PROPERTIES OF CONFINED CONCRETE FOR DESIGN OF EARTHQUAKE RESISTANT STRUCTURES

by
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INTRODUCTION

As part of an experimental and analytical investigation of structural walls for earthquake resistant buildings, elements of walls are being tested to determine effectiveness of rectangular confinement reinforcement. The investigation is supported in part by NSF-RANN Grant GI-43880.

TEST SPECIMEN

Tests are being made on large C-shaped specimens as shown in Fig. 1. The midheight of each specimen represents the compression zone of a full size structural wall. During the test the specimens are loaded to keep the strain on one face of the "C" near zero. On the opposite side of the cross section, the fibers are subjected to a monotonically increasing compressive strain. This strain distribution represents the compressive zone of a wall. The effective stress versus strain curve for concrete confined with rectangular hoops is determined from the data.

TEST PROGRAM

Variables in the program include spacing and size of confinement reinforcement, amount of longitudinal reinforcement, concrete strength, and size of specimen. The variables are given in Table 1.

Test specimen cross-sectional dimensions were 254x406 mm. A later series of tests will be conducted on specimens one-half this size. Specimens with hoops of No. 4 bars at 102 mm were provided to meet the lateral confinement requirements of ACI 318-71, Appendix A.

Values of the ratio of volume of confinement reinforcement to volume of concrete, ρ_s, are shown in Table 1. The hoop size and spacing were increased and decreased from that required by ACI 318-71. The specimens were constructed with concrete having a compressive strength of 20.7 MPa. Longitudinal reinforcement was provided by four bars, one in each corner of the cross section. Two sizes of bars were used, No. 4 and No. 11. This gave vertical reinforcement percentages of 0.5 and 3.9, respectively.

FINDINGS

Results of these and related tests are given in Fig. 2. Analysis of the test results showed that all arrangements of rectangular hoops significantly increased the limiting concrete strain. For specimens with hoop reinforcement meeting the requirements of Appendix A of the ACI Building Code, limiting concrete strains exceeded 0.015. The spacing and amount of transverse reinforcement were the primary variables affecting the stress versus strain relationship of the concrete.

Use of rectangular hoops for confinement reinforcement can significantly increase the ductility of the compressive zone of a structural wall. A lower bound curve for limiting strain is included in Fig. 2.

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TABLE 1 TEST PROGRAM

Specimen No.(1)	Cylinder Strength (MPa)	Long. Rein. Ratio	Hoop Bar Size	Hoop Spacing (mm)	Hoop Rein. Ratio ρ_s	Limiting Strain
1	23.0	0	-	∞	0	0.003
2	21.6	0.005	4	51	0.037(2)	0.045
3	21.0	0.005	4	102	0.019(2)	0.020
4	22.4	0.005	4	203	0.009	0.012
6	22.5	0.005	5	102	0.029(2)	0.054
7	23.6	0.005	3	102	0.010	0.010
8	22.1	0.039	4	51	0.037(2)	-
9	22.8	0.039	4	102	0.019(2)	0.017
10	23.9	0.039	4	203	0.009	0.014
12	20.8	0.039	5	102	0.029(2)	0.036
13	19.2	0.039	3	102	0.010	0.015

(1) 254 x 406 mm cross section
(2) Meets ACI hoop requirements

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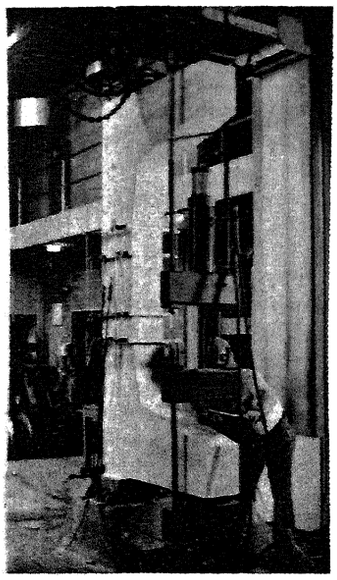

Fig. 1 Test Specimen

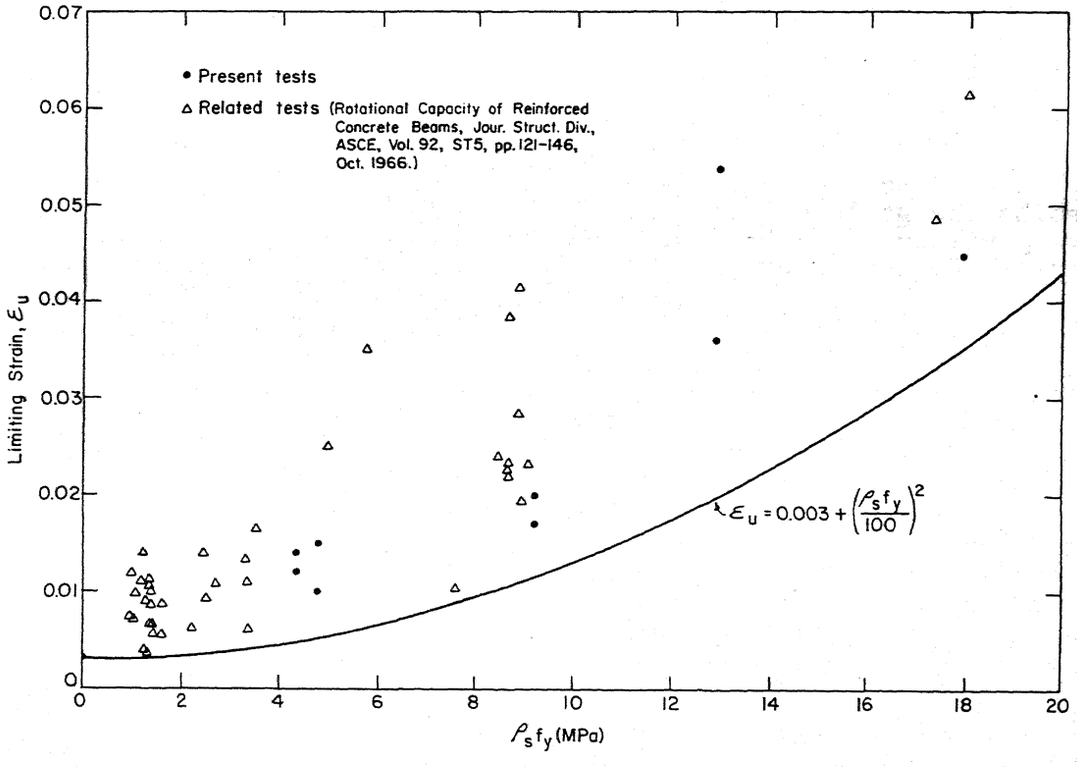

Fig. 2 Effect of Hoop Reinforcement on Limiting Strain