US Army Corps of Engineers®

ENGINEERING AND CONSTRUCTION BULLETIN

No. 2015-5 **Issuing Office:** CECW-CE **Issued:** 12 Feb 2015 **Expires:** 12 Feb 2017

Subject: Design Earthquakes, Ground Motions and Foundation Evaluations for Substantial Fill Projects

Applicability: Guidance

1. Purpose: This bulletin transmits clarifications of guidance for design earthquakes with associated performance requirements to assure that all features of substantial fill projects meet minimum seismic standards for serviceability and safety.

2. References:

a. ER 1110-2-1806, "Engineering and Design: Earthquake Design and Evaluation for Civil Works Projects"
http://www.publications.usace.army.mil/Portals/76/Publications/EngineerRegulations/ER_1110-2-1806.pdf

b. EM 1110-2-6053, "Engineering and Design: Earthquake Design and Evaluation of Concrete Hydraulic Structures'
http://www.publications.usace.army.mil/Portals/76/Publications/EngineerManuals/EM_1110-2-6053.pdf

3. Background: The 1995 publication of ER 1110-2-1806 has a gap in the guidance for the definition of the minimum Maximum Design Earthquake (MDE) for noncritical project features, as expressed in terms of design earthquake return period. In addition, it does not explicitly state the need to assess earthquake induced excess pore water pressure generation in the seismic evaluation or clearly state the need for the assessment of seismically induced deformation. This ECB addresses these deficiencies for substantial fill projects.

4. Attachment A provides clarifications for design earthquakes and foundation evaluations for seismic considerations for substantial fill projects.

5. Distribution: Unlimited.

6. The points of contact for this ECB are Dr. Joseph Koester, CECW-CE, 202-761-4828, Dr. Robert Ebeling, CEERD-IE, 601-634-3458 and Richard Ludwitzke, CECW-CE, 202-761-1580.

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JAMES C. DALTON, P.E., SES
Chief, Engineering and Construction
U.S. Army Corps of Engineers

Attachment A
Guidance Clarifications for Design Earthquakes and Foundation Evaluations Due to Seismic Considerations

1. Design Earthquakes and Ground Motions:

a. Maximum Credible Earthquake (MCE). This earthquake is defined as the largest earthquake that can reasonably be expected to be generated by a specific source on the basis of seismological and geological evidence. Since a project site may be affected by earthquakes generated by various sources, each with its own fault mechanism, maximum earthquake magnitude, and distance from the site, multiple MCE's may be defined for the site, each with its own characteristic ground-motion parameters and spectral shape. The MCE is evaluated using Deterministic Seismic Hazard Analysis (DSHA) methods informed by results from a Probabilistic Seismic Hazard Analysis (PSHA). Since different sources may result in differing spectral characteristics, selection of "maximum" ground motion parameters may need to consider different sources and magnitude events to consider the full range of possible maximum loadings e.g., peak ground acceleration from one source may be higher than from another, but reversed for one second spectral acceleration values. Therefore, both sources may need to be considered in analysis to assess the full range of potential "maximum" loadings. There is no return period for the MCE but 10,000 years will be used if needed for analysis.

b. Maximum Design Earthquake (MDE). The MDE is the maximum level of ground motion for which a structure is designed or evaluated. The associated performance requirement is that the project performs without loss of life or catastrophic failure such as an uncontrolled release of a reservoir, although severe damage or economic loss may be tolerated. For critical features, the MDE is the same as the MCE. Critical features are the engineering structures, natural site conditions, or operating equipment and utilities at high hazard projects whose failure during or immediately following an earthquake could result in loss of life. Further details are given in paragraph 5a of ER 1110-2-1806. For all other features, the minimum MDE is an event with a 10% probability of exceedance in 100 years (average return period of 950 years) assessed using a PSHA informed by the results of a site-specific DSHA. The MDE can be characterized as a deterministic or probabilistic event.

c. Operating Basis Earthquake (OBE). The OBE is an earthquake that can reasonably be expected to occur within the service life of the project, typically a 50% probability of exceedance in 100 years (average return period of 144 years) assessed using a PSHA informed by the results of a site specific DSHA. The associated performance requirement is that the project functions with little or no damage and without interruption of function. The purpose of the OBE is to protect against economic losses from damage or loss of service, therefore, alternative choices of return periods for the OBE may be based on economic considerations.

d. Estimating OBE and MDE Ground Motions. Estimates are usually made in two phases. The first estimates are used as a starting point for the study and shall be obtained within the United States from United States Geological Survey USGS spectral acceleration maps. The method to develop standard response spectra and effective peak ground acceleration for the required probability of exceedance (return period) for OBE and MDE is described in EM 1110-2-6053, Appendix B and C. Site-specific studies in accordance with paragraph 5h(2) of ER 1110-2-1806 are often required for selecting the final estimates of OBE and MDE ground motions. Both DSHA and PSHA approaches are appropriate. Combining the results of deterministic and probabilistic analyses is often an effective approach for selecting MDE ground motions. Typical results of a probabilistic analysis are a hazard curve and an equal hazard spectrum which relate the level of ground motion to an annual frequency of exceedance or return period. This information can be used to complement the deterministic analysis by removing from consideration seismic sources that appear unreasonable because of low frequencies of occurrence, by justifying median or median-plus-standard deviation estimates of deterministic ground motion or by ensuring consistency of MDE ground motions with a performance goal.

2. Foundation Evaluations due to Seismic Considerations.

Foundation evaluations shall be performed on embankments, slopes, and/or foundations susceptible to liquefaction, earthquake induced excess pore water pressure generation, or excessive seismically induced deformation for all projects located in high seismic hazard regions along with those projects located in moderate seismic hazard regions. This evaluation and analysis shall also be performed regardless of the seismic region location of the project, where capable faults are located or recent earthquakes have occurred.