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Real-Time Assessment of Building Response for Earthquake Early Warning Applications

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The study presented here introduces a new approach for real-time building response assessment based on the information provided by an earthquake early warning (EEW) system.

EEW systems (particularly 'regional' ones) typically provide early estimates of earthquake magnitude (M) and hypocenter location (i.e. source-to-site distance, R), as well as warning time to target users and the estimation of ground motion intensity measures (IMs) at the target site. A common approach for IM estimation is to use a ground motion prediction equation (GMPE) based on the estimated M and R values (together with other variables, e.g., the soil type). Current practice is often to trigger a mitigation action when the expected IM based on EEW information exceeds a pre-set threshold. Nevertheless, the shaking experienced in mid-rise to high-rise buildings is generally significantly different from that on the ground and it also differ from one building to another, depending on the building's (dynamic) characteristics.

Therefore, this study first investigates the prediction of the characteristics of shaking that can be expected in mid-rise to high-rise buildings. To this aim, we use a simplified continuum building model consisting of a combination of a flexural beam and a shear beam. By just modifying a single parameter, such a simplified model can account for a wide range of deformation modes in actual buildings, allowing the accurate estimation of lateral acceleration demands in a structural system. In particular, new empirical prediction equations, based on Italian accelerometric data, are developed correlating peak floor acceleration demands for a set of case-study buildings to earthquake-related parameters, e.g., magnitude and source-to-site distance.

A series of illustrative examples show how the newly developed prediction models can be efficiently used, in a Bayesian framework, for building-specific EEW applications based on the (acceleration) response in buildings, such as (1) early warning of floor shaking sensed by occupants; and (2) elevator control.