Rotation in buildings during earthquake loading: comparison of rotation and structural drift

Philippe Guéguen - Institute of Earth Sciences (ISTerre) Université Grenoble Alpes France

Kate H. Chen and Yao-Chieh Chen* (National Taiwan Normal University and * ISTerre)

Bor-Shouh Huang and Chin-Jen Lin - Institute of Earth Sciences, Academia Sinica, Taiwan)

Vertical civil engineering structures are usually modeled as usually free-clamped single degree of freedom systems, accounting for only horizontal translation efforts. However, their response to seismic loading produces rotational forces that can in some cases generate considerable stress and resulting damage. These rotational forces are essentially related to (1) deformation in rotation about the three horizontal axes (rocking), as a result of soil-structure interactions, considering the structure as a rigid body; (2) rotation about the vertical axis (torsion), essentially activated when the centre of mass (i. e. where inertial seismic forces apply) is displaced from the centre of rigidity (i. e. where the elastic forces apply). Simplified model including rotations of the soil-structure interaction are based on the modal decomposition, i.e. each component of the motion is assumed to be independent of the others. Thus, in the structures, only translation sensors are generally installed and the rotation components are evaluated via the spatial derivatives of the horizontal and vertical components. However, combinations of translations and rotations exist and rotations can only be evaluated with the measurement of the 6 motion components (3 translations and 3 rotations). In this presentation, a simple analysis is done to explain the rotations observed in the City-Hall building in Grenoble (France), a 12-story reinforced concrete building. This building is permanently monitored since 10 years, with 3 components accelerometers located at the bottom and the top. Modal decomposition is performed using ambient vibration. A set of earthquakes recordings are then used for assessing the rotations using derivative functions and compared to the recordings of a 6C rotational sensor temporarily installed at the building top. Comparison between the direct measurement of rotation and the spatial derivative rotation is done. Finally some recent results from the 101 Taipei tower permanent instrumentation (including translation and rotation sensors) are presented, comparing the time variation of modal parameters and concluding on the efficiency of direct rotation measurement to improve the understanding of building response.