Engineering Implications of Rotation Sensitivity of Translational Sensors

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ABSTRACT

It is now recognize that common strong motion linear acceleration sensors present sensitivity to rotational motions. This sensitivity has been demonstrated theoretically (Grazier, 1979 and Trifunac and Todorovska, 2001 among others) and evaluated theoretically and experimentally (for example Grazier, 1979 and Boroschek and Legrand, 2006). It has been demonstrated that this sensitivity is a function of the acceleration of gravity and the amplitude and frequency of rotation among other factors. It has been observed that in some cases even small rotational perturbations have strong effects on the displacements. These perturbations cannot be ignored or removed unless very restrictive situations are considered. The physical characteristic of a linear inertial seismic sensor generates the sensitiveness to rotation. One possibility to overcome this problem is to record the rotations independently and later correct the perturbed response of the linear sensors.

Boroschek and Legrand (2006) have shown that the effect of rotational motions on the response of common linear sensors can be seen on the apparent change of the zero voltage o zero acceleration of the sensor. If the rotation motional motion has permanent component the effect on the linear sensor can be easily recognize by a constant offset of the records. Nevertheless if the rotational motion does not have permanent or constant rotation it is very difficult to detect its existence. This presents a mayor problem in the interpretation of linear acceleration records because the effect of the rotation cannot be quantify. The effect of rotation motion is not necessarily strong only on displacement records derived from acceleration records, it has also been shown that acceleration can be strongly affect by this phenomena, Boroschek and Legrand (2007).

A basic conclusion is that without a proper knowledge of the effect of the rotation motion on the linear acceleration, it is not possible to remove its effect by baseline correction or by band pass filtering. The concept of correction with preestablished or parametric time domain baselines is relative old and it generally assumes that the rotational effects (together with others effects) are slowly varying functions. This is too simplistic, especially in civil engineering structures. The base rotation of an accelerometer can be related to the actual ground rotation but also due to the flexibility of foundations, elements and systems. This generates a very complex rotational excitation. As example it has been observed in some instrumented bridges that the acceleration response during seismic events has been modified by the rotation of the main girders due to the weigh of the passing vehicles. The amplitude and frequency characteristic of rotations not only depends on the seismic event but also in the number and weight of the vehicles.

The idea that we could eliminate the effect of rotation motions by band pass filtering the response of linear acceleration is not correct. As shown by Boroschek and Legrand, 2006, a simple test on a six degree of freedom shake table shows that if the linear inertial sensors are subjected to broad band rotational motions, those frequency rotational components not removed by filtering will modified the acceleration response.