



Department of the Army
U.S. Army Corps of Engineers
Washington, DC
21 December 2023

Engineer Regulation* 1110-2-1802

Effective 21 January 2024

CECW-EC

Engineering and Design

Post-Earthquake Inspections and Reporting for Civil Works Structures

FOR THE COMMANDER:

PRETTYMAN-
BECK.YVONNE.J. [REDACTED] Digitally signed by PRETTYMAN-
BECK.YVONNE.J. [REDACTED]
[REDACTED] Date: 2023.12.27 11:27:28 -05'00'

YVONNE J. PRETTYMAN-BECK
Chief of Staff

Purpose. This engineer regulation states policies and requirements for post-earthquake inspections and reporting of United States Army Corps of Engineers Civil Works structures. This regulation primarily concerns verification of post-earthquake project integrity and performance. Inspections and evaluations are to be used to help make informed decisions on response, timeliness of response, and prioritization of actions.

Applicability. This regulation is applicable to all field operating agencies having Civil Works Operation and Maintenance responsibilities. This regulation is applicable to all structures in which the United States Army Corps of Engineers is primarily responsible for operation and maintenance. Structures include, but are not limited to, dams, navigation locks, channels, levee systems, floodwalls, powerhouses, shoreline protection, and appurtenant features. Appurtenant features include intakes, outlet works, bridges, pump stations, drainage structures, utility, buildings, tunnels, access roads, paved spillways, and similar facilities.

Distribution Statement. Approved for public release; distribution is unlimited.

Proponent and Exception Authority. The proponent of this regulation is the Headquarters, United States Army Corps of Engineers, Engineering and Construction Division (CECW-EC). The proponent has the authority to approve exceptions or waivers to this regulation that are consistent with controlling law and regulations. Only the proponent of a publication or form may modify it by officially revising or rescinding it.

*This regulation supersedes ER 1110-2-1802 dated 28 July 2017.

Contents (Listed by paragraph and page number)

Purpose • 1, *page 1*

Distribution Statement • 2, *page 1*

References • 3, *page 1*

Associated Publications • 4, *page 1*

Records Management (Recordkeeping) Requirements • 5, *page 1*

Responsibilities • 6, *page 1*

Post-earthquake policies • 7, *page 2*

Inspections • 8, *page 2*

Prioritization and Timeliness of Response • 9, *page 3*

Post-Earthquake Inspection Requirements • 10, *page 3*

Post-Earthquake Evaluation and Reporting • 11, *page 4*

Funding • 12, *page 5*

Appendixes

A. References, *page 6*

Summary of Change

1. Purpose

This engineer regulation states policies and requirements for post-earthquake inspections and reporting of United States Army Corps of Engineers (USACE) Civil Works (CW) structures. This regulation primarily concerns verification of post-earthquake project integrity and performance. Inspections and evaluations are to be used to help make informed decisions on response, timeliness of response, and prioritization of actions.

2. Distribution statement

Approved for public release; distribution is unlimited.

3. References

See Appendix A.

4. Associated publications

This paragraph contains no entries.

5. Records management (recordkeeping) requirements

The records management requirement for all record numbers, associated forms, and reports required by this regulation are addressed in the Army Records Retention Schedule – Army (RRS-A). Detailed information for all related record numbers is located in the Army Records Information Management System (ARIMS)/RRS-A at <https://www.arims.army.mil>. If any record numbers, forms, or reports are not current, addressed, and/or published correctly in ARIMS/RRS-A, see DA Pam 25-403 for guidance.

6. Responsibilities

a. District engineering and operations. The Chief of Engineering and the Chief of Operations functions must jointly coordinate the composition of post-earthquake inspection teams. Coordination is also required for execution of the inspections and implementation of identified interim risk reduction measures (IRRM) to protect life and property.

b. Emergency operations center (EOC). When impact to project performance or life safety is identified, the District Emergency Manager must be notified. The Emergency Manager is responsible for coordinating all emergency response and reporting activities in collaboration with Engineering and Operations functions.

c. Post-earthquake evaluation lead. In high seismic hazard regions (see para 7), a Lead Engineer must be identified by the District in advance of an earthquake. In moderate seismic regions, a Lead Engineer must be identified for critical structures. The post-earthquake Lead Engineer must be experienced in seismic performance evaluation and be familiar with project specific features. The Lead Engineer will lead the post-earthquake inspection, verify data collection, perform data analysis, and evaluate post-earthquake performance. The Lead Engineer will document findings and provide recommendations in a post-earthquake inspection report.

d. Post-earthquake inspection team. For all structures in high seismic hazard regions and for critical structures in moderate seismic regions, post-earthquake

inspection teams must be established in advance of an earthquake. Lead Engineers, Operation Project Managers, Project Engineers, Project Geologists, and Facility Operators on post-earthquake inspection teams must be trained to effectively lead and participate in post-seismic inspections. The inspection team will include, at a minimum, engineers and geologists familiar with the project and its risk characterization. The team must consist of disciplines required to effectively inspect all project features and appurtenant structures. The inspection team must leverage seismic expertise found across United States Army Corps of Engineers (USACE), as needed.

7. Post-earthquake policies

a. In the event of an earthquake, USACE CW projects must be inspected and evaluated to assess damage and ensure stability, safety, and operational adequacy. Post-earthquake inspections and evaluations will be used to identify potential impacts to operations and safety. Post-earthquake inspections and evaluations will assess the performance of civil works projects to determine if the design and performance objectives of ER 1110-2-1806 were met. Risk-informed decision-making will be used to prioritize resources for timely response, restoration, and remediation.

b. Seismic hazard regions are classified into low, moderate, and high categories. Low seismic hazard regions are associated with a peak ground acceleration (PGA) that is less than or equal to 0.1g ($PGA \leq 0.1g$). Moderate seismic hazard regions have a PGA between 0.1g and 0.2g ($0.1g < PGA < 0.2g$). High seismic hazard regions have a PGA that is equal to or greater than 0.2g ($PGA \geq 0.2g$). These intensity measures should be determined for each project considering the following:

(1) Site geologic conditions expressed by the average small-strain shear wave velocity in the upper 100 feet (30 meters) of the site profile, V_{s30} values, using equation 1,

$$V_{s30} = \frac{\sum_{i=1}^n d_i}{\sum_{i=1}^n \frac{d_i}{V_{si}}} \quad \text{Equation 1}$$

where:

d_i = Thickness of any layer between 0 and 100 feet (30 meter),

V_{si} = Shear wave velocity in ft/sec (m/sec)

[measured or estimated using geophysical or geotechnical in-situ methods]

$\sum_{i=1}^n d_i$ = 100 feet (30 meter)

(2) Free-field conditions considering site geology and geotechnical characteristics;
and

(3) An earthquake ground motion return period of 975 years.

8. Inspections

a. *Immediate visual inspection criteria.* When the following criteria are met, project operations personnel will make immediate visual inspections:

(1) If an earthquake is felt at the project site or damage is reported near the project area.

(2) If the magnitude and distance of the earthquake epicenter are within the following parameters:

- (a) Magnitude 4.0 or greater within 50 km (31 mi) of the project.
- (b) Magnitude 5.0 or greater within 100 km (62 mi) of the project.
- (c) Magnitude 6.0 or greater within 200 km (124 mi) of the project.
- (d) Magnitude 7.0 or greater within 400 km (250 mi) of the project.
- (e) Magnitude 8.0 or greater within 600 km (375 mi) of the project.
- (f) Magnitude 8.5 or greater within 800 km (500 mi) of the project.

b. *Post-earthquake inspection team deployment criteria.* The post-earthquake inspection team must be deployed to the site as soon as practicable, when any of the following criteria are met:

(1) The PGA at the project is greater than 0.15g. Where available, strong-motion sensors will be used to identify site specific PGA. Where sensors are not installed, the District should leverage United States Geological Survey web-available earthquake interactive mapping tools (<https://earthquake.usgs.gov/>).

(2) The project operations personnel identified potential distress or potential impact to safe project operations.

(3) The post-earthquake Lead Engineer will coordinate with the Operations Division to identify a need to perform an inspection.

9. Prioritization and timeliness of response

a. The following should be considered when prioritizing inspections and response:

- (1) Risk associated with the loss of project purpose.
- (2) Project susceptibility to seismic damage considering site geology and project conditions.
- (3) Site-specific PGA (recorded or estimated).
- (4) Magnitude and distance from epicenter of earthquake.

b. For critical projects in moderate and high seismic hazard regions, remote inspection and remote instrumentation for performance monitoring capabilities must be available.

c. A plan for timeliness of response must be in place prior to an earthquake event and response procedures should be outlined in the Emergency Action Plan (EAP).

10. Post-earthquake inspection requirements

a. *Visual inspection checklists.* All visual inspections must employ a project-specific checklist. At a minimum, checklists should include the main features and components of the project and appurtenant structures. The specific failure modes of concern should be considered when developing these checklists. For projects in moderate and high seismic hazard regions, these checklists should be developed in advance of an earthquake. The inspection checklist should be documented in the EAP and be readily available to operations and engineering inspection personnel.

b. *Performance monitoring instrumentation.*

(1) For moderate to high seismic hazard regions, project surveillance and monitoring plans should identify instrumentations reading schedules for post-earthquake events. Instrumentation may include both surface and subsurface deformation

monitoring and seepage monitoring. Refer to EM 1110-2-1908 for guidance on instrumentation and monitoring programs.

(2) For underwater project features that experience PGA greater than 0.15g, a bathymetric survey and post-earthquake inspection must be performed to determine if movement of the structure or slope damage or failure has occurred. Surveys of navigational channels should determine whether ship passage safety has been compromised by underwater slope damage or failure.

11. Post-earthquake evaluation and reporting

a. Baseline conditions.

(1) An understanding of the expected project performance and impacts to safe operations is required to properly assess post-earthquake conditions. Potential IRRMs should be identified in advance of an earthquake. For water control structures, IRRM impacts upstream and downstream of the project should be considered in advance.

(2) Inspection teams should leverage project as-builts, prior inspection findings, project risk assessments, and photographic sources to understand baseline (pre-event) conditions. Information from visual surveillance and performance monitoring instrumentation (such as deformation and seepage monitoring instruments) are critical for understanding the project conditions prior to the seismic event.

(3) The pre-earthquake conditions could be different from as-built information due to operation or modifications after original construction. In the absence of adequate documentation of the pre-earthquake conditions, findings from previous inspections and instrumentation reports (to include surveys) will be leveraged.

b. Post-earthquake evaluation.

(1) Post-earthquake inspections and performance monitoring instrumentation should be used to evaluate the project performance and ability for continued safe operations. Strong-motion sensor recordings from the project site will be used (where available) to aid in assessing project performance. The effects of potential earthquake aftershocks should also be considered. Earthquake aftershocks could cause further damage or collapse.

(2) Signs of distress on the project must be evaluated and reported. Evidence of distress must be evaluated and reported, along with evidence of major distress on any feature that could impact the life safety or project mission. Distresses may include, but are not limited to, cracked, bulged, or shifted bridge pier footings or other concrete structures, cracks and/or bulges in concrete dams or earth embankments or levees and other structures, deformations and/or cracks in embankment dams or levees, boils in embankment dams or levees, and/or misalignment of hydraulic control structures or gates.

(3) Evaluations should consider loss of strength and stiffness in embankments and foundation soils. Liquefaction of saturated pervious materials could induce lateral spreading leading to instability of a structure. Similarly, cyclic or strain softening of soils could decrease shear strengths of the materials and lead to instability of a structure. Seepage monitoring instrumentation, such as piezometers, may indicate changes in pore pressure conditions. Increase in monitoring frequency and duration may be required until pore pressure levels stabilize.

(4) Seismic-induced rockfall or landslides impacting the project operations should be identified. These can pose impacts to access roads and critical bridges, or communication system disruptions. For water control structures, landslides may result in wave overtopping of the project or blockage and/or damage of gates, inlets, tunnels, etc. Landslides may also adjust the waterway, redirecting or blocking the original path. Project operational recommendations should consider the post-earthquake flow path and operational resultant impacts. Rate of movement of the pre-existing landslides near USACE projects must be compared with pre-earthquake conditions to evaluate any negative impact due to an earthquake.

(5) Evaluations should identify damages and potential project performance impacts, make recommendations for further action including identifying any necessary IRRM.

c. Reporting.

(1) For dams, the incident response must be documented and reported consistent with ER 1110-2-1156 and the project EAP. Bridge seismic inspections will be conducted according to ER 1110-2-111 and EM 1110-2-1102 for USACE Bridge Safety Program. For projects that are not dams or bridges, reporting requirements must be coordinated with the District EOC.

(2) Results of all inspections, including the immediate inspection, should be communicated according to the EAP as soon as practicable, including damage or unusual instrumentation readings. They will be documented and reported consistent with the EAP.

(3) The post-earthquake Lead Engineer should report the results of post-earthquake inspections to the District Chief of Engineering, Chief of Operations, Chief of Emergency Management, and Engineering and Construction District Leadership, including the Dam Safety and Levee Safety Officer, as appropriate.

(4) When damage is noted, inspection findings, recommendations, and actions must be communicated to major subordinate commands (MSCs) and Headquarters, United States Army Corps of Engineers (HQUSACE).

d. Activation of emergency operation center. The Emergency Manager must be immediately notified when project operations personnel, post-earthquake inspection team, or Lead Engineer identify an immediate threat to project safe operations or life safety. The EOC activates after the Commander declares an emergency.

12. Funding

For USACE-operated and maintained projects, project-specific O&M project funds will be used for post-earthquake inspections and evaluations. If project O&M funds are not sufficient to fund the full scope of inspection, the District will coordinate with the MSC and HQUSACE to identify other funding sources as needed to facilitate inspection and for completing IRRMs and permanent repairs.

Appendix A References

Section I

Required Publications

Unless otherwise indicated, all U.S. Army Corps of Engineers publications are available on the USACE website at <https://publications.usace.army.mil>.

EM 1110-2-1102

Inspection and Evaluation of USACE Bridges.

EM 1110-2-1908

Instrumentation of Embankment Dams and Levees.

ER 1110-2-103

Strong-Motion Instruments for Monitoring and Recording Earthquake Motions.

ER 1110-2-111

USACE Bridge Safety Program.

ER 1110-2-1156

Safety of Dams – Policy and Procedures.

ER 1110-2-1806

Earthquake Design and Evaluation of Civil Works Projects.

Section II

Prescribed Forms

This section contains no entries.

SUMMARY of CHANGE

ER 1110-2-1802

Post-Earthquake Inspections and Reporting for Civil Works Structures

This revision, dated 15 December 2023 -

- Clarifies the primary focus of this policy is to verify the post-earthquake integrity and performance as well as the use of the inspections and assessments for response-related informed decisions (paragraph 1).
- Clarifies applicability of this policy (paragraph 2).
- Adds seismic hazard region classifications (paragraph 7).
- Clarifies responsibilities of District Engineering and Operations, Emergency Operations Center, Post-Earthquake Evaluation Lead, and Post-Earthquake Inspection Team (paragraph 6).
- Modifies criteria for magnitude and distance of the earthquake epicenter for immediate visual inspection (paragraph 8).
- Clarifies post-earthquake inspection team deployment criteria (paragraph 8)
- Establishes prioritization and timeliness of response including requirements for Emergency Action Plan (paragraph 9).
- Updates the post-earthquake evaluation and reporting (paragraph 10).