A Definition Undone: Explicit Estimation of PMLs in the Age of Reliance on Design Ground Motion Records

Author:
Mahmoud M. Hachem, Skidmore, Owings & Merrill LLP, mahmoud.hachem@som.com

ABSTRACT

The term PML, or Probable Maximum Loss, has been employed for many years in the insurance, lending and engineering industries as a means to define the monetary risk -- expressed as a percentage of replacement value -- associated with a particular property experiencing an earthquake. PML studies have mostly been used to facilitate real estate transactions. Over time, a number of definitions of the PML have appeared. One generally agreed upon definition states that the PML represents the economical loss that would not be exceeded for 9 out of 10 buildings under a specific design seismic event. Notably, this technical meaning likely does not comport with the lay meaning that is likely to be attached to the words "Probable Maximum Loss".

Most often, PML estimates are generated by engineering firms utilizing shorthand "black box" methods implemented by commercially available computer software. Generic characteristics of the property such as structural type, number of stories, age and more are input and a PML is output. Notwithstanding the author's suspicions about the validity of such shorthand methods -- particularly in light of the technical definition of the PML, more rigorous engineering and cost estimating methods can also be used to explicitly estimate building response and damage distribution, develop repair scopes and methodologies, and derive costs. However, such explicit methods -- while capable of generating substantially more rational and defensible estimates than shorthand black box software -- also fall short because they are incapable of yielding answers consistent with the technical definition of PML. In short, modern engineering methods and the definition of PML do not play well together.

The discussion herein explores the vagueness of the definition of PML and the obvious inconsistencies between the explicit statistical significance embedded in the definition of PML and what the engineering methods traditionally used to conduct seismic response assessment can deliver, with foci on the ground motion side, on the capacity side of engineered materials and systems, and on the fragility of nonstructural systems. Many of these inconsistencies are applicable to both "shorthand" and explicit PML estimation methods. Included, for example, are discussions of selection and scaling of ground motion records -- a first step in any explicit assessment -- as this pertains to definition of a design event upon which the PML estimate is based.

Further questions are then discussed, including: Are probabilistic seismic hazard maps or site-specific deterministic ground motions to be used? Are mean ground motion estimates to be used, or mean plus 1 sigma motions, or perhaps something else? As is the current fashion, when suites of ground motions are developed, most of which may not control any aspect of the design, how can the record suites be employed to satisfy the PML criteria? Is only the single controlling record to be used in the PML estimate, or are all the records supposed to count? Should directionality be incorporated into the PML? Construction materials all have statistical distributions of strength: should that not be incorporated into a PML? How can damage to nonstructural elements that appear to have rather high variance fragilities be incorporated into a PML? Finally, what does this all mean for practitioners who are asked to develop a PML, and is it even possible that the traditional PML cannot be well-correlated to *any* rational engineering method currently used to seismically assess existing buildings?