SPATIAL SUBASSEMBLAGE TESTS FOR R/C FRAMES TO DYNAMIC CYCLIC LOADING

Dumitru Vasilescu[I]

SUMMARY

The test specimens were representative models of lower story beam-column assemblies of a prototype building designed according to present aseismic provisions. Test variables were the amount and grade of longitudinal reinforcement. The results showed that one of the main effect of using higher strength steel was a decrease in the energy absorbtion and ductility capacities.

INTRODUCTION

Reinforcement with a standard yield strength of 440 N/mm^2 and a corresponding ultimate (minimum) strength of 600 N/mm^2 (grade PC 60 steel) is the highest strength steel permitted by the P-100 Aseismic Design Code [1] , Section 5.1.3. The main purpose of the investigation reported herein was to examine experimentally the significance of using grade PC 60 bars in ductile reinforced concrete frames. Comparison is made with grade PC 52 steel.

TEST PROGRAM

The spatial subassemblage consists of a column and four adjoining beams cut off approximately at the midspan. The test specimens were half scale models of a such subassemblage of a prototype reinforced concrete frame.

The dimensions and the reinforcement details of all three types of test specimens are shown in Table 1 and Figs.1, 2 and 3. The major difference between the first two specimens, A and B, was the kind of the reinforcement used. In the third specimen , C, a larger amount of longitudinal reinforcement was provided. The properties of deformed bars used in fabricating the experimental subassemblages are given in Table 2.

A special testing facility was used to investigate their hysteretic behaviour under dynamic cyclic excitations. The facility and instrumentation used are schematically illustrated in Fig.4. The bending moment in the beam section near the face of the column due to simulated gravity loads was 1/4 of the calculated moment capacity in the case of transversal beam and 1/6 for the longitudinal beam respectively. The column axial load was 400 kN. The cyclic force, H, was applied to the bottom end of the column with gradually increasing intensities by means of a vibration generator. The frequencies ranged from 0.7 to 2.5 Hz. An overall view of the test setup may be shown in Fig.5. Each test specimen was carefully instrumented to provide detailed data on its behaviour throughout its entire loading history.

EXPERIMENTAL RESULTS

Deformation capacity of specimens are discussed herein in terms of various ductility factors (Fig.6). Although it is not strictly true, a subassemblage was considered elastic until the first yielding of the longitudinal bars was induced in the plastic hinge region. Three typical cycles of the lateral force-displacement curves for each specimen were selected and reproducel in Figs. 7 through 9: (1) a cycle "ab" in which the beam longitudinal reinforcement yielded; (2) a cycle "cd" in which the maximum lateral load was reached and (3) an ultimate cycle "ef" in which a decrease in lateral force accompanied by a rapid increase of the lateral displacement was recorder. The deflection ductility factors determined for both cycles "cd" and "ef" are shown in

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[I] Struct. Research Eng., Central Inst. For Research, Design and Guidance in Civ.Engrg. (ICCPDC), Building Research Center, Iaşi, Romania.

Table 3, where the maximum values of overage curvature ductilities, μ_{θ}^{max}, determined in a similar manner are included.

CONCLUSIONS

The conclusions reached from the test on spatial subassemblages under dynamic cyclic loading may be summarised as follows:

1. Maximum deflection ductility factors of about 3.8 and 4.5 respectively were reached in the case of specimen A and a drop in ductility capacity of 32 % was recorded for specimen B with respect to that obtained for specimen A.

2. Cyclic average curvature ductility factor, defined in a manner similar to the deflection ductility factor, was up to 4 times greater.

3. Specimen with a larger amount of longitudinal reinforcement exhibited a smaller deterioration of stiffness relatively to similar specimen with a smaller amount of reinforcement.

4. One of the main effect of using higher steel strength was a decrease in the energy absorbtion and ductility capacities.

REFERENCES

1. "Romanian Code for the Aseismic Design of Buildings and Plants, P.100-78", 1978, Central Institute for Research, Design and Guidance in Civil Engineering.

Table 1 - Specimen Properties

Specimen type	Concrete compress strength (N/mm²)	Reinforcement		Reinforcement ratio , ρ (%)			
		Grade	Diameter (mm)	Transv. beam		Longit. beam	
				Top	Bottom	Top	Bottom
A	31	PC 52	12	0.70	0.34	0.81	0.54
B	34	PC 60	12	0.70	0.34	0.81	0.54
C	35	PC 60	16	1.23	0.61	1.45	0.97

Table 2 - Reinforcement Properties

Bar	Yield strength, f_y (N/mm²)	Yield strain (%)		Ultimate strength, f_u (N/mm²)	Ultimate strain ε_u (%)
		Begining of the yield platean	End of the yield platean		
Ø12 PC 52	380	0.210	2.43	540	24.1
Ø12 PC60	445	0.225	1.60	665	18.1
Ø12 PC60	435	0.220	1.35	650	17.0

Table 3 - Ductility capacity

Specimen type	Cycle "cd"			Cycle "ef"		
	μ_δ	μ_δ^t	μ_θ^{max}	μ_δ	μ_δ^t	μ_θ^{max}
A	2.24	2.30	9.40	3.80	4.35	12.00
B	2.06	2.55	6.90	2.58	3.11	13.30
C	2.02	2.11	2.60	2.47	2.69	4.80

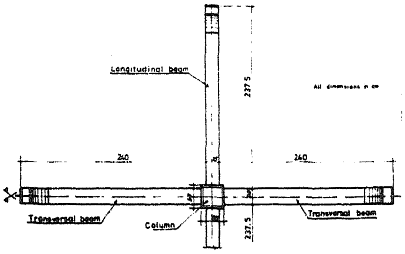


Fig. 1–Test Subassemblage-Plan View

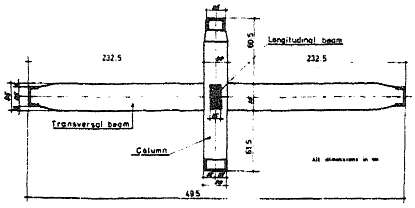


Fig. 2–Subassemblage Geometry–Transversal Direction Elevation

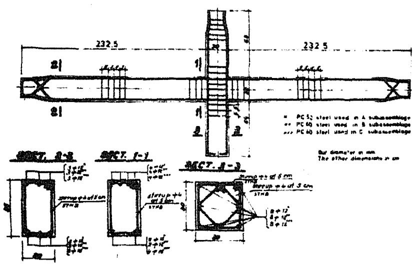


Fig. 3– Reinforcement Details –Transversal Direction

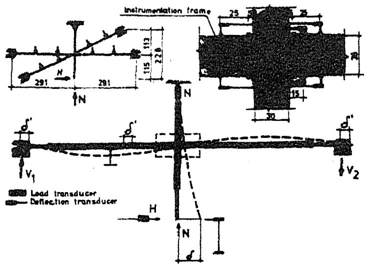


Fig. 4 Schematic Representation Specimens Loading and Instrumentation

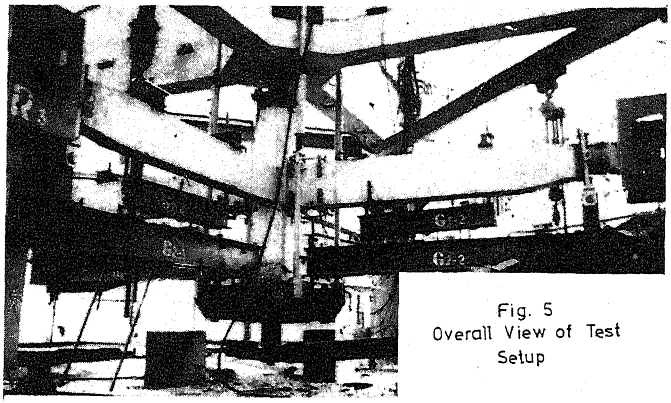
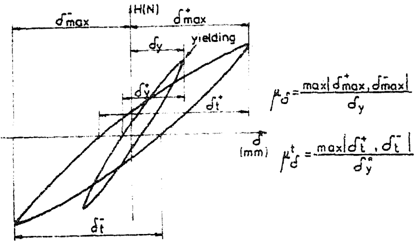


Fig. 5
Overall View of Test
Setup



$$\mu_\delta = \frac{\max|\delta^+_{max}, \delta^-_{max}|}{\delta_y}$$

$$\mu^t_\delta = \frac{\max|\delta^+_t , \delta^-_t|}{\delta^*_y}$$

Fig. 6-Definition of Ductility Factor

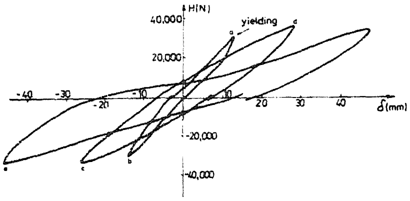


Fig.7- H-δ Diagram Specimem A

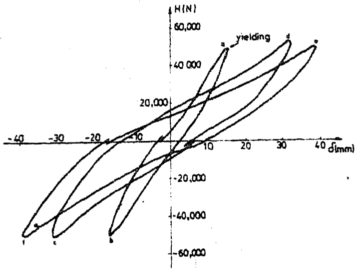


Fig 8-H-δ Diagram Specimen B

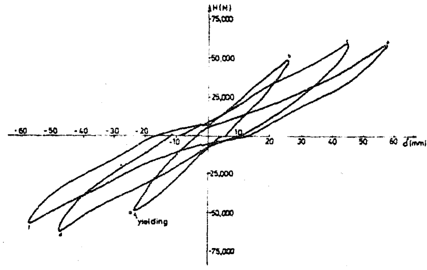


Fig. 9- H-δ Diagram Specimen C

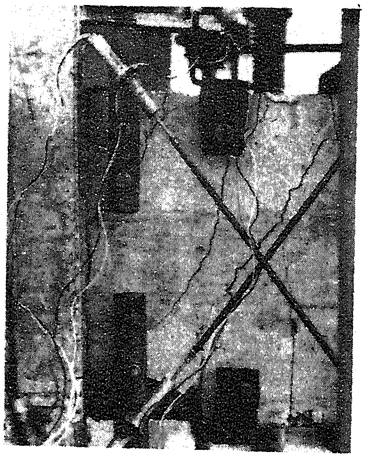


Fig 10
Specimen A Near
Failure