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DEM SIMULATION OF CRACK PROPAGATION OF TWO-STORY ADOBE WALLS IN PERU

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1. INTRODUCTION: In many developing countries such as Peru, most rural houses and some urban houses are made from adobe, and many of them are two-story houses. It is necessary for engineers to improve the behaviour of this type of housing against severe seismic forces.

We used results from the experimental tests done from 1971 to 1980 at the National University of Engineering, Lima, Peru. As computer simulation, we apply the Modified Distinct Element Method (MDEM) which was developed by Hakuno et al. (see Meguro (1989)) at the Earthquake Research Institute, The University of Tokyo.

2. REVIEW OF EXPERIMENTAL RESULTS: Failure of adobe buildings are attributed mainly to the low tensile strength and reduced adherence between adobe and mortar. These properties are notably improved in stabilized adobe. Stabilized adobe is a block of adobe made from a mixing of mud and others materials (such as Asphaltum RC-250). The humidity resistance is also improved.

The strength of the adobe masonry walls was determined from full scale tests and also standard specimens. These models were made of small blocks (26.5 cm x 26.5 cm) and big blocks (38 cm x 38 cm). Four types of mortar were used. They were (1) cement:sand:soil:asphalt (2:4:6:1), (2) cement:sand with 1% of asphalt (1:10:1%), (3) soil with 2% of asphalt (S-2) and (4) simple soil without any additive.

Summary of experimental results: a) In general, the stabilization with asphalt improved the mechanical characteristics of adobe blocks. b) The experimental results agreed well with the Coulomb's law $\tau = c + \mu * \sigma$, and c) The adobe walls that were constructed with small blocks had mechanical properties the same as those that were made of big blocks.

3. SIMULATION OF BEHAVIOUR OF ADOBE WALLS: The MDEM is a numerical method which can follow the behaviour of the media from continuous state to complete fracture. In this method, the model is composed of many circular elements (discrete elements). The Voight type model, which is composed of an elastic spring and a dashpot, is used. The effect of the material present in the pores between the granules is taken into account by an additional spring (pore spring) and a dashpot.

At the initial stage, the model behaves as a continuous body, but when the forces are increased at each time step the pore springs are destroyed and the media will become discontinuous. The destruction of the pore spring show the fracture process of the structural system.

The determination of the parameters was done according to the method presented in Meguro and Hakuno(1989), and using the experimental data mentioned in this paper.

We used two adobe wall models. The same horizontal acceleration was applied to both models using a sinusoidal function with a period of 2 sec and amplitude of 0.5 g. The horizontal acceleration that was applied had a vertical distribution of inverted triangular shape along the wall height.

The Model A was a two-story adobe wall, 4.00 m length by 5.20 m height.(See Fig.1). Propagation of cracks started at the corners of the openings. This type of opening distribution is not recommended.

The Model B was also a two-story adobe wall (See Fig 2). It was almost same as Model A but it has only one opening on the second floor (1.20 m by 2.00). We can see that the connection beams fails before the failure of the wall. This case illustrate the behaviour of the recommended couple shear wall with connection beams which fails before the failure of the wall. The energy dissipation can be very large.

4. CONCLUSIONS: The MDEM can be applied to study the cracks propagation in adobe walls and it can follow the complete fracture process even after the medium becomes discontinuous. The computer simulation show a good agreement with seismic damage observed during past earthquakes.

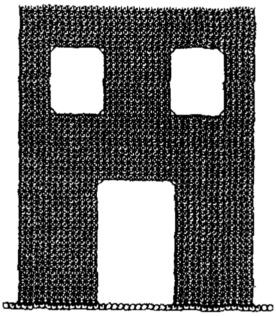

Fig. 1(a) Model A. Initial distribution of Pore Springs.

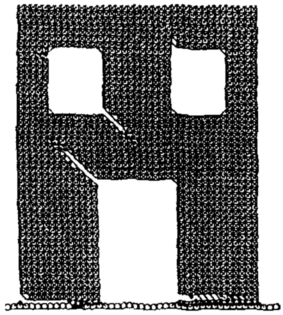

Fig. 1(b) Initial cracks at the oppening corners. t = 0.105 sec.

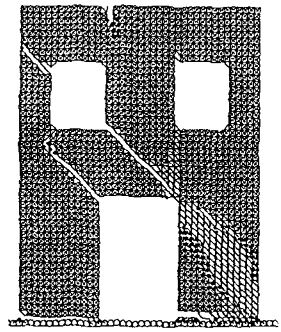

Fig. 1(c) t = 0.210 sec.

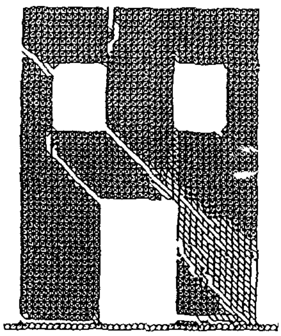

Fig. 1(d) t = 0.255 sec.

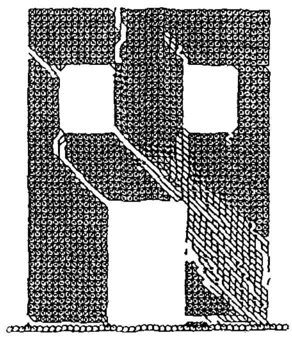

Fig. 1(e) t = 0.300 sec.

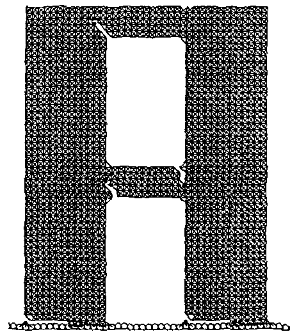

Fig. 2(a) Model B. Initial Cracks at the connection beams. t = 0.150 sec.

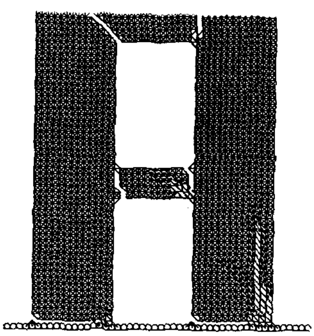

Fig. 2(b) Failure of connection beams. t = 0.210 sec.

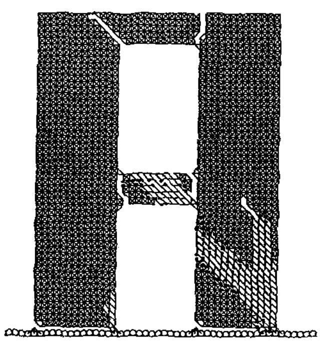

Fig. 2(c) t = 0.255 sec.

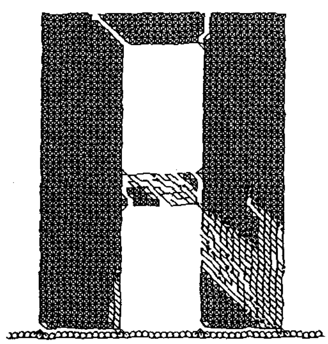

Fig. 2(d) t = 0.300 sec.

5. REFERENCES

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