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Water and the cohesion of earthen materials. Towards an optimum water content for earthquake resistance.

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ABSTRACT

The aim of this work is to provide a fundamental understanding of the humidity-dependence of the forces, which insure the cohesion of earthen materials and their energy dissipation capacity in oscillatory excitation. First, we review, in the light of recent theoretical, numerical and experimental studies, the various forces, which may contribute to the cohesion of earth. The clue of our review is the comparison between sand, clays and cement. We analyse the cohesion of each class of materials in terms of capillary forces, van der Waals forces and ionic correlation forces. Then we analyze the cohesion of model earthen materials made by mixing sand with kaolin. These materials are representative of a broad class of earthen materials used to make adobes in inter-tropical regions. Thanks to a comparison of experimental results with model calculations, we show that capillary forces are the dominant forces ensuring the cohesion of this type of materials. An important conclusion is that water is not necessarily detrimental to cohesion. There is an optimum of water content for the cohesion of each type of earthen material. Finally, we discuss the possible prediction of the maximum energy dissipation on the basis of viscoelastic properties. Similarly to what has been found for cohesion, water is also favourable to energy dissipation, in well-defined conditions. The general conclusion is that, in parallel to construction design and/or fiber introduction or stabilisation by cement, the control of the humidity content of adobes or rammed earth may significantly contribute to their resistance in seismic conditions.

Keywords: cohesion, energy dissipation, water, capillary forces, earth