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FINITE ELEMENT MODELING OF A FREE-STANDING CYLINDRICAL COLUMN UNDER DYNAMIC EXCITATION

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1. Introduction

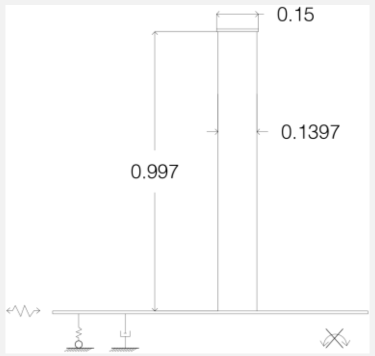
Rocking structures are the ones that are allowed to uplift, with this effect acting as a fuse, limiting the inertial forces transmitted to the superstructure.

This study aims at developing a practical three-dimensional finite element model to predict the response of free-standing cylindrical rocking columns. The validity of the proposed model is assessed by statistically comparing numerical and experimental results.

2. Statistical Validation

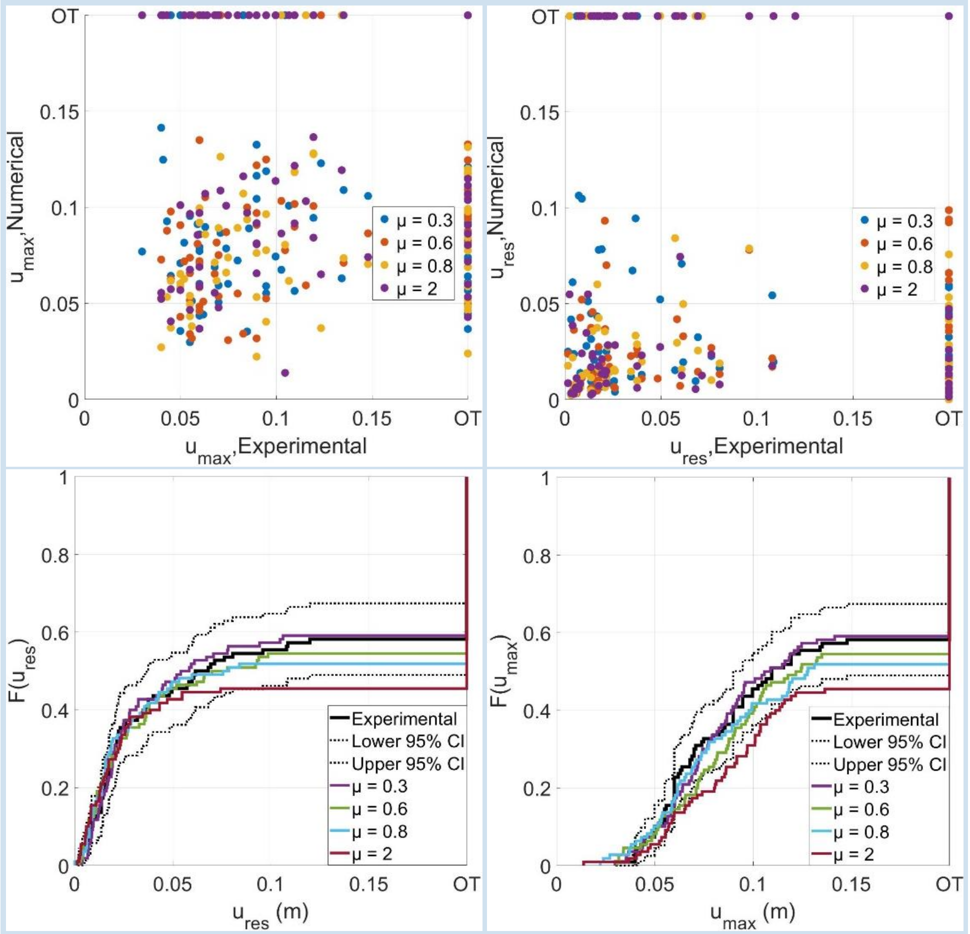
The response of rocking objects is sensitive to the initial conditions, often making tests non-repeatable and a deterministic validation impossible. Hence, a **statistical validation** procedure is proposed, where the statistical distribution distributions of the main response quantities of the model and the experiments are compared. This requires an **experimental benchmark dataset**, where the same specimen is excited by an ensemble of ground motions. Afterwards, a **numerical model** is used to create another dataset, using the same ensemble of excitations. The validity of the numerical model is assessed by comparing the Cumulative Distribution Function (CDF) of these two datasets [1,2,3].

Experimental Dataset: 115 shake table tests of a cylindrical free-standing rocking body, free to slide and rock in all directions, with a slenderness (α) of 0.15 [4].



4. Numerical Model and Results

- The finite element software ABAQUS was utilized, using rigid body parts for the shake table base and the rocking body. The model was 3D and the explicit solver was utilized.
- The base slab was vertically supported by a spring-dashpot system (vertical Eigenperiod of 0.001 sec) to simulate the vertical stiffness of the shake-table platform and the radiation/impact damping mechanism (ζ = 1 %). All rotations of the base slab were constrained.
- The response quantities of interest were the maximum (u_{max}) and the residual (u_{res}) displacement of the column.



4 Conclusions

- The friction coefficient (μ) between the rocking block and the supporting surface was varied numerically and its influence was assessed with a large number of non-linear time-history analyses. Even though the exact value of the friction coefficient significantly influences the deterministic response, it affects the statistical response only moderately.
- The model performs poorly when it is assessed deterministically. However, it can perform well, when it is evaluated based on its ability to predict the CDF of the maxima of the responses to a set of ground motions.
- The CDF curves show that an increase of the friction coefficient amplifies uplifting and leads to larger maximum rocking displacements, thus making the model more conservative. A friction coefficient equal to μ = 0.3 and a radiation damping equal to ζ = 1% leads to the optimal match between experimental and numerical results.
- Neglecting sliding (i.e. using a very high value for μ) is a conservative modelling approach, at least in terms of maximum displacement and prediction of overturning probability.

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