SEISMIC TESTS OF INFILLED REINFORCED CONCRETE FRAMES

by

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Synopsis

The main purpose of this study is to investigate the performance of traditional low-cost housing structures made of brick infilled reinforced concrete frames, subjected to the seismic actions liable to occur during the structures life.

The research program comprises the testing of eight models of 3-storey buildings scaled 1:4 on a shaking table having uni-directional horizontal movements. The models differed only in the geometry of the door and window openings and in the bracing around the openings, consisting of vertical and/or horizontal dintels.

Each model was subjected to increasingly strong ground motions until different patterns of damage in the walls or in the frames occurred. Some of the models were then repaired and tested again until having undergone all the probable seismic actions due to happen in 50 years. The costs of construction and repairing the equivalent prototypes are under gross estimation.

Although this research program is still on course, preliminary conclusions on the most economical and efficient techniques for the confinement of the brick walls could be derived. The results of this study are supposed to be included in a short handbook of building construction in seismic zones.

1. CHARACTERISTICS OF THE MODELS

Eight models scaled 1:4 were built. Each of them consisted of two 3-storey single bay reinforced concrete frames infilled by brick walls. These two panels were tied together by transverse beams. The columns were built in the base at a strong beam. The models were topped by a 4.3 ton concrete block, to simulate the weight of the buildings.

Prestressing cables tied to the platform reproduced the axial stress at the frame columns (25 tons total).

Fig. 1 sketches the main characteristics of the models. Materials were concrete with characteristic compressive strenght of 225 kgf/cm^2 (0,05 fratile in cubes at 28 days), steel with characteristic strenght of 40 kgf/mm2 and common brick.

The overall geometry of the 8 models, as well as the frame characteristics was the same. The pattern of door openings and the type of confinement-vertical and/or horizontal dintels around the openings is shown in fig. 2.

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2. TESTING PROGRAM

Most of the experimental studies on brick infilled reinforced concrete frames have been carried out under static conditions. Recently research on the dynamic behaviour of this structures has considered low-cicle large amplitude loading [3,4,5] with very interesting results.

In the present study most of the testing was performed by acting the base of the models with horizontal accelerations, sinusoidal and random, by means of a shaking table having unidirectional horizontal movemente acted by a programmed 25 ton hydraulic actuator (fig. 7).

The models were first subjected to static tests with horizontal forces applied at the top in order to determine their flexibility and stiffness. Diagonal compressive tests were also carried out on isolated masonry panels, bond only with montar, in order to obtain the mechanical properties of the masonry. In two of the models the static tests were pursued until rupture. The other models were subjected to dynamic tests, being acted first by sinusoidal acceleration of small amplitude and variable frequencies, in order to determine the dynamic characteristics of the models. The tests were then continued under quasi-resonant conditions with increasingly strong accelerations until the first craks appeared. The natural frequencies were determined again and the test went on until a further stage of damage occurred; this procedure was continued until failure. At intermediate stages of cracking the possibility of repairing the models was evaluated.

The number and duration of the tests as well as the acceleration amplitudes were compared with the seismic intensity of the earthquakes expected to occur during the lifetime of the prototypes, taken as 50 years, with a probability of 0.05 of being exceeded at least once during that time; this criteria is equivalent to adopting a return period of 1.000 years for the maximum seismic acceleration.

Inductive displacement transducers and piezoelectric accelerometers were used both in static and dynamic tests. Horizontal and vertical displacements and accelerations were recorded at the base, floor levels and top of the two frames making part of each model. Torsion of the models around a vertical axis was thus easily checked through simultaneous recording of displacements or accelerations.

3. PRELIMINARY RESULTS

The results obtained in the static tests were compared with finite element analysis, a close agreement being found for deformations, internal forces and moments both for the frames and for the masonry panels.

The main data obtained from the dynamic tests, namely frequencies, mode shapes, damping response displacements and accelerations for various stages of cracking was also compared with results obtained by means of the dynamic analysis of the models, using a computer program ONLINGRAL [1, 2] developed to study the response of complex cantilevers with non linear behaviour.

Fig. to 3 to 10 show some of the results obtained, concerning force-deflection characteristics, patterns of damage and stiffness degradation characteristics for two of the models.

4. PRELIMINARY CONCLUSIONS

Although the program is still on course it is possible to draw some preliminary conclusions from the results already obtained[6]

First it must be stated that a good agreement between analytical and experimental results even for important stages of cracking was obtained.

Further it is apparent from the tests performed up to now that a favourable interaction between frames and masonry under seismic actions requires a very careful confinement, preferable with vertical and horizontal dintels having bars conveniently connected to the columns and beams of the frames. If such a confinement is not used the damage in the masonry and on the frames can become so important that repairing becomes virtually impossible or too expensive.

A complete report of this research program will be issued as soon as possible. Its most relevant results are to be included in a short technical handbook on aseismic construction, to be published in 1977. It is hoped that this strongly contribute to improve the seismic resistance of small buildings in Portugal.

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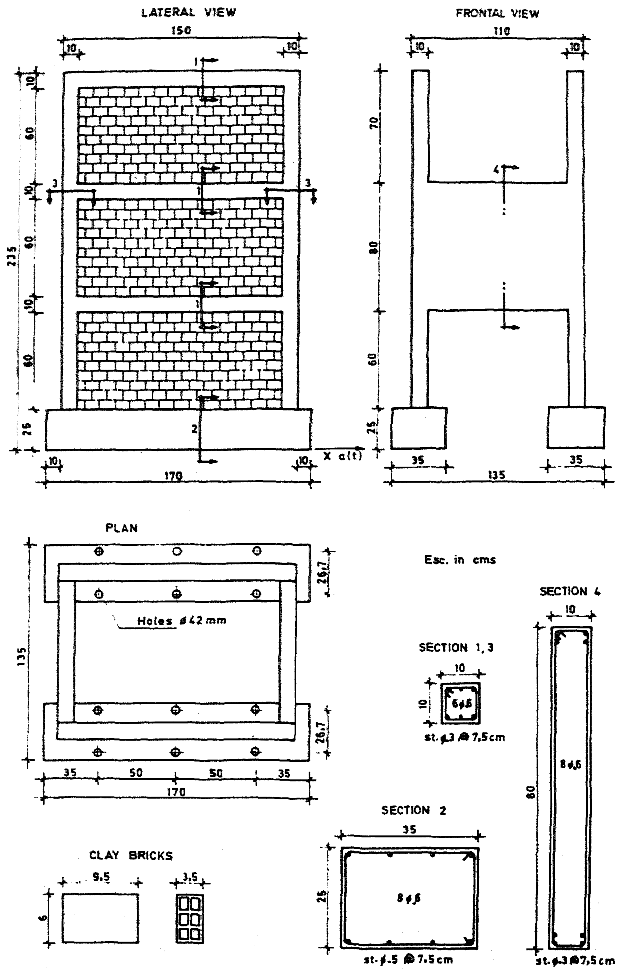

Fig.1 - First model of reinforced concrete and masonry

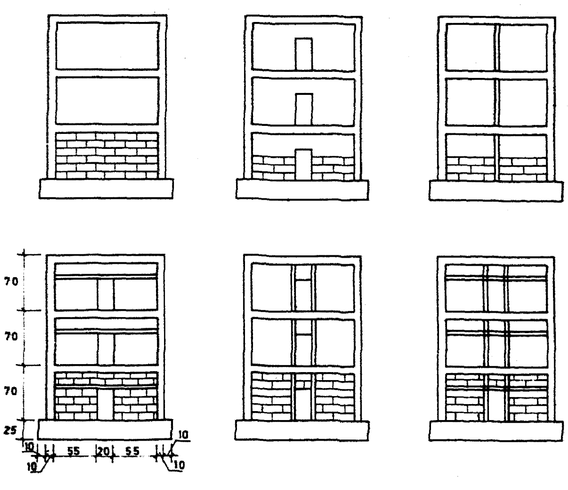

Fig. 2-Geometric shapes of mode.s tested

SECOND MODEL

INITIAL NATURAL FREQUENCY f_0=11,2Hz

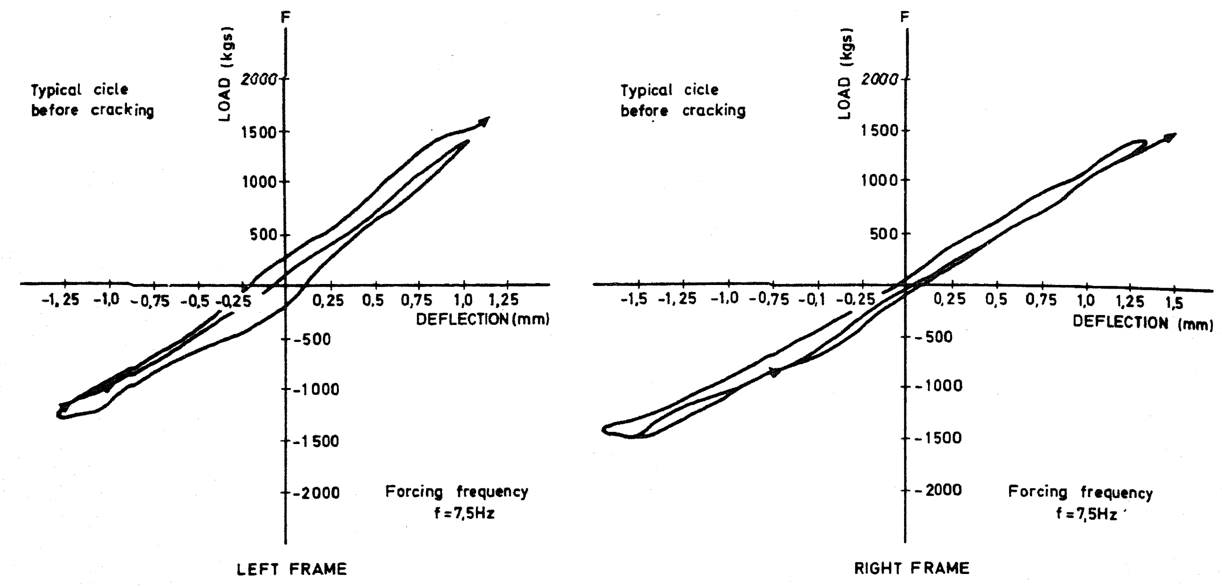

Fig. 3 - Load - deflection curve for the two frames before cracking

SECOND MODEL

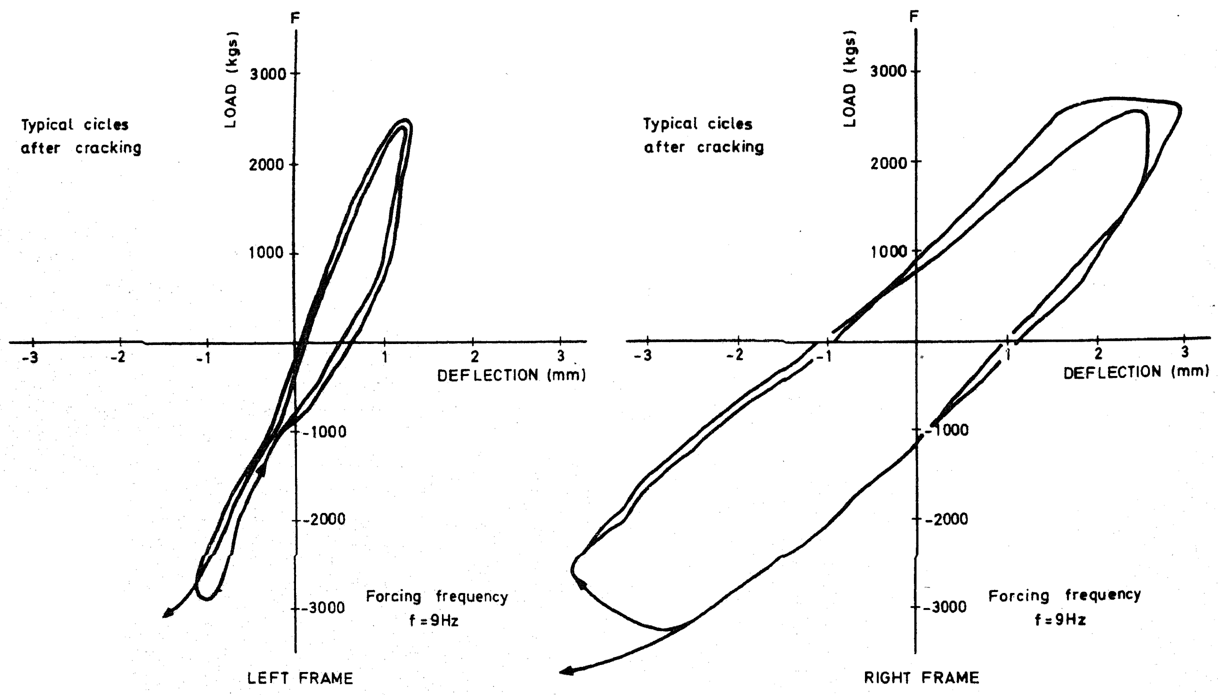

Fig. 4 - Load - deflection curve for the two frames after cracking one of them

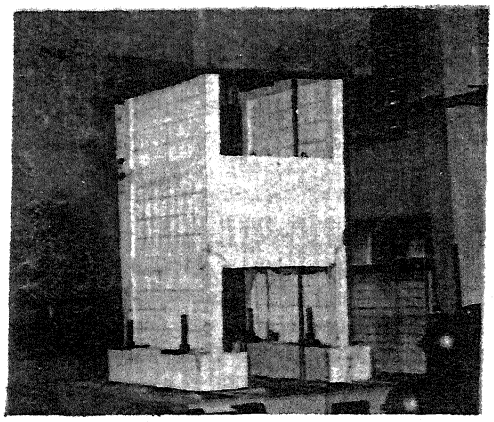

Fig.5 - General view of 1st model

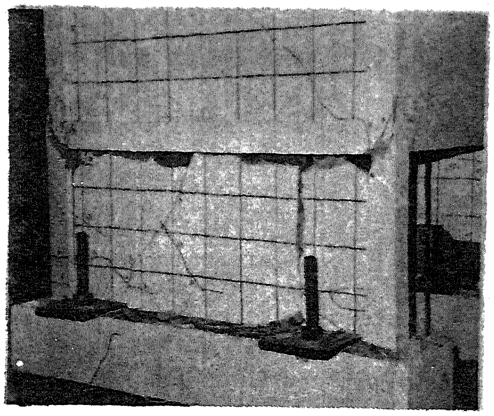

Fig.6 - Lower panel after cracking

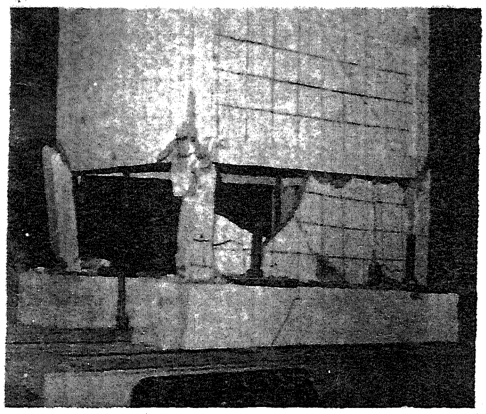

Fig.7 - Final aspect of lower panels

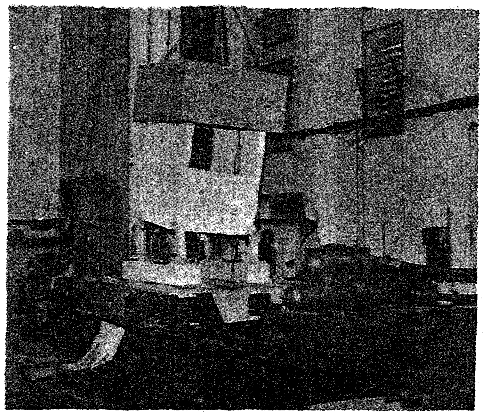

Fig. 8 - First model after collapse

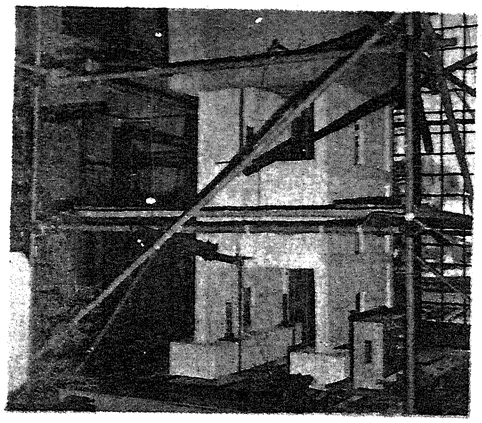

Fig. 9 - General view of 2nd model

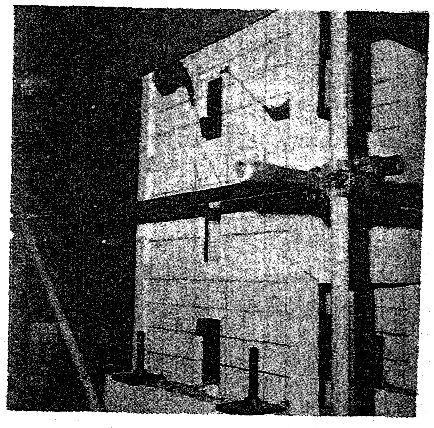

Fig.10 - Crack pattern in 2nd model