Data Bulletin

Seismic Qualification of Busway and Other Equipment Critical for Post Disaster Recovery

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Document Purpose

The purpose of this data bulletin is to present information regarding past requirements for regulatory code compliance, how the International Building Code (IBC) evolved, and the techniques for ensuring that facilities and equipment are compliant with current regulatory codes.

Introduction

Prior to 2000, seismic certification requirements for structures, installed equipment, and related systems within facilities were not very common for states outside of the west coast area of the United States. That situation changed dramatically in March 2000, when the International Code Council (ICC) published the first IBC. This code was a consolidation of the three existing regional codes in the U.S.

The IBC introduced seismic compliance requirements for critical facilities located in areas above a specific threshold level of seismicity. Critical facilities are classified as any facility whose operation is essential for post-event recovery and public safety, health, and welfare. The Federal Emergency Management Association (FEMA), U.S. Geological Survey (USGS), National Institute of Standards and Testing (NIST), and the National Science Foundation (NSF) have all worked closely with the American Society of Civil Engineers (ASCE) to develop an engineering foundation to advance seismic mitigation for building codes to maximize the probability that designated critical facilities will be available to support community post-disaster recovery.

What is true of a facility is also true of the equipment installed within the facility, including busway and other electrical equipment. Because the non-structural systems and contents of a facility can exceed the value of the building itself, earthquake mitigation for that equipment and its related systems is critical. It can mean as much as a “$3 to $4 payback for every dollar invested in a major construction project.” [1]

Mandated Code Compliance

For critical facilities, consulting and specifying engineers must now address seismic compliance requirements for the structure as well as the installed equipment and any related systems. The facility location and height, and the critical industrial and institutional applications that occur within the structure all play a role in determining how the seismic code is applied.

Within the structure, nonstructural building components must be seismically qualified, such as switchboards or busway, not the individual components within the equipment. This means that for a given area of the country, based on the probability of an earthquake occurring, the structure and assembled equipment must be designed and specified to meet the demands of the design earthquake. The design earthquake is derived from the Maximum Considered Earthquake (MCE) scenario. Refer to Figure 1, “US Probabilistic Hazard Map” [2], on page 2. Also, these structures must have a high probability of being restored to essential operational status with only minor repairs.

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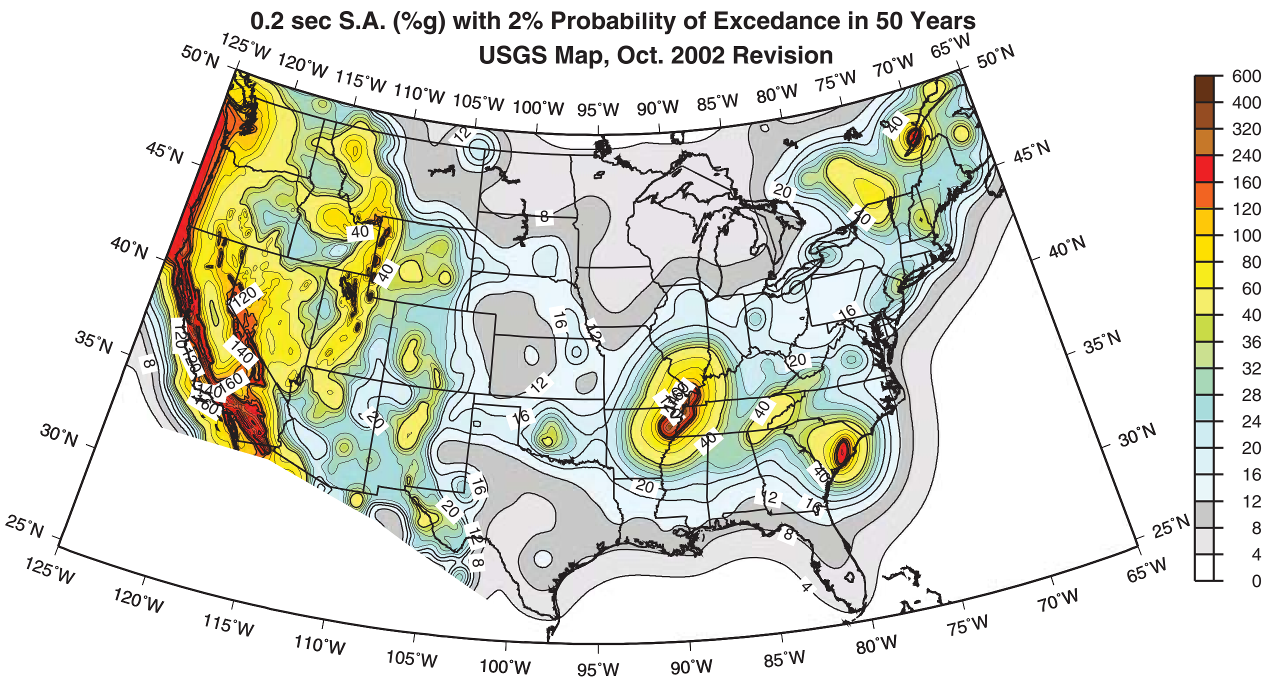
1 Multihazard Mitigation Council, “National Institute of Building Sciences”, Natural Hazard Mitigation Saves: An Independent Study to Assess the Future Savings from Mitigation Activities, 2005, http://www.nibs.org/MMC/MitigationSavingsReport/natural_hazard_mitigation_saves.htm

2 Citation: Frankel, A., C. Mueller, T. Barnhard, D. Perkins, E. V. Leyendecker, N. Dickman. S. Hanson, and M. Hopper, 1996, *National seismic hazard maps:, U.S. Geological Survey Open File Report 96-532*

Figure 1: US Probabilistic Hazard Map



This site-specific design criteria must be determined by a structural design professional registered in the location where the project is planned. To make this determination, the design professional follows a code-defined process to establish the basis of seismic design for the facility. This process includes determining:

- The occupancy category, which establishes the intended use of the building
- The level of seismicity, which is determined by code-referenced seismic hazard maps and geotechnical soil condition, or by an extensive site specific custom engineering study
- The foundation soil classification, which is determined by site-specific geotechnical reports, or as otherwise described by code
- The code-mandated limitations on building type and structural system
- Increases in the structural force-resisting capability to maximize post-event structural integrity
- The location within the facility where the installed equipment and related systems reside, from grade level to roof top. The information relating to installation location is used to determine increased equipment qualification criteria.
- The classification of the system as a “seismic designated system” if it is essential for post-event recovery and facility operation, or if its failure could have a negative impact on essential systems.

Seismic Testing for Busway and Other Nonstructural Building Components

The installer uses criteria established by the structural design professional to ensure that nonstructural building components such as busway, motor control centers, and switchboards are tested and certified to withstand a seismic event. Seismic ratings are particularly important for all of the electrical and electronic equipment that is part of a seismic designated system in facilities such as hospitals and water treatment plants, as well as schools and other government buildings designated as essential for post-disaster recovery. These facilities must be operational after a catastrophic event. Therefore, the equipment must be designed to withstand the violent forces of an earthquake and come back online with only minor repair.

It is especially critical that busway be tested and certified to withstand seismic events, as they are an integral component of critical facilities and lifeline systems.

Since busway is integral to post-event system operational reliability, it must have both the proven ability to absorb the unusual physical demands of seismic loads and a high probability of operating after an earthquake event. Therefore, busway must be subjected to a rigorous seismic qualification program. The consulting engineer must include the IBC-required certificate of compliance with the seismic requirements of the location. It is critically important that the engineers, system integrators, and facility managers know exactly where the equipment is being installed, possible seismic activity in that location, and whether or not busway is qualified for the seismic risk. The potential for equipment to be moved to another facility in a different region should also be considered by the end user. Electrical equipment, especially busway, should be clearly documented by the manufacturer to include the level of seismic activity for which the components have been qualified.

To use equipment, including busway, which does not have the IBC-mandated certificate of compliance, burdens all parties with an unnecessary risk. Obtaining qualified service personnel, parts, or replacements can be difficult, if not impossible, during the first few days or weeks after a significant natural disaster. Therefore, using non-compliant equipment is a risk that should be avoided.

Advantages of Shake Table Qualification

When possible, the preferred method to determine seismic qualifications for electrical equipment is by shake table testing. This test is performed by anchoring the equipment at the hard points to a shake table which moves in three axes simultaneously to replicate worst-case earthquake scenarios. Shake table testing typically uses a 30-second random broadband time history of full motion to envelope a wide range of possible earthquake motions.

Figure 2: 18-Pulse Device Mounted to Test Stand at Wyle Labs

When shake table tests are conducted in accordance with ICC ES AC156, the first industry qualification protocol developed specifically to translate building code seismic requirements into a shake table test, the result is earthquake-, building-, and site-independent, which means that it is not specific to any one application. Once the testing is complete, the results indicate the product qualification design issues that the consulting engineer must resolve when the components are installed in the structure. The tri-axial shake table earthquake simulation subjects the equipment to dynamic demand that can be more severe than the code design earthquake for most locations. As long as the qualified equipment is installed, anchored, and restrained in accordance with the manufacturer's guidelines regarding a seismic restraint system that is code compliant, the test is self certified as compliant to the ICC ES AC156 protocol criteria for the applicable code.

If equipment is too large for the shake table test, an accepted industry practice is to perform qualification through rigorous analysis. This is a time-consuming and engineering-intensive activity. The only other code recognized option is qualification by experience, but this is also an engineering-intensive process and can be problematic due to the number of conditions that must be satisfied and the lack of an up-to-date equipment database, which is required to validate data relevancy.

The preferred proof of compliance is the shake table test which should be used whenever possible. [3]

[3] FEMA 450-1, -2, National Earthquake Hazards Reduction Program, Part 2: Commentary, 2003, http://www.bssconline.org/

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