase in strength of the dynamically over the statically tested specimens blindly to strain rate effects may not be prudent, especially as the under reinforced specimens D1 and S1 do not exhibit significant differences.

REFERENCES

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3. Kanoh, Y. and Yoshizaki, S., "Strength of Slab-Column Connections Transferring Shear and Moment," ACI Journal, March 1979.
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TABLE 1
EFFECTIVE WIDTH FACTORS OBSERVED IN DYNAMIC TESTS

SPECIMEN, ρ		RANGE OF COLUMN ROTATION (RADIANS)			SECTION PROPERTIES ASSUMED
		.25%	0.5%	1.0%	
D1	0.65%	.20	.15		Uncracked
		.94	.72	.46	Cracked
D2	0.98%	.21	.17		Uncracked
		.81	.66	.50	Cracked
D3	1.31%	.22	.17		Uncracked
		.69	.54	.40	Cracked

TABLE 2
STRENGTH COMPARISONS: ULTIMATE MOMENT (kNm)

SPECIMEN	S1	D1	S2	D2	S3	D3	S4	S5
ρ %	.65	.65	.98	.98	1.31	1.31	.98	.98
f'_c MPa	45.8	36.3	35.1	33.9	33.9	36.5	34.9	35.2
YIELD LINE (2) kNm	36.2	32.9	54.3	54.3	73.5	76.3	52.2	59.5
ACI METHOD (4)	65.0	57.7	56.9	55.7	55.7	58.0	56.6	56.9
PARK BEAMS (2)	29.4	26.3	29.5	29.2	32.4	33.6	27.7	27.5
KANOH BEAMS (3)	44.5	39.8	42.7	42.1	45.4	47.1	40.9	40.8
OBSERVED MOMENT	34.2	35.7	38.8	48.6	41.1	53.0	35.5	37.5

ρ = Reinforcement Ratio f'_c = Concrete Compressive Strength

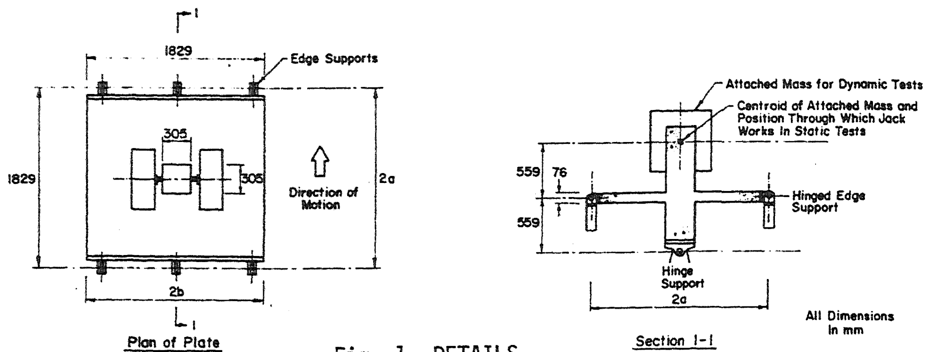

Fig. 1 DETAILS

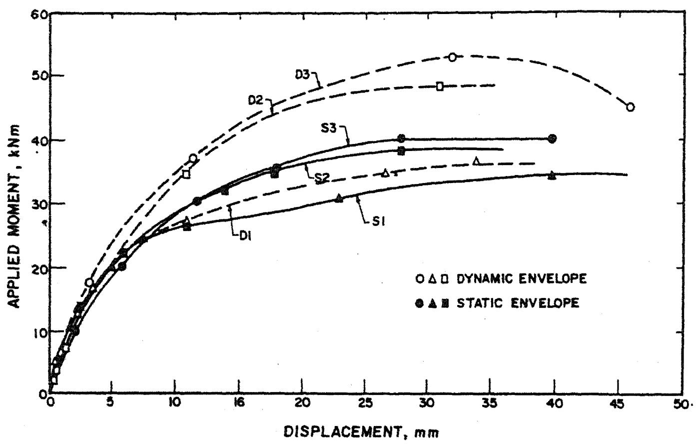

Fig. 2 ENVELOPES

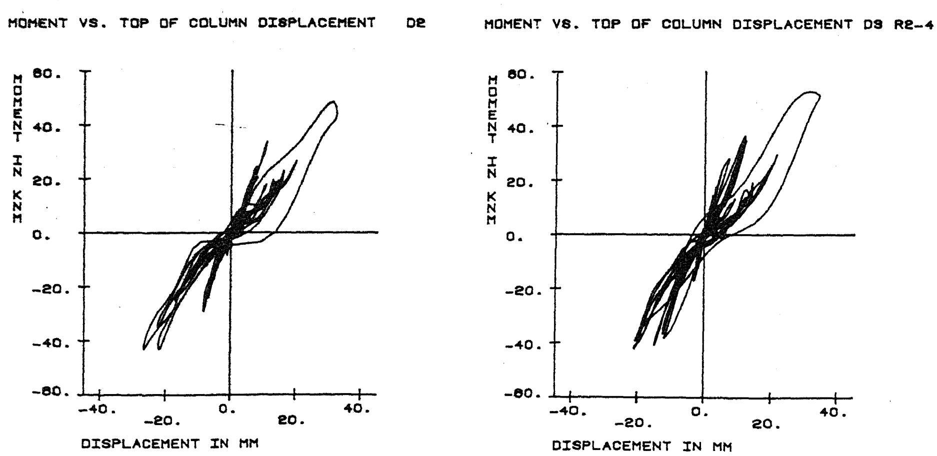

Fig. 3 HYSTERESIS