Seismic Loss Estimation

By Eugene Trahern, PE, SE, ARM

"Facility Surveys" are most commonly conducted to provide input to business decisions regarding acquisition, financing, or insurance for properties. A structural/seismic review is often performed as a part of the overall facility survey in order to identify earthquake risk to the property in terms of life-safety, property loss, business interruption and liability.

Background: Engineering studies on existing buildings originally only addressed the potential risk to life-safety (i.e. collapse) as the buildings were compared to current building code requirements. However, due to the need for understanding the potential losses associated with a building, crude loss estimation techniques were developed in the 1970's. Additional methods for estimating seismic losses were developed in the 1980's (ATC-13) and continue to be developed and refined today.

Along the way, the term Probable Maximum Loss (or PML) came into use, but had many different definitions based on the risk tolerance of various lenders and owners. Other entities, recognizing the need to limit seismic risk while remaining competitive also adopted "PML" policies which were less defined. The lack of a precise definition has resulted in confusion in the industry and lack of any "standards".

In 1999, ASTM E2029 was produced in order to "standardize" the nomenclature for seismic loss estimation, as well as establish some guidelines as to the level of review and qualifications of the reviewer. The ASTM document recommends the discontinued use of PML, and the use of new nomenclature: Scenario Expected Loss (SEL), Scenario Upper Loss (SUL), and Probable Loss (PL).

Seismic Reviews and Loss Estimation: In order to adequately address seismic loss, there are two primary items which should be addressed: Life-Safety and Loss of Real Property. Acceptable limits of risk for one of these items does not necessarily indicate that the other item is within acceptable limits.

Seismic risk is comprised of three components: Hazard, Vulnerability, and Exposure. Hazards relate to the "external forces" which cause damage, such as ground shaking, liquefaction, surface fault rupture, etc. Vulnerability relates to how well the structure is designed and detailed, along with weaknesses and deficiencies in the structural systems. Exposure is the value at risk, and can be expressed in terms of occupant loading (life-safety) or building value (property loss). A seismic review should indicate whether the structure is likely to collapse under a specified ground motion while a seismic loss estimate should indicate the likely damage to the structure (generally as a percent of building value) under a specified ground motion(s).

The United States Geological Survey (USGS) has recently developed a ground shaking map for the US which considers ground motions generated by all applicable faults as well as the return period for each fault. A commonly used return period for loss estimation is 475-yrs, which represents a 10% chance of exceedance in a 50 year period.

There are several sources of "data" which exists to estimate the damage to particular categories of buildings (ATC-13, Steinbrugge, Thiel & Zutty, proprietary software, etc.). For the most part, data is expressed as a probablility distribution for each level of ground motion and each category of building. This distribution is in the shape of a skewed bell curve. The mean (or top of the curve) represents the best estimate of damage (half have more, half have less) given a large population of building. The 90th percentile is a conservative estimate in which only 10% of the buildings are anticipated to have greater damage. PML used to be defined as the PML mean or PML 90th percentile, however the new ASTM standards recommend the use of the terms Scenario Expected Loss (SEL) and Scenario Upper Loss (SUL), respectively.

Experience and engineering judgment play an important role in attempting to compare a building to other "average" buildings within a classification. Loss estimates should be modified based on positive and negative features specific to each building.

Summary: Seismic reviews and loss estimation are useful tools in helping define seismic risk for lenders and owner. However, as engineers we can not assess our clients "risk tolerance" and thus rely on owners and lenders to establish criteria based on their needs. This criteria should include the level of review desired, qualifications of the reviewer, risk to life-safety, and the ground shaking (return period), confidence level, and limits for potential real property damage. Engineering reports should in turn state the criteria and methodology used in the review.

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