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## Seismic stations and soil-structure interaction

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At the early stages of seismology, seismic stations were installed directly on rock to minimize the effects of the fine sediments/weathering on the recorded seismic waves. The bulky size of permanent installation seismometers, their need for external batteries, cables and levelling, led to place seismic stations on artificial ground, such as ad hoc concrete platforms. In addition, to ensure protection from environmental conditions, vandalism and to facilitate maintenance, many seismic stations were placed inside structures. A common installation in Italy, as an example, is at the base of the (5-8 m tall) towers of the electrical national service.

The presence of a structure around the instrument perturbs the recorded motion. This phenomenon, generally referred to as soil-structure interaction, can be summarized into three main effects. The first one is the transmission of the structure own motion to the surrounding ground. When seismic waves hit a building, the building enters forced oscillation and this vibration is re-transmitted to the ground. Sensors placed inside the building record, therefore, a composite signal, made of seismic waves and the response of the structure to them. This affects the sensors also when they are isolated from the building foundations by means of cuts around the sensor pillars, because the ground under the pillar and the ground under the structure is the same and is continuous. The second effect lays in the fact that a foundation, typically made of reinforced concrete, acts as a layer with seismic impedance much higher than any natural soil. Seismic waves travelling upwards will be reflected downwards as they hit the foundation. On one side they shake the structure (effect 1), but on the other only a small fraction of them crosses the foundation (effect 2) and can be recorded by the instruments installed on the foundation. The same applies to the concrete pillars where seismic sensors are installed. These installations violate the basic principle of any physical measurements according to which when an interface is needed between the instrument and the object of measurement (the ground) then the interface must have an impedance as close as possible to the object of measurement, in order to minimize the perturbation of the wavefield. Clearly concrete platforms/pillars do not have this property, unless when installed on very stiff rocks. The third main effect (effect 3) concerns the back reflection of the surface waves reaching the foundation. Similarly to effect 2, when surface waves strike an extended rigid layer, such as the foundations of a building, they are mainly reflected back along the Earth's surface. This implies that, in seismic tremor recordings (or seismic events) carried out inside a structure, a fraction of surface waves will be missing.

In this work we show these effects in a number of real cases and we show the consequences that

this can have in the assessment of seismic site effects, of PGA, and on the computation of attenuation laws.