Applications of non-linear dynamics to historical structures

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Abstract

Qutb Minar in India is used as a case study for advanced numerical analysis, using different models (beam and 3d models) and different analysis techniques (push-over / equivalent static loading and dynamic time integration). Results obtained with the static and dynamic non-linear analyses indicate quite dissimilar response ofthe structure to the seismic loads.
The non-linear static analysis is highly dependent on the type of distribution of the lateral forces. In the case to use a mass proportional distribution of forces, the lowest part of the structure manifests diffuse cracking and a base overturning mechanism can be detected. But in the case to use a distribution of forces proportional to the first mode the overturning mechanism is presented in the first balcony.
On the other hand, the non-linear dynamic analyses carried out indicate that the part of the Qutb Minar more subjected to damage under the design earthquake coincides with the two upper levels, where highest accelerations and drifts were encountered.
These differences are due to the high influences of the higher modes in the seismic behaviour of the tower. In fact, the non-linear static analyses do not take into account the participation of the different modes. Therefore the results of the non-linear dynamic analyses are more representative of the real seismic behaviour of the tower. In this context, it is possible to conclude that the most vulnerable part of the Qutb Minar is the last two storeys.

On the other hand, the analyses show that the value of the damping has a great influence in the seismic response of the structure. Considering the low experimental value, the models indicates the collapse of the upper part of the structure, while considering the damping that some authors have measure in historical masonry structures during a seismic events (around 8%), the model shows some damage in the upper part but without collapse.