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Rotation in building including soil-structure interaction

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In the first order, vertical civil engineering structures are considered as usually free-clamped single degree of freedom systems, accounting for only horizontal translation efforts. However, their dynamic response to a seismic loading produce rotational forces that can in certain cases generate considerable stresses. These rotational forces are essentially related (1) to the rotational deformation around the three horizontal axes (rocking) and resulting from soil-structure interactions considering the structure as rigid body; (2) the rotation around the vertical axis (torsion) essentially when the center of mass (i.e. where the inertia seismic forces apply) is shifted from the center of stiffness (i.e. where the elastic forces apply). Simplified model including rotations of the soil-structure interaction are based on the modal decomposition. In this case, 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. For example the torsion is usually calculated as the relative difference between two horizontal sensors placed at the same floor and the rocking between two vertical sensors placed at the foundation level. However, combinations of translations and rotations exist which can only be evaluated with the measurement of the 6 motion components (3 translations and 3 rotations). In this abstract, 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 including soil-structure interaction is performed using ambient vibration and dozen earthquakes recordings and compare with the recordings provided by a iXblue 6C rotational sensor temporarily installed at the top ten at the bottom. An extensive comparison between the direct measurement of rotation and the spatial derivative rotation is done, validating the classical soil-structure interaction models used in civil engineering.