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6-dof strong surface seismic record of MM intensity VII and its effect on a slender tower and tall buildings

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(abstract)

1. Introduction and problem statement

So far, most of the efforts in measuring rotational seismic signals are devoted to acquire weak, teleseismic records. However, some attempts to measure strong rotations can also be found [1-3]. As it was demonstrated in reference [4] ground rotations can substantially contribute in seismic response of slender towers and the interaction between rocking and horizontal components plays important in the overall structural response. Thus, to properly study structural response one needs combined 6-dof seismic record with proper phases, which requires appropriate sign conventions of all the 6 records (3 rotations and 3 translations). Such 6-dof seismic surface ground motion (Fig. 1) can be defined using:

- two horizontal translations on a ground surface: $u(t)$, $v(t)$ along x & y axes,
- a vertical record $w(t)$ along axis z,
- two rocking records $\psi(t)$ and $\theta(t)$ about the horizontal axes x & y respectively,
- a torsional record $\varphi(t)$ about vertical axis z.

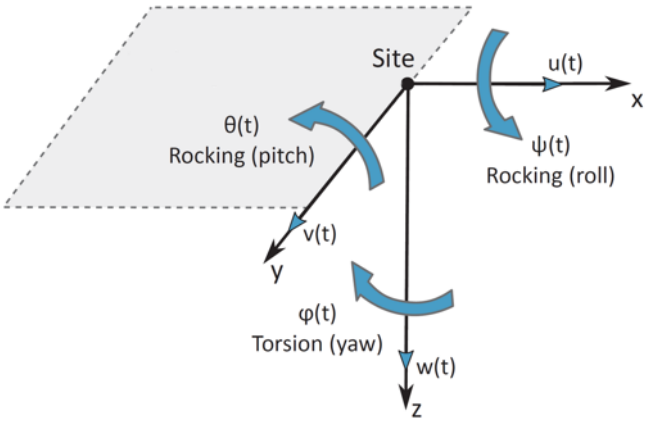

Fig. 1 A system of 6 coordinates on the ground surface with rotational '+' signs defined by a right-hand rule

In the search for strong 6-dof seismic records, first induced seismic events were studied with maximum MM (Modified Mercalli) intensity reaching MMI = IV, [5]. However, when searching for strong rotational ground motion a data base of seismic records from recent campaign of measuring aftershocks on Greek island of Kefalonia was investigated [6]. One of the recorded ground motions reached MM intensity VII and contained all 6 components with properly recorded signs. The maximum rotational acceleration and velocity about horizontal axis are equal to:

- PGA_{rot} = 409 mrad/s^2 = 23.4 deg/s^2, PGV_{rot} = 6.00 mrad/s = 0.344 deg/s

and maximum horizontal translational acceleration and velocity:

- PGA_x = 3.72 m/s^2, PGV_x = 0.184 m/s, [7].

2. Results and conclusions

The purpose of the lecture for the 5th IWGoRS Workshop is to present detailed analyses of structural response to intensity VII, 6-dof strong motion record. First respective Fourier and response spectra are analyzed in detail. It is well known that the rocking ground motions may

become particularly important for slender towers and tall buildings. In this case a combined translational and rocking ground motion and their interaction plays particular role (Fig. 2). In order to investigate these effects a 160m high, reinforced concrete industrial chimney and two tall, 10-story and 30-story buildings were chosen to carry on detailed 'time-history' response analyses. properties detailed analysis of the strong 6-dof seismic record with MMI = VII.

The results demonstrate substantial contribution of the rotational (rocking) component in the overall structural response. It was also confirmed that the phase properties of the response to horizontal excitations u(t) interacting with rocking component θ(t) play important role in the overall structural response (see also [4]), so respective signs of the 6-dof record components should properly be identified when retrieving the 6-dof seismic records used in structural response analyses.

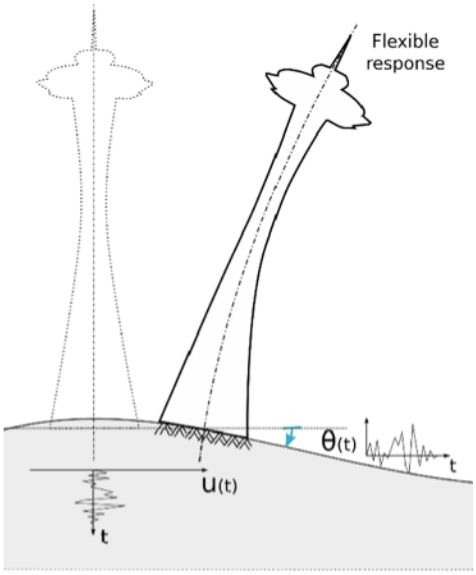

Fig. 2 Slender tower-shaped structure under combined horizontal and rocking excitations

Eurocode 8 part 6, [9], formula for the design of structures under rotational seismic surface excitations is also examined. It is concluded that its respective response spectrum formula overestimates rotational contribution in seismic response of slender, tower-shaped structures.

References

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