White Paper

Seismic Certification and the Consulting Engineer

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SEISMIC CERTIFICATION AND THE CONSULTING ENGINEER

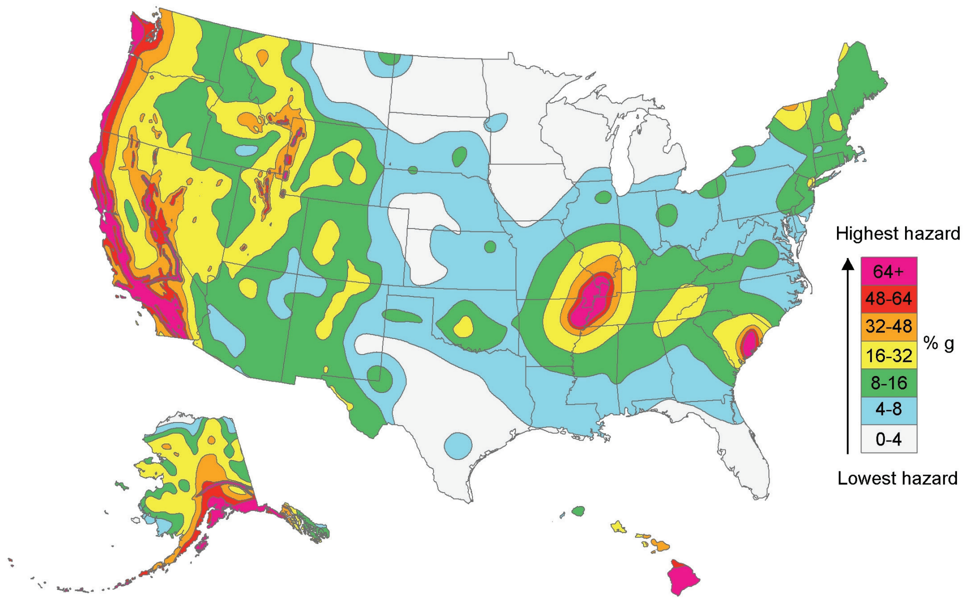
Building code standards for seismic certification require that critical mechanical, electrical and plumbing equipment must endure specific ground acceleration levels, or risk being red-tagged during inspection or worse. These standards are also being more broadly applied than before.

The International Building Code[1] (IBC) requires that critical equipment, such as on-site power systems that power critical branches, may need to withstand higher ground acceleration levels[2] in certain areas of the United States, including those generated near the San Andreas Fault in California.

Four Critical Issues:

- Understanding Requirements
- Providing Well-Written Specifications
- Assuring Quality
- Specifying Certified Equipment

An important element in designing power systems to resist seismic events is Seismic Demand Spectrum (S_{ds}), or short period spectral acceleration. It represents the base acceleration forces on equipment for a specific site, which can range up to a value of 2.5. Equipment must be certified to the S_{ds} values for both the site at which it will be installed and the location within the building where it will operate. Any electrical equipment with an IBC-designated Importance Factor (Ip) of 1.5, such as switchgear, power transfer switches, and engine-generators and their support equipment must be able to operate following a severe seismic event.



U.S. Geological Survey Peak Ground Acceleration map showing a two percent in 50 year probability of exceedance.

The IBC Code requirements for seismic certification of electrical equipment can be game changers for consulting engineers. The requirements require proof that the design, construction, and operation of the equipment will enable essential facilities to continue their intended function following severe seismic events. The proof must include actual shake table testing of a system and its components, not just an engineering analysis.

Special inspectors, not building code officials, evaluate facilities for compliance. If a facility does not comply, the inspector can withdraw a building's certificate of occupancy, even if the building is already occupied. An insurance company could declare the building uninsurable.
In order to meet code requirements and protect themselves, consulting engineers should focus on the following four critical issues:

1. Minimizing their exposure to risk and liability by familiarizing themselves with evolving seismic code standards;
2. Providing well-written specifications that account for ground acceleration and other site-specific seismic data;
3. Working with contractors to develop a quality assurance program;
4. Specifying equipment that is properly certified for the specific usage location.

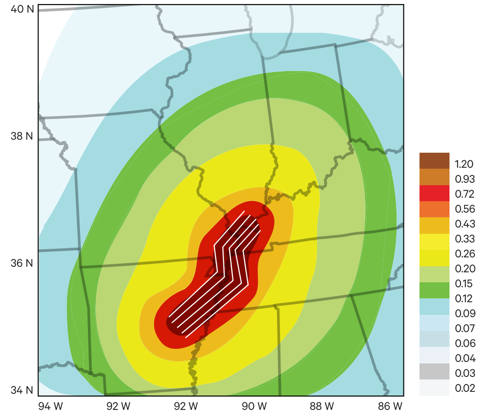
[1] The IBC refers to American Society of Civil Engineers Minimum Design Loads for Buildings and Other Structures (ASCE 7-10) as the performance benchmarks for seismic criteria.
[2] The U.S. Geological Survey assigns ground acceleration levels.

Real-Life Risk

Officials can red-tag noncompliant, essential power equipment in critical facilities in jurisdictions that have adopted the IBC code. Engine-generator equipment installed in a recently constructed hospital in St. Louis, Missouri has been red-tagged for not being seismically qualified. St. Louis is located near the New Madrid fault, which has generated the most severe ground acceleration levels in the U.S. Ground acceleration during a seismic event is a major determinant of destruction. The IBC seismic standards refer to the higher ground acceleration levels specified in ASCE 7-10, based on the New Madrid events of 1811 and 1812.

For the hospital project, the engine-generator manufacturer had to send a retrofit kit to the site that was subsequently installed to bring the equipment into compliance. It could have been worse—for the hospital as well as others involved in the project. Non-compliant equipment could increase a building owner's insurance premium. If the equipment fails to operate after a seismic event, it could result in physical damage and perhaps loss of life. Insurance claims could be, and have been, denied after non-compliant equipment was involved in a seismic event.

Even if equipment operates properly following a seismic event, liability still may arise for the consulting engineer. One example could occur if the emergency power design did not include all of a hospital's chillers. After normal source power failed following a seismic event, ambient temperature and relative humidity might rise to levels that could affect patients on life support or the ability of operating rooms to function comfortably. The consulting engineer, hospital owner, and others could be liable.



New Madrid Seismic Zone and vicinity. Seismic events in the zone have caused damage to structures in Ohio.

It's Not Just Building Owners at Risk

Besides building owners, risk and potential liability also extend to contractors, consulting engineers, project engineers, and critical equipment manufacturers. The building owner and other plaintiffs could sue for improperly designed and installed systems.

Engineering professionals can minimize their exposure by ensuring that critical equipment is specified and installed according to current code standards. It seems simple enough, but it isn't always. Too many professionals may believe they are protected by a master specification. But if the master specification is improperly written, it can be of little value when litigation arises. The code's Consequential Damage clause makes clear that the work of one also is the responsibility of others. Bottom line, consulting engineers and other project team members may share liability regardless of their role.

Consulting engineers and other team members also may be unaware or confused about changes in the building code, especially regarding seismic requirements. One reason is that the building code is primarily used by structural engineers, not electrical engineers. The seismic certification requirements for electrical equipment are not included in electrical handbooks. In addition, the IBC revises its seismic provisions every three years to include new information and capitalize on new technologies. This is why it's important for state and local governments to be sure the latest seismic standards become part of their code requirements.

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The IBC is in use or has been adopted in 50 states, Puerto Rico, and the U.S. Virgin Islands. The status and use of seismic standards can vary because some states may not have adopted the latest version of the code. For instance, State of Ohio adopted IBC standards because Ohio has been, and can be, affected by New Madrid area events. The events of 1811 and 1812 caused structural damage across Ohio. However, other states have adopted seismic code standards for the first time. It will take time for authorities having jurisdiction and the engineering professionals in those states to become fully accustomed with them.

Still, many earthquake-prone communities in the U.S. do not have up-to-date building codes with seismic provisions. In general, structures that comply with seismic standards should withstand minor seismic events without damage, moderate events without significant structural damage, and severe events without collapse. This is especially critical for installations in states such as Washington, Nevada, Oklahoma, and Colorado, which can experience frequent and sometimes intense seismic activity. Interestingly, codes only recently began to address mitigation of content hazards in buildings, which can cause casualties and expensive damage.

Examine the Structural Engineer's Notes

Another reason for confusion about seismic qualification is that the associated criteria are not presented in the mechanical, electrical and plumbing sections of the code. They are presented in the structural engineering sections.

One way to ensure properly written specifications is to review the structural engineer's notes for a project and address them in the specifications. The specification writer will find data on the building type and its seismic design category, ground acceleration, soil conditions and other seismic information. Specifiers also should refer to details in construction documents because the registered design professional must include them in pertinent seismic qualification standards for critical systems.

Finally, the project team could ask an outside expert in seismic building code standards to opine on a project's ability to qualify for seismic certification. A structural engineer licensed in California, for example, must review and approve all test reports or analyses for buildings constructed in that state.

With practice and the proper information, specification writers will be able to write clear specifications that help ensure that only code compliant critical systems qualify for a project. However, specifications should be part of overall project management planning to protect engineering professionals from exposure to liability. Engineers with equipment manufacturers can help with the proper specification text for this purpose.

Other actions should include working with contractors on a quality assurance program, specifying only properly certified equipment in accordance with the manufacturer's recommendations for seismic use, and confirming that equipment is properly installed. For their part, manufacturers also should review the structural engineer's notes for a project to make certain equipment will be code compliant. ASCO Power Technologies switchgear, for example, is certified to withstand the highest ground acceleration levels in the United States, even those experienced in the New Madrid fault zone. The equipment also is certified for rooftop installation, which is required to withstand three times the design force as ground level installations. The company indicates that its power control systems comply with the seismic standards of the new building code. Independent tests show that ASCO transfer switches operate even during severe seismic events, even though the IBC codes do not require such operation.

For critical facilities such as hospitals, these capabilities could be literally life-saving. In real life, transfer switches undoubtedly could be called to operate during a typical 30-second quake. Tests prove the transfer mechanisms do not jam or otherwise fail to complete power transfers, even during the vibrating conditions of a seismic event. This is important because standards for hospital emergency power systems require the systems be fully operational within 10 seconds following a power outage.

Working with contractors and other project team members on a quality assurance program is one way consulting engineers can help ensure the project satisfies codes and reduces their liability.

Shake, Rattle and Roll

To qualify for seismic certification, building codes require that flexible critical systems and components (transfer switches, switchgear, fire pump controllers and other on-site power systems) be subjected to simulated seismic events on a shake table. Code compliance can no longer be achieved with engineering analysis alone. When qualifying on a shake table, testing must adhere strictly to AC156 criteria for non-structural systems and components. Equipment that already has been qualified via the Telcordia GR 63 standard may need to be de-rated to lower S_{ds} levels. The consequences of not complying with the standards may mean that equipment could be red-tagged or worse … litigation to determine liability and judgments.

The VMC Group specializes in shock, vibration, seismic, and noise control and is the largest certifying agency for the power generation market. The VMC Group has certified ASCO equipment on a tri-axial seismic simulator that tested the equipment with thousands of pounds of force. The systems also remained operational during and after the test and performed as designed.

During such tests, mounting bolts take the brunt of the force. They are a critical factor in withstanding a seismic event, considering enclosures may move as many as three inches in all three axes. The top of the enclosure may move up to four inches. Test results show that the transfer switch's ruggedness ensures mounting bolts remain seated, doors remain shut, and the robust design of mechanically locked critical components such as contacts prevents jamming.

Bolts and braces also are important for another reason—to protect against consequential damage and the potential liability that could result. This type of damage occurs when non-essential equipment breaks loose during a seismic event and causes essential equipment to fail. The notion of consequential damage makes the work of one designer responsible for another.

This stop-motion image shows a 4000 amp bypass-isolation automatic transfer switch withstanding thousands of pounds of force during shake table testing.

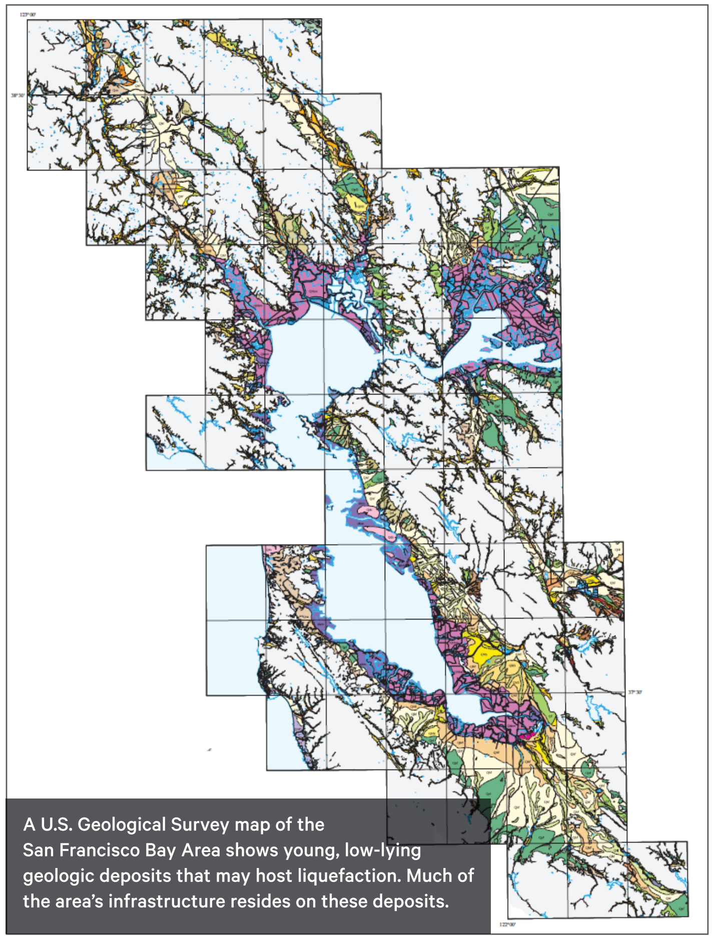
It's In The Codes

Chapter 17, Section 1708.5 details the seismic qualification of mechanical and electrical equipment such as emergency power systems. These systems encompass open gensets, enclosures, sub-base fuel tanks, remote radiators, automatic transfer switches and switchgear, batteries and battery racks, and battery chargers and day tanks.

It falls to the consulting engineer to determine whether equipment is essential to enabling a facility to perform its intended function during a seismic event and to advise appropriate manufacturers through the specification and construction documents. If the equipment is a life-safety component, contains hazardous material, or is required to function in order to keep an essential facility online, it is assigned a seismic component Importance Factor of 1.5. In assigning an Ip of 1.5, using Section 13.1.3 of ASCE 7-10 as the guide. As noted earlier, Chapter 13 of ASCE 7-10 is the performance benchmark added in the IBC codes.

The Importance Factor also applies to components in or attached to Occupancy Category IV or Category III structures that are essential to the continued operation of designated facilities. Category IV designates essential facilities, such as hospitals, airports and emergency services. Category III facilities are those that could present a substantial hazard to human life if they should fail. Examples include schools, day care facilities, power plants and facilities with occupancy capacities exceeding 5,000 people. Category II and Category I facilities and their equipment must comply with seismic standards when the Ip is 1.5 due to life safety or hazardous material issues.

There are instances when an existing building could change categories. When space in a 35-story office building in Jersey City, N.J. was leased to a 911 call response center, the Occupancy Category for the entire building changed to Category IV and the entire building became subject to Category IV standards. In another example, if a school's gymnasium is designated as an emergency shelter, the gym can't be considered an "island." The entire school is categorized as Occupancy Category IV.



A U.S. Geological Survey map of the San Francisco Bay Area shows young, low-lying geologic deposits that may host liquefaction. Much of the area's infrastructure resides on these deposits.

For equipment that needs to meet standards, a certificate of compliance must be provided to the specifying engineer during submittal review and also submitted to the building official for approval. In addition, a label, mark or other identification on the system or component must be affixed to signify compliance. This identification proves to the inspector that the equipment that arrived on site is the same as that approved during the submittal process. The certificate of compliance and the equipment label must contain the name of the certifying agency, the name of the manufacturer, the model designation of the equipment, and the seismic performance criteria for the equipment.

For its part, the building owner or its professional engineering representative must submit a statement of inspections identifying the building's seismic force-resisting systems, seismic systems, and architectural and electrical components requiring special inspections.
Besides the building's occupancy category, the type of soil at the project site is also used to establish whether seismic standards apply to a specific facility. Soils affect an event's peak ground acceleration, or degree of ground motion. There are six soil types: hard rock, rock, very dense soil and soft rock, stiff soil, soft soil, and extremely vulnerable soil. Soft soils over bedrock amplify motion. Other soils liquefy, causing foundation failure. Soil profiles are important because they help determine a site's S_{ds} value. The S_{ds} value and the Occupancy Category, in turn, help define the Seismic Category.

The question often arises: "Does existing construction need to meet evolving code standards?" That's a state-by-state decision. Typically, however, if a hospital adds a new wing, that project will need to meet the new criteria, but the remainder of the facility will not.

Increasingly demanding seismic standards and broader application of them add another dimension to the responsibilities of engineering professionals. They can minimize their exposure to risk and liability by familiarizing themselves with evolving seismic code standards, developing well-written specifications that account for ground acceleration and other seismic characteristics, working with contractors on a quality assurance program, and specifying only properly certified equipment.

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