SPIRALLY REINFORCED CONCRETE COLUMNS SUBJECTED TO LOADING REVERSALS SIMULATING EARTHQUAKE EFFECTS

by

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SYNOPSIS

Description of tests and analysis of spirally reinforced columns subjected to idealized earthquake loading. Object of the investigation was to develop hysteresis curves to be used in the dynamic analysis of structures supported by "spiral" columns.

INTRODUCTION

This paper summarizes an experimental study of the response of spirally reinforced concrete columns subjected to a constant axial load and lateral-load reversals. Six specimens were tested as indicated in Table 1 and Fig. 1. Nominally, the columns were half-scale models of certain columns in the main building of the Olive View Medical Center in Sylmar, California, but some of the basic variables were modified to make the tests more generally applicable.

After the application of the axial load, the columns were subjected to 12 complete cycles of the lateral load as follows: four cycles to a deflection of three times the crushing deflection; two cycles to half the previously reached load; four cycles to six times the crushing deflection; two cycles to half the previously reached load; and loading to the maximum deflection possible within the limits of the test setup.

Measurements included the loads, rotation of the column, lateral deflection of the column, and strains in the longitudinal and spiral reinforcement, and crack patterns.

Measured data were analyzed with respect to numerical solutions of the load-displacement characteristics. Reinforcing bars were tested with large strain reversals in order to provide bounds for a Ramberg-Osgood function to define hysteresis. Different hysteresis relationships were assumed for confined and unconfined concrete. The comparison of the measured and calculated results for a test specimen is given in Fig. 2.

Some of the more important observations from the tests and their analyses are listed below. Details of the study are provided in a report available from the University of Illinois Department of Civil Engineering.

(1) The spalling of the compressed concrete during the first cycle caused a drop in the applied load considerably less than would be predicted

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by a calculation based on complete loss of the shell concrete upon reaching the useful limit of compressive strain.

(2) The load-deflection response of the columns without longitudinal bars outside the spiral was virtually stable after crushing of the concrete.

(3) The corner bars placed outside the spirals were effective during the first cycle but their contribution to resistance declined progressively during subsequent cycles.

(4) The resisting moment at the fixed end of the column did not decline in spite of a deflection that corresponded to a rotation of 1/5.

(5) As predicted by the numerical solution, the longitudinal strain in the reinforcement of columns with relatively high axial loads increased cumulatively in successive cycles.

(6) The spiral reinforcement was very effective in acting as confining and web reinforcement. Strain readings indicated that the spiral reinforcement did not reach yield.

(7) Post-test inspection revealed that the confined concrete had completely crumbled and the column owed its success to confinement.

(8) The numerical solution, which started with assumed hysteresis in the materials, was successful in predicting the measured moment-rotation curves.

ACKNOWLEDGMENT

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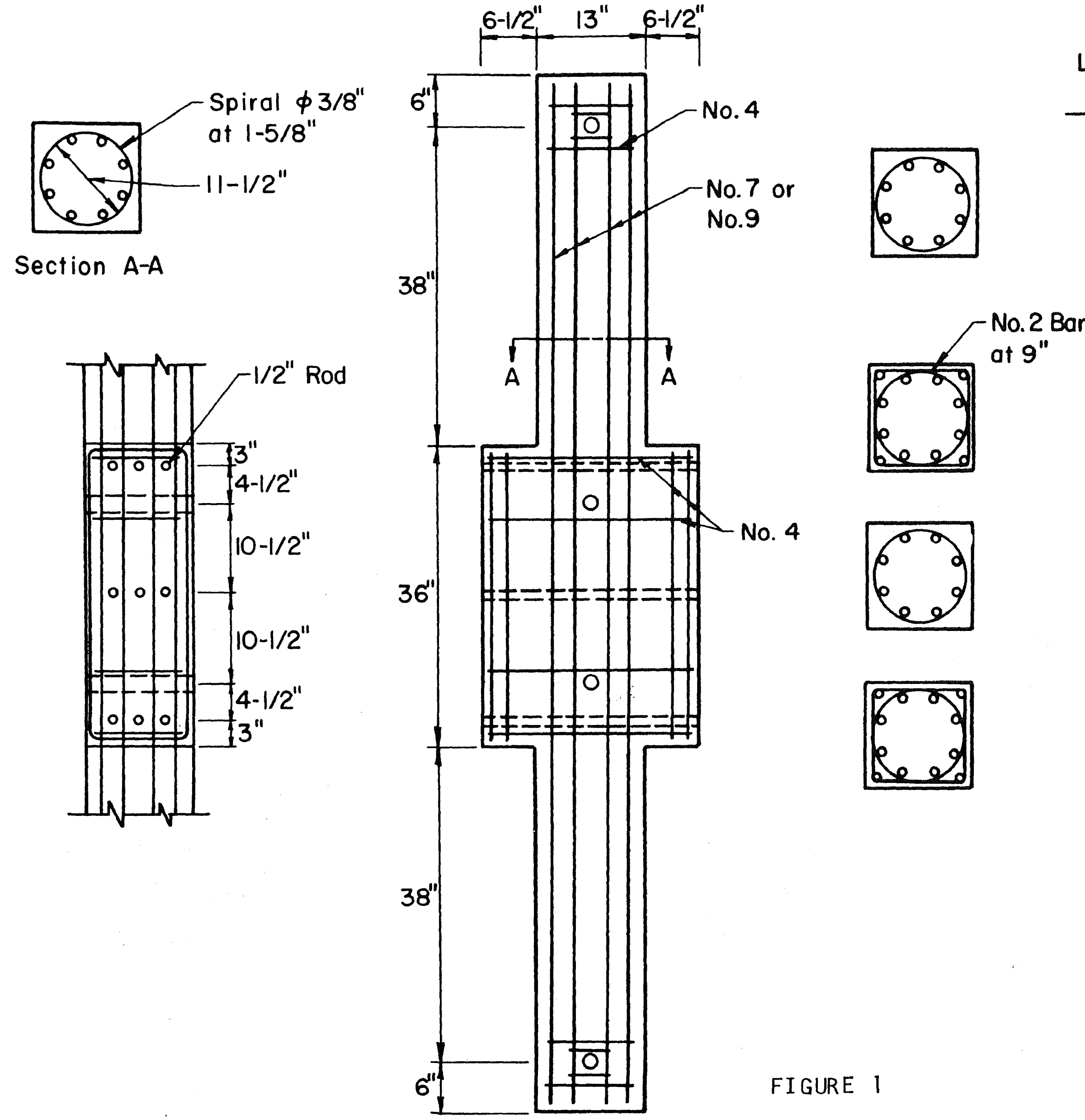
TABLE 1

Mark	Reinf. Bars Size	Reinf. Ratio %	Axial Load kips	Meas. Maximum Moments + (kip-in)	Meas. Maximum Moments - (kip-in)	Concrete: Comp. Str. f'_c	Concrete: Split Str. f_t	Concrete: Meas. Modulus psi	Maximum Lateral Force kips	Calc. Max. Mom. + (kip-in)	Calc. Max. Mom. - (kip-in)
1	8#7	2.85	100	1800	1700	5660	440	3.73	45.1	1780	2020
3	8#7	2.85	200	2110	2000	5410	400	3.64	51.8	2090	2190
2	8#7	2.85	300	2250	2160	5350	410	3.50	53.9	2020	2180
4	12#7	4.27	200	3100	3080	5770	420	3.85	74.0	2860	3060
5	8#9	4.74	200	2650	2590	5820	447	3.81	63.6	2690	2760
6	12#9	7.10	200	3730	3350	5000	438	-	87.0	4130	4320



Longitudinal Bars	Mark	Axial Force kip
8 No. 7	1	100
	2	200
	3	300
12 No. 7	4	200
8 No. 9	5	200
12 No. 9	6	200

FIGURE 1

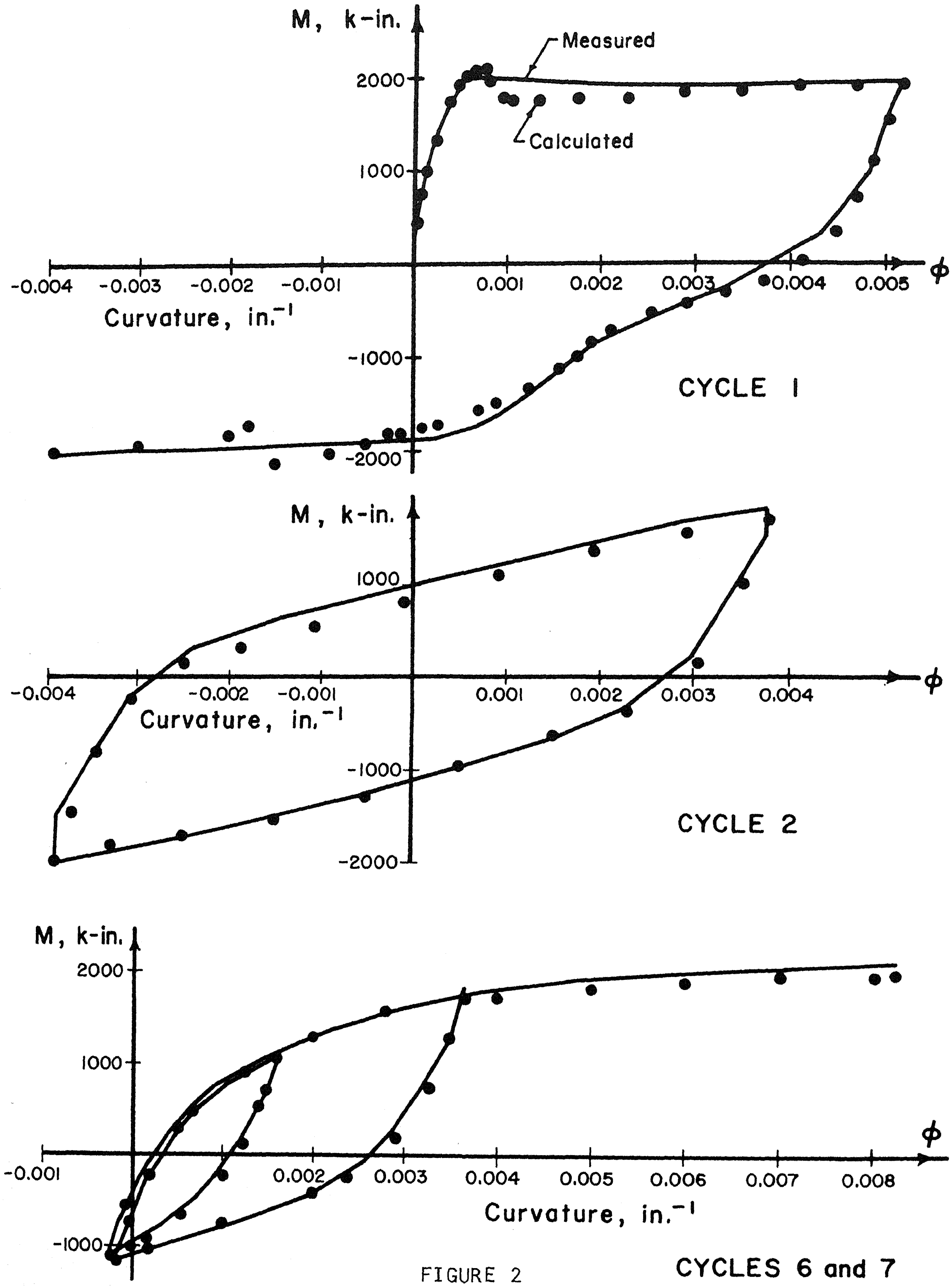

M, k-in.
Measured
Calculated
2000
1000
-1000
-2000
-0.004
-0.003
-0.002
-0.001
0.001
0.002
0.003
0.004
0.005
ϕ
Curvature, in.⁻¹
CYCLE 1
M, k-in.
1000
-1000
-2000
-0.004
-0.002
-0.001
0.001
0.002
0.003
0.004
ϕ
Curvature, in.⁻¹
CYCLE 2
M, k-in.
2000
1000
-1000
-0.001
0.002
0.003
0.004
0.005
0.006
0.007
0.008
ϕ
Curvature, in.⁻¹
CYCLES 6 and 7

FIGURE 2