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COMPARISON OF THEORETICAL AND TEST RESULTS ON SHEAR WALL SEISMIC RESPONSE

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1 INTRODUCTION

As reinforced concrete shear walls are important resisting components of buildings in nuclear power facilities, it is important to study their ultimate behavior under dynamic loading. An experimental and analytical work has been undertaken on shear walls with and without openings, in order to develop and validate their model. This paper is related to the walls without openings.

While pretest calculations have already been reported (Wang and al. 1989) and the test results are given in Gantenbein and al. 1991. this paper is mainly related to the comparison of test and calculation results on the wall initial stiffness and the time history of the wall motion.

2 DESCRIPTION OF THE STRUCTURE

The structure tested (see Fig. 1) consists of a shear wall (height = 0.375 m, width = 0.75 m, thickness = 0.05 m) to which a 1.25 ton mass is added on the upper beam (Gantenbein and al. 1991).

The dynamic force which is applied to the mass is sinusoidal with an linearly increasing amplitude. Seven walls were tested and the input force frequency is 13, 26 or 40 Hz. In some cases, various slight modifications were brought to the test set-up such as stops at the base of the wall to prevent sliding, uplift ...

3 INITIAL STIFFNESS

As usually done before dynamic tests, the modal characteristics of the walls were analysed. The examination of these results and the comparison of calculations with tests results gives some informations on what is currently called the initial stiffness.

3.1 Calculation model

A finite element model of the wall was defined. The 54 elements represent the shear wall and the upper beam. Masses were introduced on each node of the symmetry axis of the top beam in order to represent the added mass. The base of the wall is supposed clamped.

The concrete Young's modulus is given for each wall, from the measurement on standard cylindrical specimens (16 x 32 cm). The Poisson's ratio is taken as the french regulatory value of BAEL, which is equal to 0.2.

3.2 Results

Two modes were calculated for the in plane motion and the mode shapes which are drawn on Fig. 2 and 3 are in good agreement with the experimental ones. For the wall PJ03, the first one to be tested, the measured frequencies f are equal to 38.8 Hz and 114 Hz which correspond to 0.38 and 0.42 of the calculated values, f_c.

The ratio f/f_c for all the other walls varies from 0.70 to 0.74 as the calculated frequency of the first mode is about 100 Hz while the measured one is about 70 Hz. That is to say, the measured stiffness value is about half the calculated one. This phenomena is rather usual in all shear wall tests (Moehle 1990).

As it was already noticed (Gantenbein 1991, Wang 1990), the low initial stiffness of the PJ03 wall is due to initial and non visible cracks.

4 DYNAMIC BEHAVIOR OF THE WALLS

To study the dynamic behavior of the walls, a global model was developed which is a single degree of freedom (SDOF) model. It was then applied for the comparison between the calculated and measured motion of the top of the wall.

4.1 Description of the model

To obtain this SDOF model, the following hypothesis were taken :

- the behavior of the wall is mainly influenced by the first mode and the higher modes have negligeable contribution ;
- the variable of the problem is the displacement of the mass gravity center.

The SDOF mass is equal to 1.5 ton which is the sum of the added mass and that of the top beam, actuator head and half wall.

The examination of the measured hysteretic curves shows that the SDOF stiffness could be described in two steps which correspond to pre-yielding and post-yielding. Before steel yielding, one can represent the stiffness by the secant stiffness : this means that the behavior is elastic in each cycle but the stiffness changes from one cycle to another (see Fig. 4). After yielding, the behavior can be represented by a slip model ; it means that the stiffness is equal to zero while the closing (and the opening) of the cracks and beyond is equal to the secant stiffness at the beginning of yielding (see Fig. 5).

For each shear wall, the envelope of hysteretic loops introduced in the calculation is the experimental one and the damping value was adjusted to obtain the best agreement.

4.2 Results

A comparison of the top motion calculated and measured are given on the Fig. 6, 7 and 8 where the calculated cyclic loops are also drawn.

On these curves, it can be observed that the agreement between tests and calculations is very good before the steel yielding and this remains true for the first cycles after yielding. Afterwards, the discrepancy between calculations and tests increases.

5 CONCLUSION

A non linear model was established for the analysis of shear wall dynamic behavior. It takes into account the stiffness decrease due to the concrete cracking and becomes a slip model after steel yielding.

Nevertheless before the application of the model to estimate margins in comparison to elastic models, some additional work has to be done to show the sensibility of the wall response to various factors such as the damping, the variability in the hysteretic loops.

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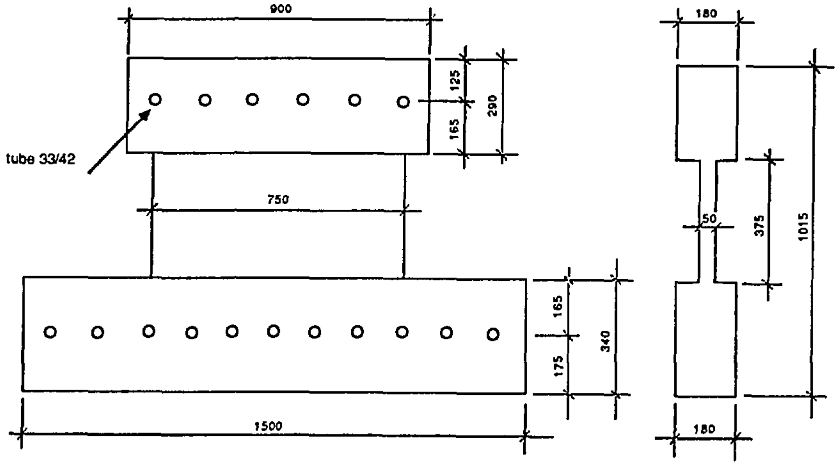


Figure 1 - Geometry of the shear wall (unit = mm)

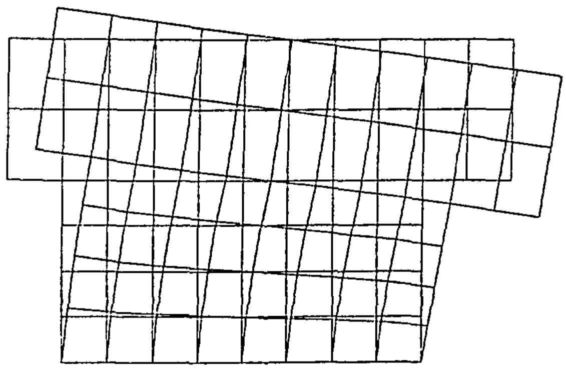


Figure 2 - First vibration mode
frequency = 100 Hz

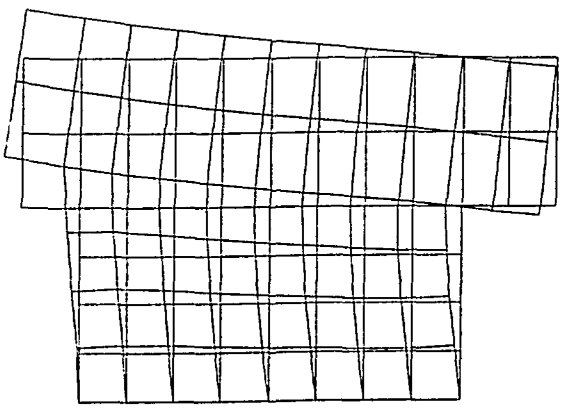


Figure 3 - Second vibration mode
frequency = 270 Hz

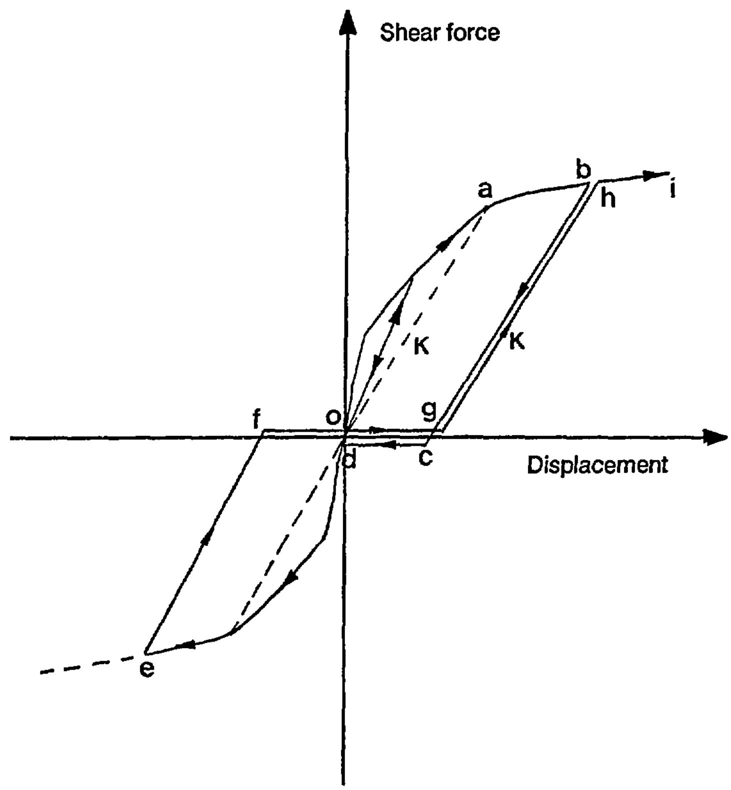
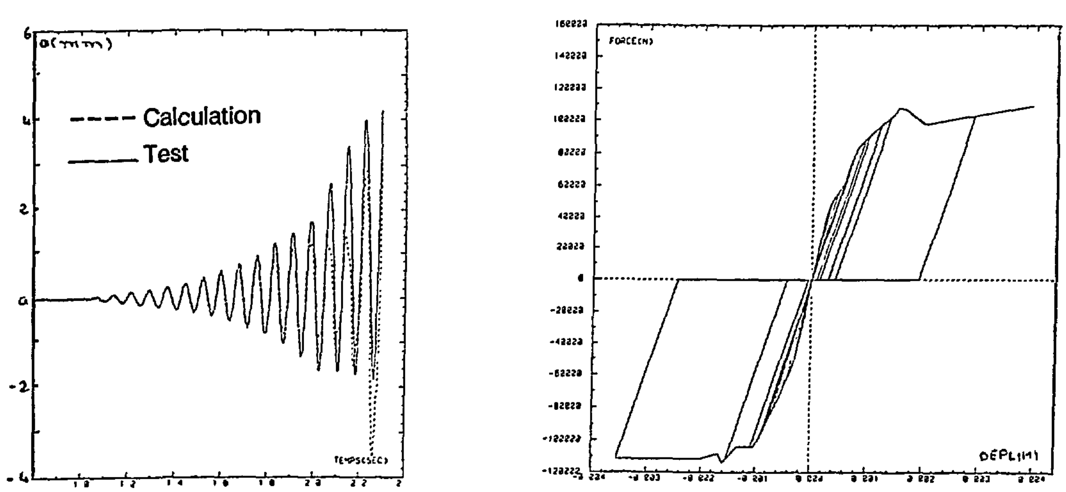


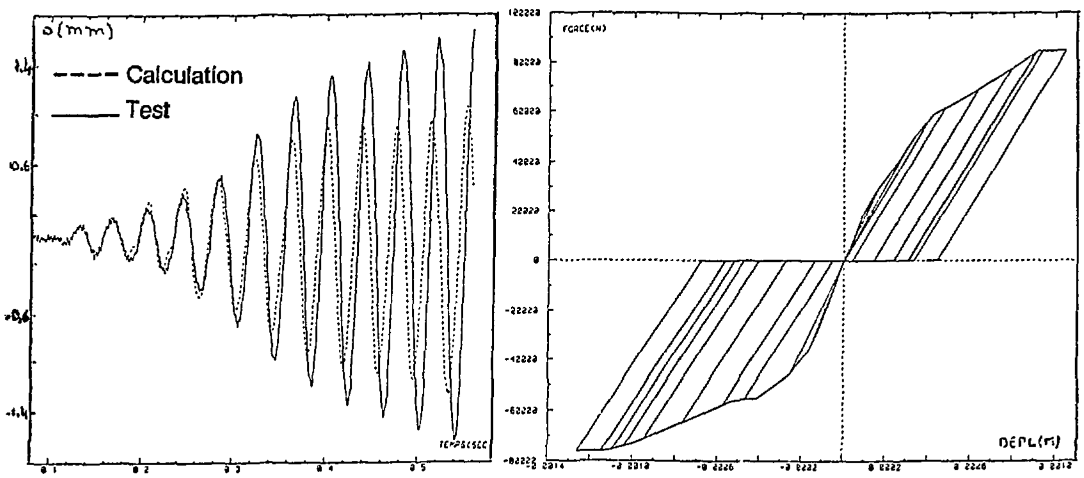
Figure 4 - Nonlinear model



Motion

Calculated hysteretic loops

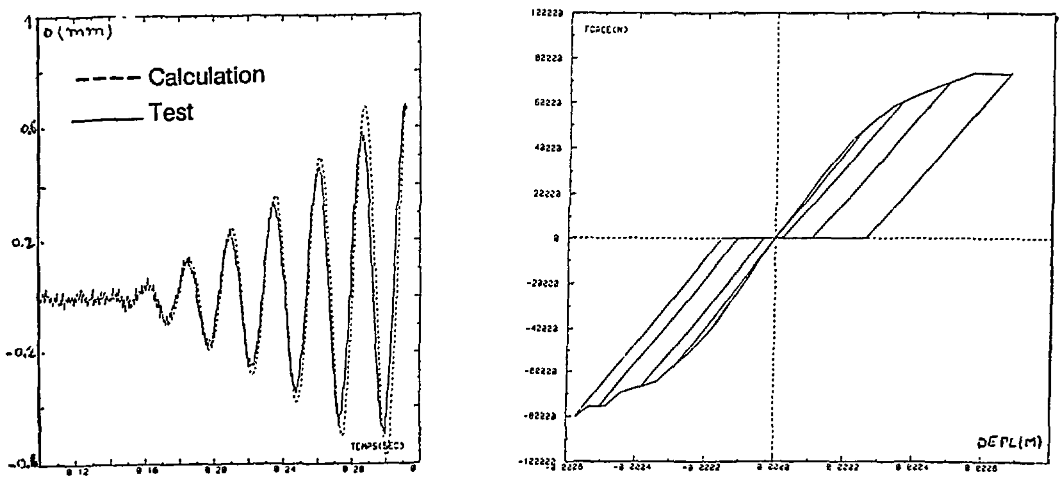
Figure 5 - Response of the wall (frequency of excitation = 13 Hz)



Motion

Calculated hysteretic loops

Figure 6 - Response of the wall (frequency of excitation = 26 Hz)



Motion

Calculated hysteretic loops

Figure 7 - Response of the wall (frequency of excitation = 40 Hz)