Designation: E2557 – 16

AnAmerican National Standard

Standard Practice for Probable Maximum Loss (PML) Evaluations for Earthquake Due-Diligence Assessments[1,2]

This standard is issued under the fixed designation E2557; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice establishes standard-of-care for evaluation and classification of the financial risks from earthquake damage to real estate improvements for use in financial mortgage transactions and capital investment evaluation. As such, this practice permits a user to satisfy, in part, their real estate transaction due-diligence requirements with respect to assessing and characterizing a property's potential losses from earthquakes. This practice is intended to address only physical damage to the property from site and building response.

1.1.1 Hazards addressed in this practice include earthquake ground shaking, earthquake-caused site instability, including faulting, subsidence, settlement landslides and soil liquefaction, earthquake-caused tsunamis and seiches, and earthquake-caused flooding from dam or dike failures.

1.1.2 Earthquake-caused fires and toxic materials releases are not hazards considered in this practice.

1.1.3 This practice does not purport to provide for the preservation of life safety, or prevention of building damage associated with its use, or both.

1.1.3.1 This practice does not address requirements of any federal, state, or local laws and regulations of building construction or maintenance. Users are cautioned that current federal, state, and local laws and regulations may differ from those in effect at the times of construction or modification of the building(s), or both.

1.1.3.2 This practice does not address the contractual and legal obligations between prior and subsequent Users of seismic risk assessment reports or between providers who prepared the report and those who would like to use such prior reports.

1.1.3.3 This practice does not address the contractual and legal obligations between a provider and a user, and other parties, if any.

1.1.4 It is the responsibility of the owner of the building(s) to establish appropriate life-safety and damage prevention practices and determine the applicability of current regulatory limitations prior to use.

1.2 Considerations not included in the scope: the impacts of damage to contents, loss of income(s), rents, or other economic benefits of use of the property, or from legal judgments, fire sprinkler water-induced damage or fire.

1.3 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

2. Referenced Documents

2.1 *ASTM Standards:*[3]

E2026 Guide for Seismic Risk Assessment of Buildings

2.2 *Other Standards:*[4]

UBC-97 Uniform Building Code, 1997 Edition

IBC International Building Code, current edition

2.3 *ASCE Standards:*[5]

ASCE 7 Minimum Design Loads for Buildings and Other Structures, current edition

ASCE 41 Seismic Evaluation and Retrofit of Existing Buildings, current edition

3. Terminology

3.1 See also definitions in Guide E2026.

3.2 *475-year site ground motions, n*—seismic induced ground motions at a site with approximately: a return period of 475 years, a 10 % probability of exceedance in 50 years, and an annual frequency of 0.21 %. Also referred to as the DBE.

3.3 *field assessor, n*—field assessor, as defined in Guide E2026.

[1] This practice is under the jurisdiction of ASTM Committee E06 on Performance of Buildings and is the direct responsibility of Subcommittee E06.25 on Whole Buildings and Facilities.

Current edition approved Jan. 1, 2016. Published June 2016. Originally approved in 2007. Last previous edition approved in 2007 as E2557-07. DOI: 10.1520/E2557-16.

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[3] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[4] Available from International Code Council (ICC), 500 New Jersey Ave., NW, 6th Floor, Washington, DC 20001, http://www.iccsafe.org.

[5] Available from American Society of Civil Engineers (ASCE), 1801 Alexander Bell Dr., Reston, VA 20191, http://www.asce.org.

3.4 *independent reviewer, n*—independent reviewer, as defined in Guide E2026.

3.5 *lateral load-resisting system, n*—lateral load-resisting system, as defined in Guide E2026.

3.6 *MCE, n*—Maximum Capable Earthquake, as defined in Guide E2026.

3.7 *probable loss (PL), n*—probable loss, as defined in Guide E2026.

3.7.1 *Discussion*—When there are multiple buildings in the seismic risk assessment, then the damageability values for the group of buildings is to be determined as specified in Guide E2026.

3.8 *probable maximum loss (PML), n*—probable maximum loss, as defined in Guide E2026.

3.9 *provider, n*—provider, as defined in Guide E2026.

3.10 *scenario expected loss (SEL), n*—scenario expected loss, as defined in Guide E2026.

3.10.1 *Discussion*—When there are multiple buildings in the assessment then the SEL for the group of buildings is to be determined as specified in Guide E2026, Section 5.3.

3.11 *scenario loss (SL), n*—scenario loss, as defined in Guide E2026.

3.11.1 *Discussion*—When multiple buildings are in the seismic risk assessment, then the SL for the group of buildings is to be determined as specified in Guide E2026, Section 5.3.

3.12 *scenario upper loss (SUL), n*—scenario upper loss, as defined in Guide E2026.

3.12.1 *Discussion*—When there are multiple buildings in the assessment then the SUL for the group of buildings is to be determined as specified in Guide E2026, Section 5.3.

3.13 *SEL475, n*—the scenario expected loss due to the occurrence of 10 %/50-year site ground motions.

3.14 SEL_{MCE}, *n*—the scenario expected loss due to the occurrence of MCE site ground motions.

3.15 *senior assessor, n*—senior assessor, as defined in Guide E2026.

3.16 *significant damage, n*—significant damage, as defined in Guide E2026

3.17 *SUL475, n*—the scenario upper loss due to the occurrence of 10 %/50-year site ground motions.

3.18 SUL_{MCE}, *n*—the scenario upper loss due to the occurrence of MCE site ground motions.

4. Summary of Practice

4.1 The objectives of this practice are as follows:

4.1.1 To synthesize and document good commercial practice for the determination and rating of seismic risk for buildings.

4.1.2 To facilitate standardization of earthquake risk evaluation terminology for financial transactions.

4.1.3 To establish an industry standard for the requirements to evaluate the financial risk for real estate.

5. Significance and Use

5.1 This practice is intended for use as a voluntary standard by parties who wish to undertake the seismic risk assessment of properties. The goal is for users to objectively and reliably compare the financial risks of earthquake damage to buildings, or groups of buildings, on a consistent basis.

5.2 This practice is designed to provide requirements for the evaluation of earthquake damage risk so that technical reports prepared for the evaluation and rating of seismic risk of a building(s) will be adequate for use by other entities. Potential users including, but are not be limited to, those making equity investments, lending, and financial transactions, including securitized mortgage lending by mortgage originators, loan servicers, underwriters, rating agencies, and purchasers of bonds secured by the real estate.

5.3 The use of this practice may permit a user to satisfy, in part, their requirements for due diligence in assessing a property's potential for losses associated with earthquakes for real estate transactions.

6. Due-Diligence Investigation

6.1 The site stability, building stability and building damageability of the property shall be assessed.

6.2 The user shall specify the condition of the property to be evaluated. The seismic performance can be evaluated for the property in its current condition, or as changed by proposed modification of the seismic response of the soils supporting the building or a proposed seismically retrofitted condition of the building(s) or its sections, or any combination of these conditions.

6.2.1 The proposed seismic modifications of the site must be sufficiently described to allow evaluation of the modifications by an Independent Reviewer.

6.2.2 The proposed seismic modifications of the building systems must be sufficiently described to allow evaluation of the modifications by an Independent Reviewer.

6.3 The Guide E2026 level of investigation shall be specified by the user. The same level of investigation should be performed for each type of the seismic risk assessment. Appendix X1 gives guidance on the setting of the level of investigation.

6.4 The qualifications of the Provider shall be specified as required for the level of investigation specified in 6.3 of Guide E2026. The qualifications level must be equal to or higher than the corresponding level specified in 6.2 and 6.3.

6.4.1 For an assessment of Level 1 or higher, the qualifications of Senior Assessor and the Field Assessor of the property and its buildings shall be those of Guide E2026 Sections 6.2.3.2 and 6.2.3.3.

6.4.2 Notwithstanding the asserted level of investigation of a report, if the Senior Assessor or the Field Assessor, or both, do not demonstrate the qualifications of Guide E2026 Section 6.2.3.2 and 6.2.3.3, then the report shall be designated a Level 0 report.

6.5 *Seismic Risk Assessment Report*—The findings shall be reported in conformance to the requirements of Guide E2026

for the level of investigation specified by the user in 6.3 and by a provider qualified in accordance with the requirements of 6.4, with the following sections:

6.5.1 A summary that contains the conclusions of the seismic risk assessment:

6.5.1.1 Location of the building(s), characterization of the site and site soils, and gravity and lateral load-resisting systems.

6.5.1.2 Stability determination of each building site under consideration when subjected to the seismic loadings for the building site location and building characteristics as set forth in Section 9 of Guide E2026. Site stability determination need only be qualitative in nature for an SS0 investigation. For SS1 investigations the site stability is a qualitative assessment that includes the implications on damage to the building structural elements. For SS2 and SS3 investigations the site should be considered unstable if significant damage is caused to the building by the site instability.

6.5.1.3 Stability determination of each building under consideration in the seismic loadings for the building site location and building characteristics and for the level of investigation specified, as set forth in Section 8 of Guide E2026.

6.5.1.4 The building damageability values for the building or group of buildings as a whole for the level of investigation specified as set forth in Section 10 of Guide E2026.

(1) PML shall be user-defined. At a minimum, the SEL_{DBE} and SUL_{DBE} shall be reported.

NOTE 1—CMBS industry is currently defining PML as SEL_{DBE}. It is advisable that SEL and SUL values also be reported for MCE events in areas of low and moderate seismicity areas where MCE poses significantly higher risk than the DBE.

6.5.1.5 A specification of the level of investigation for each assessment and a review of the methods used and the personnel engaged.

6.5.1.6 Results for each of the conditions described in 6.2 that apply.

6.5.1.7 Appropriate reliance language for the report and signature. For Level 1 or higher investigations, the professional seal of the provider.

6.5.1.8 All deletions and deviations from this practice (if any) shall be listed individually and in detail.

6.5.1.9 The report conclusion shall include the following statement: “We have performed a probable maximum loss (PML) evaluation for earthquake due diligence assessment in conformance with the scope and limitations of Guide E2026 and Practice E2557 for a Level XX (specify) assessment of [insert address or legal description], the property. Any exceptions to, or deletions from, this practice are described in Section [ ] of this report. This probable maximum loss (PML) evaluation for earthquake due diligence assessment has determined the PML to be [ ]%.” PML is defined as [fill in the definition used]. The project [meets/does not meet] the building stability and [meets/does not meet] the site stability requirements.

6.5.1.10 Each report should include a completed Appendix X2.

6.5.1.11 Each report should include a completed Appendix X3.

6.5.2 A body of the report that provides:

6.5.2.1 All detailed reporting information required by Guide E2026, Section 13, including the basis and background for the work performed in support of the conclusions presented in the report.

6.5.2.2 PML values for each building, and, if appropriate, for the group of buildings.

(1) Report of any other information required by the user, which may include business interruption, and contents damageability.

(2) The organization that commissioned the report and the professional liability limitations of the report provider shall be disclosed in the report.

6.5.3 Attachments and appendices to the report as appropriate including detailed resumes of the Senior Assessor and the Field Assessor that demonstrate their qualifications to perform this work as stated in this Practice.

APPENDIXES

(Nonmandatory Information)

X1. LEVEL OF INVESTIGATION

X1.1 The selection of the level of the investigation performed should be guided by the level of uncertainty in the result that is acceptable to the User. In addition, two guidance tables are provided: *1)* based upon the level of uncertainty in the results and *2)* based upon the building replacement cost.

X1.1.1 If the degree of uncertainty is the guiding consideration in selecting the level of investigation, then Table X1.1 is offered as a guide to selection of the levels of investigation to match the acceptable level of uncertainty. The zone references are from the map of seismic zones as it appears in UBC-97, which is reproduced in Fig. X1.1. The acceptance uncertainty levels are not defined, but are given to reflect the progression of investigation levels with changes in acceptable uncertainty.

X1.1.2 If the cost of replacement of the building is the guiding consideration in selecting the level of investigation, then Table X1.2 is offered as a guide to selection of the levels of investigation.

X1.1.2.1 The rationale for changing requirements for different property values is as follows. It is expected that the uncertainty in seismic loss for a given property will decrease significantly with increasing level of investigation. Since most loans will be part of a limited group of financial commitments, the larger an individual loan, the greater is its participation as a fraction of the total risk of the group. A method to reduce the level of uncertainty is to require a higher level investigation for the greater value property. When the pool gets larger, say for a security, then the impact is the same. Therefore, it was assumed in preparing the table threshold values that some parity was needed to keep the uncertainties of the same order for groups of lower property values compared to one larger property.

X1.1.2.2 It should be noted that the costs of doing higher-level investigations are higher and they do not go up linearly, so there is an administrative cost of the decisions made based on this table.

X1.2 The seismic zone references in Tables X1.1 and X1.2 are from the map of seismic zones as it appears in the UBC-97 which is reproduced in Fig. X1.1. These maps were developed so that each zone corresponded with a range of peak ground accelerations associated with the DBE. While there are more recent seismic risk maps, these generally require specific information on the seismic response characteristics of the site and structure that are seldom available before the seismic risk assessment has begun. Therefore, for ease and consistency of use, the 1997 map is used.

X1.2.1 Where a digital ground motion tool (such as the USGS website) is used to determine PGA the DBE for use of these Tables, then the Zone can be determined from the PGA assessed for the specific site assumed to be ASCE-7 Soil Class D, and as follows: if the PGA $\geq$ 0.35 g, then use Zone 4, if 0.25 g $\leq$ PGA $<$ 0.35 g, then use Zone 3, and if 0.175 g $\leq$ PGA $<$ 0.25 g, then use Zone 2, and for all others use Zone 1. While these are not exact, they will lead to more precise site values than use of the maps, particularly near the zone boundaries. It must be noted that the UBC maps were not developed to reflect the exact boundaries of ground motions, but to reflect professional judgment on the part of the UBC for the appropriate relative seismic hazard for design of the sites. The digital procedure may not yield identical Zone assignment for the site as estimated from the UBC map, but are expected to be on average consistent zone determination of the UBC map, and sufficiently accurate for this purpose of determining what level of investigation should be made. When a map is used to determine the need for a seismic assessment, it is prudent to include in a Provider's scope-of-work confirmation of whether the criteria of the User are met to complete a seismic assessment before significant effort is undertaken to complete the assessment.

X1.3 Use of either the Map tool or a web-based DBE determination as suggested always has some uncertainty in whether these tools yield a reliable result. If the User has a low tolerance for making mistakes in determining whether a PML assessment is required, then it is advised that the DBE be determined numerically, and the threshold ground motions of X1.1.1 for requiring a PML assessment be decreased by 0.05 g from those given.

TABLE X1.1 Seismic Zone of the Site and the Level of Uncertainty Acceptable to the User

Acceptable Uncertainty Level	Zones 0, 1	Zones 2A, 2B	Seismic Zone/UBC-97	
			Zone 3	Zone 4
Low	none	BS0, SS0, BD0	BS1, SS1, BD1	BS2, SS2, BD2
Moderate	none	none	BS0, SS0, BD0	BS1, SS1, BD1
High	none	none	none	BS0, SS0, BD0