

Seismic Risk Assessment - Probable Maximum Loss Estimate

Seismic Risk Assessments (SRA), sometimes referred to as Probable Maximum Loss or PML reports, can help property owners, investors, and lenders to screen commercial properties for significant earthquake risks.

There are many protocols for evaluating seismic risks; however, most assessments are based upon the ASTM Standards E2557 Standard Practice for Probable Maximum Loss (PML) Evaluations for Earthquake Due Diligence Assessments and E2026 Standard Guide for Seismic Risk Assessment of Buildings.

Probable Maximum Loss (PML) is a user-defined term that relies on statistical parameters for ground shaking and damage probability identified by the client. Interpreting the findings of PML reports requires an understanding of a few key variables.

Key Variables

Ground Shaking – The intensity of ground shaking varies at properties depending upon the distance to an earthquake, and the type and condition of soils both at the site and between the site and epicenter of the earthquake. SRA reports typically rely on estimates of ground shaking intensity provided by USGS. The USGSs estimates are periodically updated to reflect new geological, geophysical, and seismological data or ground motion prediction models. Estimated ground shaking is generally based on a 10% chance of exceedance in 50 years, ground shaking with a 475-year return period, and is not intended to reflect the greatest possible ground shaking at a property. Additional ground shaking scenarios can be requested by the client.

Building Damageability – Damage in the event of an earthquake is evaluated based on the historical performance of similar buildings and characteristics and may reflect property-specific design elements and construction quality.

Soils – Soil type and depth of groundwater can impact the intensity of ground shaking at properties as well as the potential for soils to lose the ability to support improvements due to liquefaction.

Resonance – When subjected to shaking, buildings oscillate in a wave pattern. When the frequency of building movement is similar to that of an earthquake, damage can be aggravated; or when the two are dramatically different, damage can be lower than expected. Though this can have a significant impact on building damage, information adequate to evaluate resonance is not typically available or considered except in intensive, high-level investigations.

Confidence Level – Ultimately, PMLs are based on statistical analysis and a damage curve can be developed where a very favorable scenario would mean the building sees very little damage and a very bad scenario would include 100% damage. Engineers report the statistical middle of the curve, the Scenario Expected Loss (SEL), with a 50% chance of exceedance and report the reasonable worst-case scenario, the Scenario Upper Loss

(SUL), with a 10% chance of exceedance. Nether estimate represents the greatest possible damage to improvements at the property.

Scope of Work

The depth of assessment is another user-defined variable. Users should work with their consultant to assure their concerns are adequately addressed by the SRA. ASTM standards provide for varying degrees of assessment. Level 0 reports provide a basic screening of properties, but are based on extremely limited information, resulting in the highest degree of uncertainty. Additional confidence can be achieved through Level 1 or higher levels of assessment.

The Level 1 scope of assessment is frequently used to improve the confidence in Seismic Risk Assessment without the expense of more detailed engineering studies. The precise scope of Level 1 assessment should be documented by contract, but generally includes:

- Observation of readily accessible and easily visible building components
- Review of plans, soils reports, prior estimates of PML, regulatory files and other relevant documents provided during completion of the work. (Research to obtain additional documents may be conducted but may result in higher costs.)
- Review of select published resources to estimate ground shaking, building stability and site stability
- Development of opinions of Scenario Expected Loss and/or Scenario Upper Loss, site stability and building stability.

Objectives

The objective of each assessment should be documented by the contract and may be referenced in the report. Since the appropriate scope of work and key variables may differ depending on the objective and risk tolerance of the client, reports should only be used for the agreed upon purpose.

Reliance and Use

Seismic Risk Assessments are prepared under contract for the benefit of specific users. No third-party beneficiaries are intended, and reports should not be used or relied upon by others without the express written authorization of the consultant and thorough review to assure satisfaction of the user's needs.

Limitations

Unless otherwise agreed, Seismic Risk Assessments are subject to the following limitations:

- **No warranty of performance:** The assessment is not a warranty of future building performance and the user should not consider a Seismic Risk Assessment as a substitute for insurance.

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- **PML studies should not be used to determine if a building will provide adequate earthquake safety to occupants. For this use, other types of assessments are recommended.**
- **Risk is not eliminated:** Assessments are limited by the agreed scope of services and are not intended to be exhaustive.
- **Other Types of Loss:** Owners who see their building damaged in an earthquake may experience other losses that are not estimated by the PML. For example, lost rents, damages to the contents of the building, market stigma, and repairs that cost more due to elevated construction costs or code compliance issues. SRAs generally do not opine on these costs.
- **Statistical Models:** The statistical models used in SRAs are generally not developed by the engineering firm applying the model. Models depend on data of building and system performance and because the United States has not had many major earthquakes in urban centers, there are large data gaps for some building types. Advanced methods like computer modeling and ASCE 41 Tier I and Tier II evaluations can be used to refine the evaluation of damageability, but significant increases in information, time and engineering evaluation consistent with ASTM E2026 Level 2 or Level-3 assessments, result in increased costs and longer turn-around times than the Level 1 PML studies. As of the date of the white paper, the commercial real estate finance industry and most commercial real estate buyers customarily rely on the quicker and less expensive Level 1 models.
- **Published Sources:** Unless site-specific data is available, information and methods such as liquefaction potential and proximity to active faults are based upon resources developed governmental agencies.
- **Exclusions:** The work excludes removal or relocation of obstructions; testing building components; design services such as evaluation of the adequacy of design or compliance with current building code requirements; evaluation of the condition of improvements; and all other matters not required in developing the estimate of building damage.
- **Temporal Considerations:** Reports represent the consultant's opinion at the time of preparation. Since conditions at the property and the availability of information may change and the knowledge of ground shaking and building performance is not static, aging reports may not reflect current opinions.
- **Other Limitations and Considerations:** Users are encouraged to review the referenced standards and consult a professional to help assure related investigations are consistent with their risk tolerance.

Frequently Asked Questions

Do I need a new report?

Reports represent the consultant's opinion at a point in time. Since conditions at the property and available information may change and the understanding of ground shaking and building performance is not static, aging reports may not reflect current opinions. Reports provide an opinion of damageability at the time

of the report and should only be used by the original client and for the original purpose. Users most often assume that reports are no longer useful after six to twelve months.

I have two reports by different consultants or performed at different times. Why are the conclusions different?

Reasonable engineers can differ when predicting the future. Since the Practice allows clients to define key variables and methods for estimating loss can support different conclusions, the results of assessments for different clients or by different consultants can differ. Differences among reports can also result from changes in the state of industry knowledge, conditions at the property, extent of research, and information available for review as well as opinions of the consultant and models used in the analysis. For example, USGS Hazard Model values are updated periodically, based on the updated seismic activity. As a result, PGA values may increase, or be decreased, potentially affecting real estate purchase or re-finance decision-making. Considering the extent of variables, reports prepared at different times or by different consultants would not be expected to reach identical conclusions.

What is an acceptable PML estimate?

This depends on the user's risk tolerance and objectives. Many users consider an estimated SEL of 20% or less to be acceptable, though some users establish thresholds based on the estimated SUL. Users should carefully consider the degree of risk inherent in the estimate. For sensitive operations or high value properties, and for significant investments, more restrictive thresholds could be appropriate. Note that many municipalities have robust mandatory retrofit programs that are keyed to providing public safety with no regard for damageability thresholds.

What standards should be referenced in the Scope of Work?

ASTM has published two standards for seismic risk assessment:

E2026 Standard Guide for Seismic Risk Assessment of Buildings provides structured guidance for various levels of study to evaluate ground shaking, site stability, building stability, building damageability, contents damageability, and business interruption.

E2557 Standard Practice for Probable Maximum Loss (PML) Evaluations for Earthquake Due Diligence Assessments provides a more targeted protocol for use in PML assessments.

Who can perform the report?

Level 0 reports can be prepared by anyone.

Level 1 and more detailed studies require the oversight of an engineer with experience in seismic design and evaluation.

Are the reports stamped by an engineer?

Level 1 and above assessments rely on a combination statistical models and the informed opinion and experience of the preparer. Though the assessment may be overseen by an engineer, no

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design services are provided. As a result, the assessment is not considered to be an engineering work product and need not be stamped.

Are E2557 appendix forms X4 and X5 required?

The inclusion of appendix form X4 is optional. Though language on the form states that the form “is to be completed and attached to all reports”, section 6.5.1.10 of the Practice states that the form should, not must, be included in reports.

Will the report identify mandatory retrofit requirements implemented by municipalities?

No, not according to the ASTM defined scope of work. However, a user could reasonably ask for the consultant to include a discussion of municipal requirements for seismic retrofit.