Seismic Safety

Brief

Title: Seismic Safety
Publication date: 3/8/2017
Effective date: 4/29/2014

BRIEF

Policy Summary

Berkeley Lab designs and constructs its physical plant and program facilities to prevent the loss of life and, to minimize the risk of personal injury, program interruption, and property damage due to earthquakes. Furnishings and equipment in buildings must be secured in accordance with the requirements of this policy, the applicable provisions of the California Building Code, and the applicable provisions of Department of Energy and University of California seismic policies and standards.

Who Should Read This Policy

Laboratory employees, contractors, and affiliates

To Read the Full Policy, Go To:

The POLICY tab on this wiki page

Contact Information

Berkeley Lab Structural Engineer
Facilities Division

Policy

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POLICY

A. Purpose

The Seismic Safety policy at Lawrence Berkeley National Laboratory (Berkeley Lab) provides seismic requirements for the construction of new buildings, renovations, and/or furnishings of Laboratory-owned or Laboratory-leased buildings. Additionally, this policy describes the UC Seismic Performance Rating System for Laboratory buildings.

B. Persons Affected

This policy applies to employees, affiliates, and subcontractors involved in the construction, renovation, and/or furnishing of Laboratory-owned or -leased buildings.

C. Exceptions

Not applicable

D. Policy Statement

Berkeley Lab designs and constructs its physical plant and program facilities to prevent the loss of life and to minimize the risk of personal injury, program interruption, and property damage due to earthquakes. Furnishings and equipment in buildings must be secured in accordance with the requirements of this policy, the applicable provisions of the California Building Code (CBC), and the applicable provisions of Department of Energy and University of California seismic policies and standards.

D.1 New Buildings and Other Structures, Including Programmatic Equipment

All new Laboratory buildings and other structures, including program equipment and heavy shielding, must be designed and constructed to resist the seismic ground motions associated with a Maximum Considered Earthquake (MCE) without collapse; and to resist the seismic ground motions associated with a Design Basis Earthquake (DBE) without damage that would pose a significant risk of life-threatening injuries to the building occupants. Special facilities, as defined in Section D.2, New and Existing Special Facilities, are to be designed to a higher standard as discussed in that section.

The determination that the buildings and other structures can satisfy these criteria is the responsibility of qualified structural engineers under the supervision of the Facilities Division Structural Engineer.

All programmatic facilities and equipment are under the jurisdiction of the Facilities Division.

All buildings and other structures must be structurally designed and constructed by, or under the supervision of, a structural engineer registered in the state of California in accordance with the current edition of the California Code of Regulations (CCR), Title 24, Part 2, California Building Code (CBC or the Code). In addition, all Department of Energy-owned and -leased facilities are to be designed and constructed in accordance with DOE Order 420.1C, Facility Safety. The CBC and Order 420.1C are supplemented by reference standards found in the Document Information Facility Safety section of this policy.

D.1.1 Physical Plant Facilities

- All building projects must be designed on the basis of geological and geotechnical investigations used to establish foundation design values and to assess hazards from fault movement (e.g., landslides and ground motion). No building may be constructed over an active fault, and the proposed location of a building relative to an active fault must be reviewed and approved by the Facilities Division.
- Calculations, drawings, and specifications for buildings must be submitted to the Facilities Division for review before construction, and each must be signed and stamped with the registered engineer's seal.

D.1.2 Design Criteria for Programmatic Facilities

The following equipment and structures must be constructed and/or seismically secured in a manner that ensures life safety and is acceptable to the Facilities Division Structural Engineer:

1. All permanent buildings
2. Any structure that personnel can enter, such as trailers, radiation hutches, shielding structures, or environmental test chambers
3. Any structure that supports personnel, such as mezzanines and personnel platforms more than 4 feet high
4. Any research equipment or non-structural component that falls within one of the categories defined in Section D.6 below

In addition to seismic considerations, the Structural Engineer’s review will also address California Building Code (CBC) issues and floor-loading concerns.

The following design criteria must be incorporated:

- All new programmatic facilities must be designed for the seismic forces and design criteria specified in the current edition of American Society of Civil Engineers (ASCE)-7, as amended by the current edition of the CBC and the current version of the Berkeley Lab Lateral Force Design Criteria Resource Document RD3.22.
- For building structures that are not permitted by ASCE-7 to be designed using an Equivalent Lateral Force (static) Analysis or that are base-isolated, a spectral or time history analysis using site-specific ground motions must be used to determine the seismic design forces. An independent seismic peer review, as defined in the UC Seismic Safety Policy, is required for such structures.
- Any non-building component specified in Section D.6 as requiring seismic restraints must be designed for conformance with the seismic provisions of ASCE-7, as amended by the CBC and RD3.22. The provisions of ASCE-7 Chapter 13 must be applied to non-structural facilities and equipment that are attached to the building structure. The provisions of ASCE-7 Chapter 15 must be applied to non-building structures, including those that are used to support equipment (e.g., cooling tower frames and tank skirts). Equipment that is not attached to the building structure or supported by a non-building structure covered in ASCE-7 Chapter 15 must be designed per the provisions of ASCE-7 Chapter 13. Either Chapter 13 or 15 can be used to design non-building structures that are inside buildings and are only attached to the building's foundation (e.g., hutches and walk-in test chambers). If the component is provided with adjustments, it must resist the governing accelerations when the adjustments are in the most unfavorable positions. Friction due to gravity cannot be relied on to resist movement. The use of mechanically induced friction to resist movement must be reviewed on a case-by-case basis by the Facilities Division. Secure structural connections to the floor or to the building are needed to resist seismic accelerations.
- Where a separate national standard or document is used as the basis for the earthquake-resistant design of a particular type of system or component, that document is permitted to be used provided that the design earthquake forces are not less than those determined in accordance with the CBC, and the component’s interactions with components connected to it and with the structure that supports it are accounted for in the design.
- Where the maximum allowable stress and displacement in seismic restraining systems are not specified in the CBC or its referenced standards, these criteria must be established by the Project Engineer and must be such so that life-threatening lateral movement (relative to the support) or overturning will not occur due to the governing seismic accelerations.
- For equipment or other objects mounted on bases or floors that isolate seismic accelerations, spectral analyses using the Berkeley Lab Design Basis Earthquake or site-specific ground motions must be used to determine the seismic forces on the object. This requirement does not apply to equipment mounted on vibration isolators.

D.1.3 Non-Ductile Structures

Structures constructed of components or materials that fail in a brittle manner (i.e., no apparent plastic deformation takes place before fracture) and that do not exhibit ample reserve strain-energy capacity are considered non-ductile structures. One example is a structure made of non-ductile reinforced concrete blocks held together with ductile metal attachments that are not configured, or do not have enough mass, to safely absorb the seismic strain energy in the structure. For non-ductile structures and bracing systems, the design must be based on the following:

- Non-ductile structures and components must not be used for new construction except where specifically permitted by the CBC. The applicable provisions of the CBC must be used for the design of these elements.
- Existing non-ductile structures that will be used to support new construction must be evaluated per the applicable provisions of the CBC. DOE-owned facilities must also be evaluated per the applicable provisions of Standards of Seismic Safety for Existing Federally Owned and Leased Buildings, ICSSC Recommended Practice 8 (RP-8).
- The maximum allowable stress in existing non-ductile structural elements that are used to support new construction must not exceed the following:
  - 75% of the ultimate compressive strength, or the stresses permitted by the CBC, for concrete in bearing or compression
  - 50% of the ultimate strength for welds
  - The allowable capacities for anchor bolts and post-installed anchors are to be calculated assuming that the concrete is cracked at service load levels
  - 75% of the ultimate strength for other structural elements

D.2 New and Existing Special Facilities

The determination that special facilities meet the following criteria will be made by qualified structural engineers under the supervision of the Facilities Division Structural Engineer.

D.2.1 Critical Emergency Facilities

Critical emergency facilities must be designed to remain functional during and after the Design Basis Earthquake specified above. The essential facility provisions of the CBC must be used for the design of these facilities.

D.2.2 Enclosures and Systems Containing Radioactive and Other Hazardous Dispersible Materials

Enclosures and systems containing radioactive or other hazardous, dispersible materials (e.g., toxic, flammable, or infectious substances) must
be designed and constructed to ensure confinement during and after the design earthquake specified above and to ensure that the acceptable risk, established during the appropriate work authorization is not exceeded. These enclosures must be designed in accordance with Facilities Division Resource Document RD3.22 and inspected by the Environment/Health/Safety (EHS) Division before use.

D.3 Existing Buildings and Other Structures

D.3.1 Rating of Buildings and Other Structures

All permanent DOE- and UC-owned Laboratory buildings have been reviewed by qualified structural engineers to determine their rating in accordance with the requirements of the UC Seismic Safety Policy. One of the following UC-mandated performance ratings has been assigned to each building:

A Performance Level III (formerly “Good”) rating typically applies to buildings and other structures whose performance during a major seismic disturbance is anticipated to result in some structural and/or non-structural damage and/or falling hazards that would not significantly jeopardize life. Buildings and other structures with a Performance Level III rating typically have a level of seismic resistance such that funds need not be spent to improve their seismic resistance to gain greater life safety, and that they represent an acceptable level of earthquake safety.

A Performance Level IV (formerly “Fair”) rating typically applies to buildings and other structures whose performance during a major seismic disturbance is anticipated to result in structural and non-structural damage and/or falling hazards that would represent low life hazards. Buildings and other structures with a Performance Level IV seismic performance rating typically are given a low priority for expenditures to improve their seismic resistance and/or to reduce falling hazards so that the building could be reclassified as Performance Level III (formerly “Good”).

A Performance Level V (formerly “Poor”) rating typically applies to buildings and other structures whose performance during a major seismic disturbance is anticipated to result in significant structural and non-structural damage and/or falling hazards that would represent appreciable life hazards. Either such buildings or structures are given a high priority for expenditures to improve their seismic resistance and/or to reduce falling hazards so that the building could be reclassified as Performance Level III (formerly “Good”), or are considered for other abatement programs, such as reduction of occupancy.

A Performance Level VI (formerly “Very Poor”) rating seismic performance rating typically applies to buildings and other structures whose performance during a major seismic disturbance is anticipated to result in extensive structural and non-structural damage, potential structural collapse, and/or falling hazards that would represent high life hazards. Such buildings or structures either are given the highest priority for expenditures to improve their seismic resistance and/or to reduce falling hazards so that the building could be reclassified as Performance Level III (formerly “Good”), or are considered for other abatement programs such as reduction of occupancy.

D.3.2 Re-Evaluations

An existing building must be re-evaluated and re-rated if one of the following occurs:

- There is a change in the building's function that results in an increase in the building's level of use, importance, or occupancy.
- A project is planned that significantly extends the building's useful life through alterations or deferred maintenance that total more than 30 percent of the replacement cost of the building.
- The building or part of the building has been damaged as a result of a natural phenomenon or other event to the extent that, based on evaluations performed by qualified professional engineers, significant structural degradation of the building's vertical and/or lateral load carrying systems has occurred.
- When an alteration or addition to the building results in either a greater than 10 percent reduction in the capacity of the building's lateral-load support system or a greater than 10 percent increase in the lateral loads being applied to the building.
- When an alteration or addition to the building results in a structural irregularity as defined by ASCE 7.

Seismic re-evaluations must be performed by qualified structural engineers under the supervision of the Facilities Division Structural Engineer. These evaluations must be in accordance with DOE-STD-1020 and the UC Seismic Safety Policy.

D.3.3 Use Restrictions for Buildings and Other Structures with Seismic Ratings of Performance Level V (Formerly “Poor”) and Performance Level VI (Formerly “Very Poor”)

The use of each building or other structure with a rating of Performance Level V (formerly “Poor”) or Performance Level VI (formerly “Very Poor”) will be reviewed by the Laboratory managers responsible for the building or structure for the purpose of determining what seismic risk-reduction strategy will be implemented. The determination will be based on recommendations from the Facilities Division Structural Engineer.

D.3.4 Posting of Seismic Information for Buildings and Other Structures

The seismic rating of buildings and any use restrictions or limitations are posted on the Laboratory's Seismic Status web page. The structural rating of buildings and the use limitations and restrictions will be maintained by the Facilities Division Structural Engineer and based on the risk mitigation measures adopted by management as described in the next section. See http://fac.lbl.gov/Facilities/DandC/CvStr/.

D.4 Process for Determining Use Restrictions for Buildings and Other Structures with Performance

Lawrence Berkeley National Laboratory. The official or current version is located in the online LBNL Requirements and Policies Manual. Printed or exported versions are not official. Users are responsible for working with the latest approved revision.
Level V (formerly "Poor") or Performance Level VI (formerly "Very Poor") Seismic Ratings

The Facilities Division Structural Engineer advises Laboratory managers of the seismic rating of each building that has been evaluated, and provides a summary of the issues that cause buildings to have a Performance Level V or VI rating. Based on this information and on a review of the present use of the building with the occupying divisions' safety coordinators, the Facilities Division makes seismic risk mitigation recommendations to the responsible division directors and the Laboratory's Deputy Director for Operations concerning appropriate risk-reduction measures for buildings that have a seismic rating of Performance Level V or VI.

For Performance Level VI-rated buildings, the following applies:

- No new or additional operations that result in personnel exposure to the seismic hazard may be located in buildings with a Performance Level VI seismic rating.
- Funding must be requested to upgrade the building to a Performance Level III seismic rating or to replace or remove the building. The building may be vacated and abandoned in place until a plan has been developed.
- Activities that bring additional personnel into the building will be curtailed; for example, conference rooms will be closed.
- Every effort will be made to relocate personnel who spend most of their time in the building to other, safer facilities; for example, occupants of continually occupied offices will be moved in a specified period of time.
- Laboratory and experimental facilities that cannot be moved will only be used for essential activities, and where possible, personnel working in these spaces will be assigned other, safer spaces for office work and other activities that can be performed elsewhere.
- Personnel remaining in the building will be briefed on the hazards and use restrictions by the Structural Engineer and the EHS Seismic Subject Matter Expert. The use restrictions will be posted on the Laboratory's Seismic Status web page.

The use of buildings seismically rated Performance Level VI for unattended storage of material and equipment is permitted.

For buildings seismically rated Performance Level V, the following applies:

- No additional operations that result in personnel exposure to the seismic hazard may be located in buildings with a Performance Level V seismic rating. Replacement of activities with like activities may be acceptable, depending on specific circumstances.
- Funding must be requested to upgrade the facility to a seismic rating of Performance Level III or to replace or remove the facility.
- Personnel remaining in the building must be briefed on the hazards and use restrictions by the Structural Engineer and the EHS Seismic Subject Matter Expert. The use restrictions must be posted on the Laboratory's Seismic Status web page.
- A hard copy of the briefing of Hazards and Use Restrictions must be posted in a prominent and central location for review by building occupants, particularly those who become occupants after the initial briefing. Division line management is responsible for informing new building occupants of the location of the posted briefing or requesting a new briefing by the Facilities Structural Engineer and the EHS Seismic Subject Matter Expert. The building occupants are each responsible for reviewing the posting and contacting the Facilities Structural Engineer, or the EHS Seismic Subject Matter Expert, if they have any questions.

D.5 Programmatic Equipment and Structures

The following equipment and structures must be constructed and/or seismically secured in a manner that is acceptable to the Facilities Division Structural Engineer:

- Any structure that personnel can enter, such as trailers, radiation hutches, shielding structures, or environmental test chambers.
- Any structure that supports personnel, such as mezzanines and personnel platforms more than 4 feet high.

In addition to seismic considerations, the Structural Engineer's review will also address building code issues and floor loading concerns.

D.6 Non-Structural Earthquake Safety Measures

Seismic anchoring of furnishings and equipment is required where it may prevent blocking of exit passages, and where items may topple and crush personnel in case of an earthquake. Note that the seismic anchoring that is typically possible will provide protection in cases of minor earthquakes, but may fail during a design basis earthquake, depending on the direction of the ground motion.

Where equipment is anchored, it must be bolted to structural elements, such as studs in walls, or secured to concrete with approved anchors. Seismic anchoring may require Facilities Division Penetration permits, depending on the depth of the anchors and the location. Contact the Facilities Division Work Request Center for seismic anchoring. Facilities Division carpenters have been instructed on acceptable methods of anchoring typical furnishings.

Post-installed anchors placed into concrete must be pre-qualified for seismic applications and installed in accordance with the requirements of the anchor manufacturer and the CBC. Anchors that are required to be engineered must be designed in accordance with the CBC. The anchor installation must be inspected by a qualified Special Inspector. The anchors must be tested by the Special Inspector as directed by the Facilities Structural Engineer responsible for the anchor design.

Where the contents of shelves or cabinets may fall and pose hazards during an earthquake, they must be secured in the cabinet or shelf by doors or other restraining mechanisms such as 3/4-inch-tall lips at the front of shelves, or elastic cords on bookshelves.

The following items are required to be secured against toppling or emptying of contents:

- Bookcases, file cabinets, storage cabinets, electronics racks, and other furnishings that are more than 4 feet high, regardless of weight.
- All equipment and furnishings that are mounted at 4 feet or less above a floor level and weigh more than 400 pounds.
- All equipment that is mounted more than 4 feet above a floor level to a vertical surface and weigh more than 20 pounds.
All equipment that is suspended below a floor and weigh more than 20 pounds.
Bookcases and other furnishings regardless of height or weight where they might block doors or exit passages.
Equipment that is mounted to a table top and weigh more than 100 pounds.
160-liter Dewars and compressed gas cylinders.
Any equipment, storage cabinet, or container that contains hazardous materials.
Heavy items on shelves where they might fall down on personnel below.

In addition, all mechanical, electrical, and fire suppression distribution systems must be braced for seismic loads where required by the CBC.

E. Roles and Responsibilities

<table>
<thead>
<tr>
<th>Role</th>
<th>Responsibility</th>
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</table>
| Employees, affiliates and subcontractors | • Follow the requirements of this policy  
• Secure non-structural items that may cause injury or block exit paths from buildings  
• Attend briefings and understand the hazards and use restrictions if occupying a seismic Performance Level V or VI rated building |
| Facilities Division Structural Engineer | • Supervises other structural engineers in the determination of buildings’ and other structures’ seismic performance rating  
• Reviews and determines acceptability of Berkeley Lab structures  
• Determines seismic risk-reduction strategies for seismic Performance VI-rated buildings  
• Maintains the structural rating of buildings, as well as the use limitations and restrictions  
• Advises Laboratory managers of the seismic rating of each building that has been evaluated, and provides a summary of the issues that cause buildings to have a Performance Level V or VI rating  
• Makes seismic risk mitigation recommendations to the responsible division directors and the Laboratory’s Deputy Director for Operations concerning appropriate risk-reduction measures for buildings that have a seismic rating of Performance Level V or VI  
• Assists with the development and delivery of briefings to occupants of seismic Performance V or VI rated buildings |
| EHS Seismic Safety Subject Matter Expert | • Assists with the development and delivery of briefings to occupants of seismic Performance V or VI rated buildings.  
• Advises occupants on non-structural seismic anchoring methods, which do not require engineering. |
| Division management                | • Adopts seismic risk mitigation measures for occupied buildings  
• Posts briefings provided to division occupants of seismic Performance V or VI rated buildings; provides information in the briefing to new building occupants. |
| Laboratory management              | • Makes decisions regarding capital improvements or demolition of structures with seismic performance ratings of V or VI based on recommendations of the Facilities Division Structural Engineer. |

F. Definitions/Acronyms

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
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<tbody>
<tr>
<td>EHS</td>
<td>Environment/Health/Safety Division</td>
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<tr>
<td>UC</td>
<td>University of California</td>
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<td>CBC</td>
<td>California Building Code</td>
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<td>CCR</td>
<td>California Code of Regulations</td>
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<tr>
<td>UC Seismic Performance Rating System</td>
<td>University of California’s system for rating the structural integrity of buildings and other structures for how they would perform during a major earthquake</td>
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<tr>
<td>Non-ductile</td>
<td>Structures constructed of components or materials that fail in a brittle manner (i.e., no apparent plastic deformation takes place before fracture) and that do not exhibit ample reserve strain-energy capacity</td>
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<tr>
<td>DOE</td>
<td>Department of Energy</td>
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<tr>
<td>ASCE</td>
<td>American Society of Civil Engineers</td>
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<tr>
<td>ACI</td>
<td>American Concrete Institute</td>
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<tr>
<td>AISC</td>
<td>American Institute of Steel Construction</td>
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AMERICAN WELDING SOCIETY

MCE Maximum Considered Earthquake, defined as an earthquake with ground motions that have a 2% probability of being exceeded within a 50-year time period. These ground motions are the result of hazard analyses conducted by the U.S. Geological Survey (USGS) and have been incorporated into the building codes and standards.

DBE Design Basis Earthquake, two-thirds of the corresponding Maximum Considered Earthquake (MCE)

G. Recordkeeping Requirements

A listing of the seismic status of all Berkeley Lab buildings and seismic risk reduction plans for all occupied Laboratory buildings with seismic performance ratings of V or VI are maintained on the Facilities Division website at https://commons.lbl.gov/display/fac/Seismic+Status.

H. Implementing Documents

- Berkeley Lab Facilities Master Specifications

I. Contact Information

Berkeley Lab Structural Engineer
Facilities Division

J. Revision History

<table>
<thead>
<tr>
<th>Date</th>
<th>Revision</th>
<th>By whom</th>
<th>Revision Description</th>
<th>Section(s) affected</th>
<th>Change Type</th>
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<tr>
<td>4/29/2014</td>
<td>0</td>
<td>Hart</td>
<td>Re-write for wiki</td>
<td>All</td>
<td>Major</td>
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<tr>
<td>3/8/2017</td>
<td>0.1</td>
<td>M. Stoufer</td>
<td>Update “Chief Operating Officer” position title to “Deputy Director for Operations”</td>
<td>All</td>
<td>Editorial</td>
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Document Information

Title: Seismic Safety
Document number: 07.07.027.000
Revision number: 0.1
Publication date: 3/8/2017
Effective date: 4/29/2014
Next review date: 4/29/2017
Policy Area: Major Construction and ES&H – Industrial Hygiene & Safety
RPM Section (home): Facilities Management
RPM Section (cross-reference): Facilities
Function Division: Facilities
Prior reference information (optional)

Source Requirements Documents

- DOE Order 420.1C, Facility Safety
- University of California Seismic Safety Policy, August 25, 2011.

Other Driving Requirements

- DOE P 454.1, Use of Institutional Controls
• California Code of Regulations (CCR), Title 24, Part 2, California Building Code
• DOE-STD-1020, Natural Phenomena Hazards Analysis and Design Criteria for DOE Buildings
• Executive Order 12941, Seismic Safety of Existing Federally Owned or Leased Buildings

Other Related Berkeley Lab Policies

• Permit to Penetrate Ground or Existing Surfaces
• Construction, Seismic Safety Design

Implementing Documents

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<tr>
<td>031500</td>
<td>LBNL Master Specifications - Concrete Accessories</td>
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