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BEHAVIOR OF R.C. SHEAR WALLS WITH STAGGERED OPENINGS IN SEISMIC ZONES

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Abstract:

In generally, RC shears walls are used in buildings situated in due to theirs rigidity and capacity to dissipate energy. After years of theoretical and experimental studies, we have only information about the behavior of RC walls with regular openings. This paper presents recent results of theoretical and experimental programs that were obtained from four types of RC shear walls with different position of openings.

1. INTRODUCTION

The study was realized on three types of structural walls with staggered openings, differentiated by the position of the openings (Fig.1), a filled wall and a coupled wall.
The behavior of the walls in elastic domain was studied with Axis VM 7 program (Fig.2) and in post elastic domain with BIOGRAF program, based on a nonlinear analysis of push-over type (Fig.3–4).
The experimental studies were realized in Construction and Architecture Faculty of Timisoara and thy confirmed the theoretical studies. During all the time of tests there were verified the maximum deflections at the top (Fig. 5–6).

2. RESEARCH RESULTS

The seismic behavior of structural walls with staggered openings is explained by theoretical studies and experimental studies: The reinforcement from the walls with staggered openings reach the yielding limit at values of relative displacement higher (0,15 - 0,20%) than those of coupled walls (0,10%);

- The plastic hinges are recorded always at the base of posts of the walls with staggered openings for relative displacements of 0.50%, and in the coupled wall at the extremities of coupling beam for relative displacements of 0,35%;
- At the failure of the walls with staggered openings, the concrete is crushed at the base of small post, while at the coupled walls the concrete is crushed at the extremities of coupling beams, if these beams are not especially reinforced for withstanding shear force;

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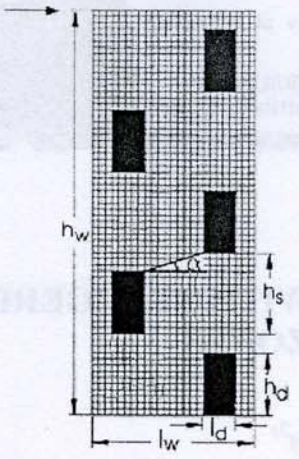

Fig. 1 Type of models

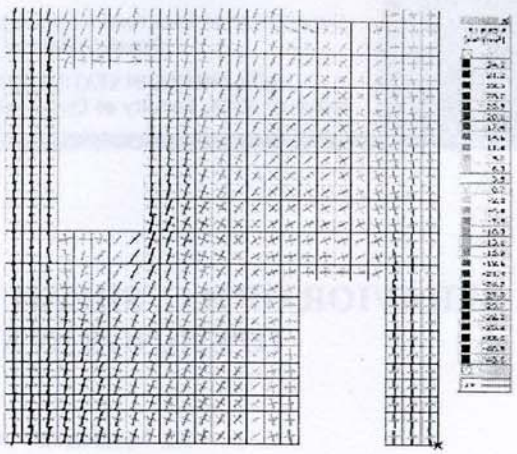

Fig. 2 Principal efforts directions

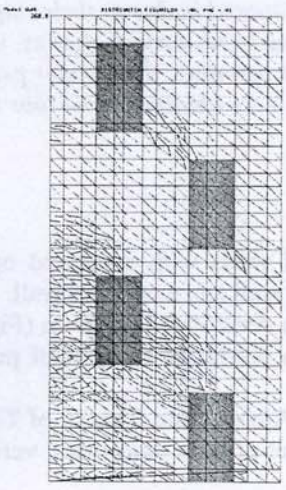

Fig. 3 Distribution of the cracks

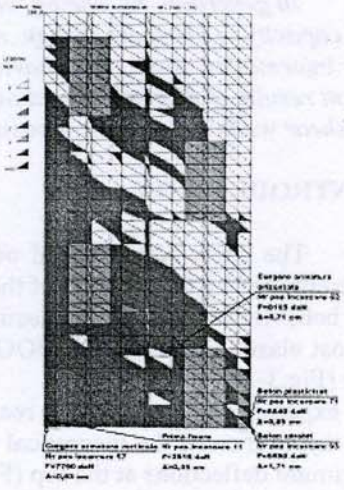

Fig. 4 Failure mechanism of staggered openings

➢ The walls with staggered openings dissipate an amount of seismic energy smaller than the wall with no openings but bigger than the coupled walls, with no special way of reinforcing the coupling beams. For a maximum dissipation of energy it is recommended that the staggering of the openings to be realized such as the value of α angle to be as close as possible of 45°. The smallest amount of energy is dissipated in the walls in which the openings are far away (α=18°) or very near (α=62°);

➢ The energy dissipation takes place due to cracking of concrete and yielding of reinforcement. The main source of dissipating the energy is the yielding of vertical reinforcement. It is not recommended that the horizontal reinforcement from connections to reach the yielding limit because there will be important distortions of the walls and there won't be any redistribution of stresses in the posts;

➢ The displacement ductility of structural walls with staggered openings varies proportionally with the value of α angle for values between 18°- 45° and inversely proportionally for the interval 90°- 45°; with no special reinforcing measures, structural walls with staggered openings have a limited displacement ductility, having values between 3 and 5 (Fig 7).

➢ For increasing the displacement ductility it is recommended the confinement of the concrete on entire height of the small posts from the first two levels and stronger reinforcing with horizontal bars of the zone limited by two successive openings;

➢ Structural walls with staggered openings develop ductile failure mechanisms with no special measures of reinforcing, with reduced reinforcing ratios (Fig. 8). Due to this way of failure, the walls are more efficient economically, requesting low reinforcing ratios;

➢ The degrading of initial stiffness for the walls subjected to alternating cycles is influenced by the way of staggering the openings. The smallest reduction of the stiffness in the failure stage takes place for α=32° (approximate 20% from initial tangent stiffness) and the greatest reduction of stiffness was at the wall SW4-5 (α=32°). The stiffness is decreasing progressively with the increasing or decreasing of the angle α=62° above this value;

➢ It is recommended, for the establishment of seismic code forces, the use of the following values for the behavior factor q: 3 for 45°>α>32° and 2 for other values;

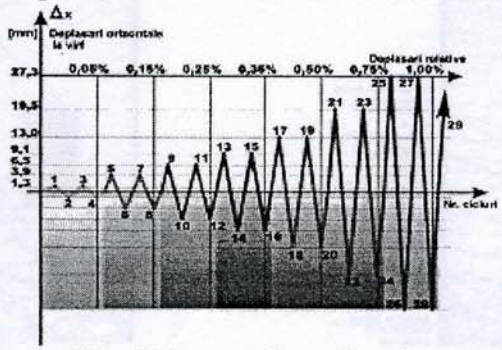

Fig. 5 The number of cycles

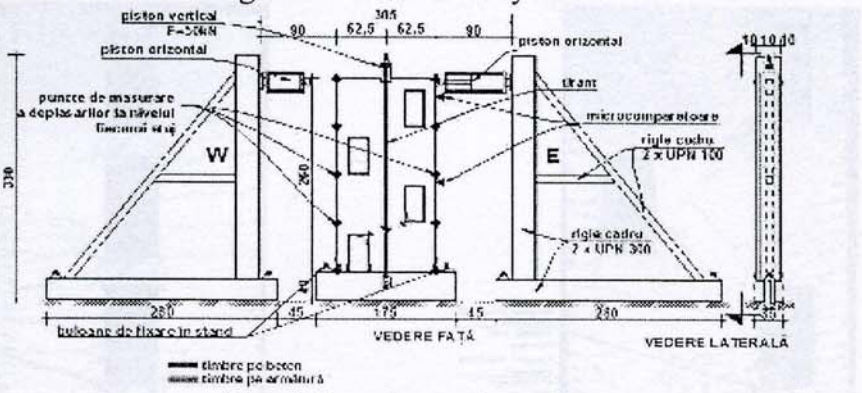

Fig. 6 Experimental stand

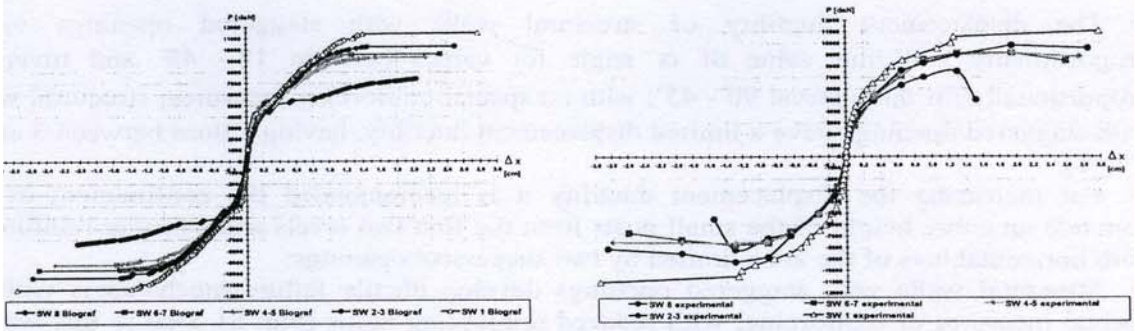

Fig. 7 Theoretical and experimental P-Δ curves

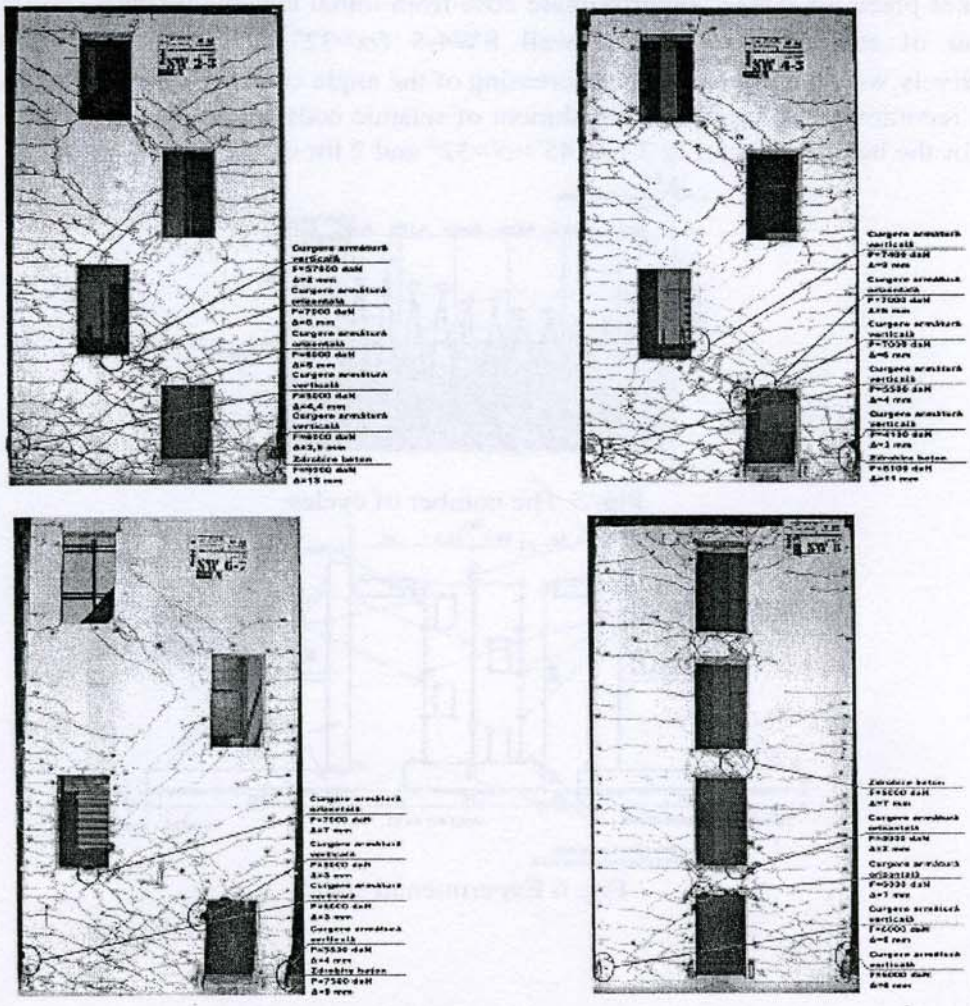

Fig. 7 The type of failure of experimental model SW2-3, SW4-5, SW6-7, SW8

3. REFERENCES

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