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Seismic Certification and the Consulting Engineer

4 Critical Factors at Issue: Minimizing Liability, Good Specs', QA and Certified Equipment

By: Bhavesh S. Patel, Director of Marketing, ASCO Power Technologies

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

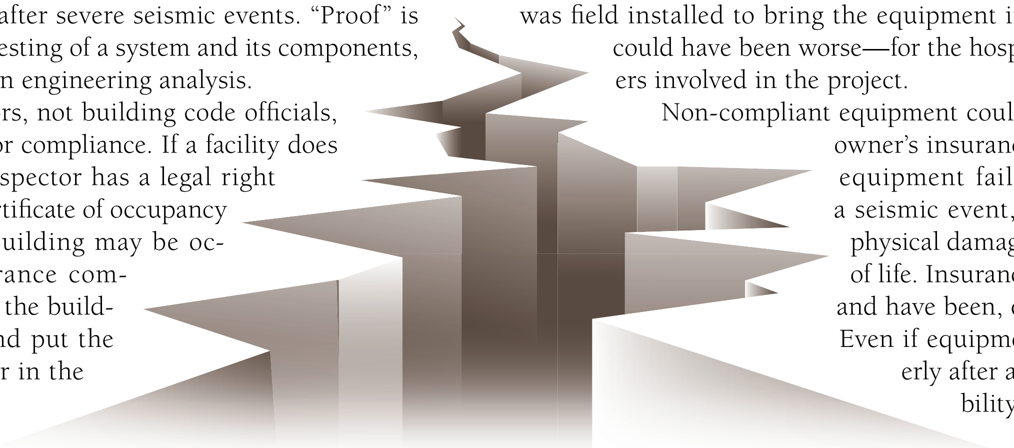
International Building Code (IBC) editions since 2000[1] demand that critical equipment, such as on-site power systems that power life safety and critical branches, may need to withstand higher ground acceleration levels[2] throughout the country, including those generated by the San Andreas Fault in California.

An important element in designing power systems to resist seismic events is seismic demand spectrum. It stands for short period spectral acceleration and is designated in the code as SDS. It represents the base acceleration forces for a specific site, which can range from 0 to 2.46. Equipment must be certified to the SDS values for both the site at which it will be installed and the location in the building where it will operate. For example, power systems installed on rooftops in California must be certified for rooftop applications at the SDS value for the project. In California's case, the value is 1.93.

Bottom line, engine-generators and their support equipment, switchgear and power transfer switches must be able to operate after a severe seismic event.

The IBC Code requirements for special seismic certification of electrical equipment can be game changers for consulting engineers. The requirements raise the bar to the level of "proof" that design, construction and equipment specification, installation and operation will enable essential facilities to continue their intended function after severe seismic events. "Proof" is actual shake table testing of a system and its components, rather than solely an engineering analysis.

Special inspectors, not building code officials, evaluate facilities for compliance. If a facility does not comply, the inspector has a legal right to withdraw the certificate of occupancy even though the building may be occupied. The insurance company could declare the building uninsurable and put the consulting engineer in the cross hairs.



Consulting engineers need to address four critical issues to ensure their projects meet code and they protect themselves.

They need to:

1. Minimize their exposure to risk and liability by familiarizing themselves with evolving seismic code standards,
2. Develop well-written specifications that account for ground acceleration and other seismic data for a site,
3. Work with contractors on a quality assurance program, and
4. Specify equipment properly certified for the specific building location.

Real-Life Risk

On-site power equipment that is essential to building operation and that is specified and installed in critical facilities but does not comply with IBC standards in jurisdictions that have adopted the code risk being red tagged. Already, engine-generator equipment installed in a new construction hospital in St. Louis, MO was red tagged for not being seismically qualified.

St. Louis is near the New Madrid fault area, which has generated the most severe ground acceleration during a seismic event in the U.S. Ground acceleration during a seismic event is a major determinant of destruction. The seismic standards of IBC refer to higher ground acceleration levels specified in ASCE 7-05, based on the New Madrid events of 1811 and 1812.

What that meant to the hospital project is that the engine-generator manufacturer had to send a retrofit kit to the site that was field 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 boost 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.

Even if equipment operates properly after a seismic event, liability still may arise for

1. IBC 2000 refers to ASCE 7-98, 2003 refers to ASCE 7-02, and 2006 and 2009 refers to ASCE 7-05 as the performance benchmarks for seismic criteria.
2.The U.S. Geological Survey assigns ground acceleration levels.

the consulting engineer. One example could occur if the emergency power design didn't include all of a hospital's chillers. After normal source power failed after a seismic event, ambient temperature and relative humidity might rise to levels that could compromise patients on life support or the ability of operating rooms to function comfortably. The consulting engineer, hospital owner and others could be liable. Richard Berger, chairman of The VMC Group, a company specializing in shock, vibration, seismic and noise control and the largest certifying agency for the power generation market said, "It could be a legal issue to be tried in court."

An air handling unit at an office building in Houston, for example, did not withstand wind speeds that were included in the building's design criteria. After Hurricane Ike hit the area in 2008, the unit dislodged from the building allowing water to enter ductwork and cause extensive interior damage to the building. The insurance company denied the building owner's claim because the unit had not complied with building codes.

It's Not Just Building Owners at Risk

Besides building owners, risk and liability also lie with contractors, consulting engineers, project engineers and critical equipment manufacturers. The building owner and other plaintiffs could sue them for improperly designed and installed systems. As of May 2010, for example, Berger of The VMC Group said 38 lawsuits have been filed as a result of the code.

Engineering professionals can minimize their exposure by ensuring 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 the master specification. But if it isn't written properly, it can be of little comfort when litigation arises. Bottom line, consulting engineers and other project team members are joined at the hip regardless of their role. The code's Consequential Damage clause makes clear that the work of one also is the responsibility of others.

Consulting engineers and other team members also may be unaware or confused about changes in the building code, especially for seismic events. One reason is that the building code is the handbook for structural engineers, not electrical engineers. The seismic certification requirements for electrical equipment that it contains are not included in electrical handbooks.

Another reason the IBC revises its seismic provisions every three years is 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 are part of their codes.

All states have adopted one version of the IBC code and 44 states have adopted IBC 2006. The state of Ohio, for instance, has adopted seismic code standards since it has been, and can be, affected by New Madrid area events. The events of 1811 and 1812 caused structural damage across Ohio.

Other states have adopted seismic code standards for the first time. It will take time for authorities having jurisdiction and engineering professionals in those states to become fluent 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 undamaged, moderate events without significant structural damage, and severe events without collapse. This is especially critical for installations in states, such as Washington, Nevada, Idaho 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.

Note the SE's Notes

Another reason for confusion about seismic qualification is that the criteria are not included in the mechanical, electrical and plumbing sections of the code. They're in the structural engineering sections. One way to ensure properly written specifications is to review the structural engineer's notes on a project and address them in the specifications. The specification writer will find data on building type and its seismic design category, ground acceleration, soil conditions and other seismic design forces that the building and its critical equipment must withstand.

Specifiers also should refer to detail in construction documents since the registered design professional must include in them pertinent seismic qualification standards for critical systems.

Finally, the project team could ask an outside expert in seismic building code standards to review 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 at hand, specification writers will be able to write clear specifications that help ensure that only code compliant critical systems qualify for a project. Specifications, however, should be part of overall project management planning that helps immunize engineering professionals from exposure. 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, and specifying only properly certified equipment in accordance with the manufacturer's recommendations for seismic use and to confirm equipment is installed properly.

Manufacturers for their part also should review the structural engineer's notes for a project to make certain their equipment is code compliant. ASCO Power Technologies switchgear, for example, is certified to withstand the highest ground accelerations in the country, even those experienced in the New Madrid fault zone. The equipment also is certified for rooftop installation, which requires 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.

In fact, 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, that could be literally life saving. Because in real life, these switching mechanisms could undoubtedly be called to operate during a typical 30-second quake. Tests prove the transfer mechanisms do not jam or otherwise fail to complete the transfer, even during the vibrating conditions of a seismic event. This is important since standards for hospital emergency power systems require the systems be operational within 10 seconds of a power outage.

Shake, Rattle and Roll

To qualify for seismic certification, building codes require that flexible critical systems and components, such as transfer switches, switchgear, fire pump controllers and other on-site power systems, be subjected to simulated seismic events on a shake table, rather than just an engineering analysis. Code compliance no longer can 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 has qualified via the Telcordia GR 63 standard may need to be de-rated. The consequences of not complying with the standards may mean equipment may be red tagged, or worse…litigation to determine liability and judgments.

The VMC Group, for example, certified ASCO equipment on a tri-axial seismic simulator that punished the equipment with thousands of pounds of force. It was fully cabled with the rated ampacity cable from the top, which raised the center of gravity and added weight. Testing with fully rated cables proves the cables did not loosen from their lugs. The systems also were tested live during the exercise 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 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. Bottom line, the system remains operational throughout and after the test.

Bolts and braces are also 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-action image shows a 4000 amp bypass-isolation automatic transfer switch withstanding thousands of pounds of force in three directions. The enclosure can move as much as three or four inches. Photo: Courtesy of ASCO Power Technologies

It's in the Codes!

Chapter 17, section 1708.5 describes in more detail seismic qualification of mechanical and electrical equipment, such as emergency power systems. Such systems encompass open gensets, enclosures, sub-base fuel tanks, remote radiators, automatic transfer switches and switchgear, batteries and battery racks, battery chargers and day tanks.

It falls to the consulting engineer to determine whether equipment is essential to enable 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's assigned a seismic component importance factor (Ip) of 1.5. In assigning an Ip of 1.5, the consulting engineer must use Section 13.1.3 of ASCE 7-05 as the guide. As noted earlier, Chapter 13 of ASCE 7-05 is the performance benchmark added in the IBC 2006 and 2009 building codes.

The Importance factor also applies to components in or attached to an Occupancy Category IV structure (IBC 2003/2006) or Category III structure (IBC 2000) that are essential to the continued operation of designated facilities.

Occupancy Category is the new term for Seismic Use Group that was used in previous versions of the code. Category IV is essential facilities, such as hospitals, airports and emergency services. Category III facilities are those that represent a substantial hazard to human life if they should fail. Examples are schools, day care facilities, power plants and facilities with occupancy capacities exceeding 5,000. Categories II and I facilities and their equipment need to comply with seismic standards when the Ip is 1.5 due to life safety or hazardous material.

There are instances when an existing building could change categories. Berger of The VMC Group recounted an experience by Goldman-Sachs with a 35-story building it owns in Jersey City, NJ. Because the brokerage house leased space to a 911 call response center, the category for the entire building changed to Occupancy Category IV. That made it an essential facility that was considered new construction and subject to Category IV standards.

In another instance, 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.

Equipment that needs to meet standards, however, must carry a certificate of compliance (C of C) that is submitted 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 determine compliance. This identification is the proof to the inspector that the equipment that arrived on site is the same as what was submitted and approved during the submittal process. The C of C 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 performance criteria of the equipment (i.e. the seismic capacity of the equipment).

For his part, the building owner or his 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 also helps establish whether seismic standards apply to a given facility. Soils affect an event's peak ground acceleration (PGA), or degree of ground motion. Soft soils over bedrock amplify motion. Another liquefies, causing foundation failure. There are six soil types: hard rock, rock, very dense soil and soft rock, stiff soil, soft soil, and extremely vulnerable soil. Soil profiles are important because they help determine a site's S_{DS} value. The S_{DS} value and 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 facilities 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 data for a site, working with contractors on a quality assurance program, and specifying only properly certified equipment. ■