Beyond the SEL:
Building and Site Stability in Seismic Risk Assessments

Seismic Risk Assessment

Seismologists with the United States Geological Survey (USGS) have little doubt that the United States will face a major earthquake within the next 30 years, and with nearly one quarter of all Americans living in areas vulnerable to earthquake hazards, this is a profound statement. Earthquakes can cause devastation on a mass scale, damaging or completely destroying buildings and potentially harming people. Using statistical and historical data, it is possible to quantify the extent of potential damage from earthquakes by means of a Seismic Risk Assessment (SRA). When performed for purposes of property due diligence, SRAs help anticipate the damage incurred by buildings in the face of a building code level seismic event and the degree of related damage.

ASTM International produced standard E2026 in 1999 to establish industry nomenclature and as a guide to seismic loss evaluations. This streamlined the assessment process and lead to the concept of Scenario Expected Loss (SEL), a percentage that represents the 50% confidence level on building damage for a particular type of building at a particular location. The SEL has long been used as the primary determinant of seismic risk and estimated damage. However, when ASTM standard E2026 was updated in 2016, an important distinction was made, requiring the reporting of building and site stability in addition to the SEL.

Site Stability

Example of Damage from Soil Liquefaction

Site stability focuses on external earthquake-induced threats to a site's stability, the most common being landsliding, soil liquefaction, or faulting. Landsliding, in response to an earthquake ground motion, happens when soil and rock material rapidly move downslope, which is particularly concerning for properties built on or backing to steep slopes or hillsides. Soil liquefaction occurs in areas with loose, saturated, sandy soil, which transforms into a fluid-like state. It is especially a concern in areas where there is a high water table and the structure is not provided with a deep foundation system (caissons or piles) or other form of ground mitigation. Earthquake ground fault rupture concerns the risk of active fault movements breaking through to the ground surface, thereby creating site instability.

A site stability assessment consists of the review of published maps and databases from federal, state or local government agencies identifying landsliding, liquefaction, or active fault zones. Where available, the assessment also includes the review of site-specific geotechnical investigation reports that address the potential for seismic induced hazards.

Building Stability

Unlike site stability, which is concerned with external hazards, building stability is concerned with the construction type, configuration and condition of the structural elements. Specifically, it determines whether a building will remain stable through an earthquake by assessing a building's structural integrity and load carrying-capacity during a seismic event. Similar to a building code review of a structure, a building stability assessment involves reviewing available construction documents (e.g. structural drawings), as well

as onsite visual observations of the structural elements to assess the lateral load-resisting systems (the elements of the structural system such as shear walls and moment-resisting frames that provide support and stability to the building under seismic and wind forces). Certain conditions may determine if there is instability in whole, or in part, for the building, creating the potential of total collapse or localized falling hazards during a code level earthquake event.

Some examples of instability in whole are the soft or weak story at a building's first level, discontinuous shear walls or other types of vertical irregularities, lack of sill plate anchorage of wood sill plates to foundations, or lack of substantial wall to roof anchorage ties (for example, in masonry or concrete tilt-up buildings).

Example of Failure in Concrete Tilt-Up Building

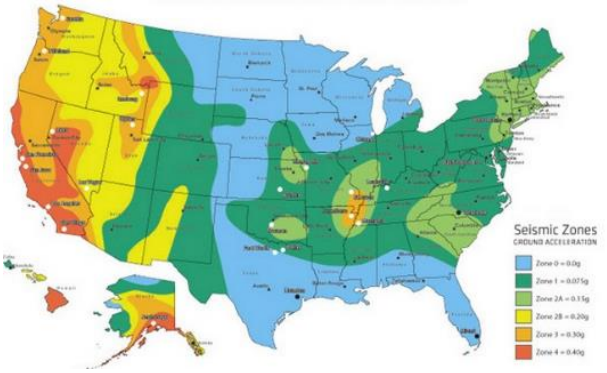
Some examples of instability in part are unbraced canopies or parapets, brick veneer lacking sufficient anchorage to the primary structural or curtain wall framing, or architectural pre-cast panels lacking sufficient anchorage or bracing. These conditions have the potential to create falling hazards during a code level earthquake event, but do not represent a global instability in whole condition such as those mentioned above.

Beyond the SEL

The updated ASTM requirements have brought into new light the importance of building and site stability in understanding seismic risks beyond the SEL, and the CRE industry has been taking notice as more lenders require adherence to the current ASTM seismic standards (2026-16a and 2557-16a). Additionally, several cities have implemented ordinances requiring that structures not meeting building stability standards be retrofitted. As mentioned above, before these ASTM updates, the primary concern with SRAs was the outcome of the SEL. The issue of building stability is somewhat independent of an actual loss percentage, so it is not unheard of for a vulnerable building to receive an SEL in an acceptable range, but have conditions of instability. The ASTM revision and city ordinances were created to ensure critical life safety deficiencies such as a soft story are adequately documented in the SRA report and potentially mitigated through a retrofit. Having the data on building or site stability, in addition to the SEL, puts investors, owners, insurers and lenders in a better position to leverage a deal or protect their assets.

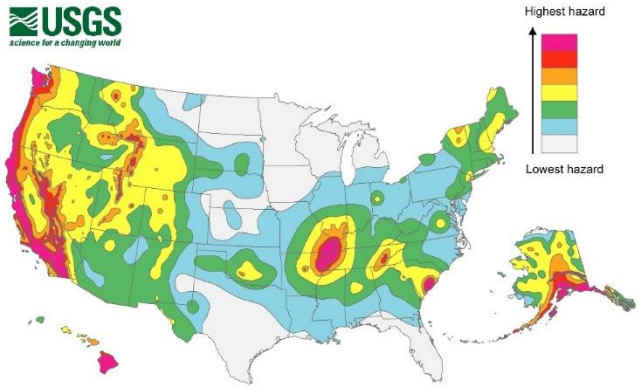
Updated Maps and Expanded Areas of Risk

The need for SRAs is often reserved for properties located along major fault lines in California, as well as areas of the western US previously classified as seismic zone 3 under the 1997 Uniform Building Code (UBC): Seattle, WA, Salt Lake City, UT, and Portland, OR. However, updated models from the USGS point to sometimes overlooked cities, such as Memphis, TN, and Charleston, SC which have significant risk of major earthquake occurrences.



UBC Seismic Zone Map (1997)

The seismic map shown here is based upon the peak ground acceleration (PGA) data from the USGS, effective for 2014. In comparison to the 1997 UBC seismic map, this represents a significantly more recent compilation of data and research. PGA data provides a more accurate representation of risk as it is mapped in higher detail, incorporates local effects such as fault proximity, and is updated regularly by USGS. Areas demonstrating seismic risk under the 2014 USGS include, but are not limited to: an expanded area around western Tennessee (including Mississippi, Arkansas, and Missouri), eastern Tennessee near Knoxville, and Charleston, South Carolina.



USGS Seismic Map (2014)

Best Practices

If a property of interest falls within these hazard zones, hiring an engineering consultant is the best measure to determine the stability of the structure. SRAs should be customized to meet the client's specific needs, whether they are a lender, an insurance company, owner or prospective owner. As such, EBI Consulting takes a project management approach, considering the client's business needs and risk tolerance in conjunction with the site's seismic zone, local ordinances, and seismic standards (client scope of work) to which an investment is held. Following the highest standards outlined by ASTM, those preparing reports and field assessors should be registered Professional Structural Engineers for a Level I investigation or higher. As a minimum, each report should contain the following:

- Property information and description of buildings,
- Review of site seismic hazards and site stability,
- A list of documents reviewed, such as structural drawings,
- Level of review provided by the report,
- Estimation and definition of building loss and the analysis and methods used to determine loss,
- Determination of building stability (collapse potential) and methods used to reach opinion, and
- Qualifications of the reviewer and those conducting the site visit.

It is especially crucial to hire a consultant who adheres to the latest ASTM standards in their Seismic Risk Assessments, addresses site and building stability concerns, and interprets findings when necessary.

Case Study

The significance of an ASTM building stability evaluation can be demonstrated by the case of a small apartment building in California. The first level of this building consisted of tuck under parking. When a structure lacks walls or frames on the first floor, it becomes substantially weaker and more flexible than the stories above. When this level is less than 70% as stiff as the floor immediately above, it creates a soft story condition. Very often, a soft story is also accompanied by a weak story that is less likely to carry the weight of the stories above during an earthquake.

The prospective buyer at the time obtained a Seismic Risk Assessment as part of his acquisition due diligence. Given the conventional wood frame construction and low site hazards, the SRA resulted in a Scenario Expected Loss (SEL) of 18%, despite the soft story condition. Under the ASTM standard in effect at the time, building stability was not a specific concern, and the buyer and his lender completed the acquisition without considering a retrofit or earthquake insurance.

Building failure due to soft story condition caused by tuck-under parking

After the initial report on the property, as part of a refinance, the owner retained EBI Consulting to complete a new SRA. This SRA also resulted in an SEL of 18%, but in accordance with the new ASTM standard, it stated that the property did not meet building stability requirements because of the soft story condition. The significance of this statement, now an ASTM 2026-16a requirement, became clear to the owner and his lender in a way not previously considered: they came to understand that it was not simply the loss estimate, but also the presence of building or site instabilities that could raise red flags for a property. EBI worked with the parties to assist them in understanding the issue, then developed a seismic retrofit concept and cost opinion that allowed the owner and his lender to proceed with the refinance in a timely manner.

Experience and Expertise

Choosing the right consulting firm is essential to fully understand a site's seismic risks and adequately protect one's interests. Over the past 20 years, EBI Consulting has completed thousands of seismic risk assessments and remains at the forefront of assisting commercial real estate owners, managers, investors and lenders in better understanding the implications of seismic risk in their businesses. EBI's expert engineers have long followed the practice of considering building stability and site stability in their reports, even before ASTM updated its standards to include them. EBI continues to follow the highest standards of excellence as outlined by the ASTM. Our reports have been accepted by Fannie Mae, Freddie Mac, HUD, and most CMBS and insurance industry investors. Consider the case study above as a testament to the value of having SRAs performed by EBI Consulting's knowledgeable and proactive team. By adhering to the highest standards, employing the best methods available, and leveraging practical engineering expertise, EBI Consulting can save time and allow transactions to run smoothly, while giving confidence to all interested parties.

About the Author

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Mr. Chan is a registered professional engineer has over 15 years of experience in the structural engineering, seismic design and construction field. His expertise includes the design and analysis of commercial, residential and institutional projects. Mr. Chan also has 5 years of experience in the structural evaluation of existing properties, including the preparation of over 1000 seismic reports for real estate due diligence studies. At EBI Consulting, Mr. Chan specializes in structural risk evaluation and structural condition assessments.

To learn more about how EBI Consulting and our Seismic Risk Assessment services, please visit our website or contact us.

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