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The Challenges in Earthquake Loss Modelling at Urban and Regional Levels

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Constructing an earthquake loss model for a city, region or country involves compiling databases of earthquake activity, ground conditions, ground-motion prediction equations, building stock and infrastructure exposure, and vulnerability characteristics of the exposed inventory. This lecture will look at the challenges that a loss modeller is faced with when compiling these databases and combining them within a seismic risk assessment. In particular, the choices related to the geographical resolution of the exposure data, the generation of ground-motion fields in seismic hazard assessment, and the epistemic uncertainty in vulnerability assessment will be covered.

Exposure data available to developers of earthquake loss models is often very crudely aggregated spatially, and in such cases very considerable effort can be required to refine the geographical resolution of the building stock inventory. The influence of the geographical resolution on loss estimates has been investigated to ascertain whether this additional effort is necessary. The results show that although the variability in the estimated losses is reduced when the distribution of the building stock inventory is known to a high resolution, the effect is largely masked by the inherent variability in the ground motion.

Adequate treatment of the spatial and temporal variability in the ground motion is necessary when the aggregate loss due to all possible future earthquake events within a given region needs to be estimated. In this case, the joint probability of shaking at the different sites needs to be estimated in the seismic hazard component of the model. Conventional site-specific probabilistic seismic hazard assessment cannot be directly implemented for this purpose. Instead, an event-based procedure should be applied where a stochastic earthquake catalogue is first generated and then ground-motion fields are simulated for each event in the catalogue. This method requires the modeller to consider issues such as how to model the spatial correlation of the ground-motion variability, which is seen to increase the variance of the losses.

The vulnerability component of a loss model estimates the probability that a given structural typology exceeds a certain damage state (e.g. collapse), given a level of seismic intensity of the ground motion. This vulnerability can be modelled using empirical or analytical procedures, or a combination of the two (hybrid methods). Both approaches have positive and negative aspects and it is often not possible to identify an ideal methodology that should be applied. A logic-tree type approach may be implemented in order to model this epistemic (knowledge-based) uncertainty.

All of these issues will be discussed and illustrated in detail using a number of example loss models.