Your Guide to Data Center Earthquake Preparedness
by David Geer

"I have never experienced anything of this magnitude in such an industrialized area," says Bob Laliberte, senior data center analyst, the Enterprise Strategy Group, Milford, MA, speaking of the recent 9.0 earthquake in Japan. "With this tragedy," says Kris Domich, principal data center consultant, Dimension Data Americas, New York City, "there has been a lot of reconsideration in the data center industry of the potential for damage as a result of seismic activity."

Earthquakes point a huge portion of their damage potential at the enterprise's wallet. If organizations are not prepared, says Laliberte, a new data center can cost them up to hundreds of millions of dollars. "And the biggest impact is that, if the data center is lost and there is no backup, many enterprises may go out of business," Laliberte says soberly. That impact can be far-reaching if the data center has several partners relying on it.

Here's what a half-dozen experts had to say about assessing data center locations, addressing building codes, constructing the data center inside and out, protecting infrastructure and operations, and replicating to and running secondary operations at distant and dissimilar locations. Data center leaders looking to shore up an existing facility or build out a new one should do some digging here before doing any digging there.

Location, Location, Location

The term is site analysis, and the process should be exhaustive and thorough. "Get on the Internet, surf to US Geological Service mappings, and take a look at the major faults and occurrence and frequency of seismic activity in the area," says Rick Schuknecht, vice-president, The Uptime Institute, Santa Fe, NM. An enterprise and its data center design and construction team will discover 95 percent of what they need to know about a location's risks including manmade and naturally occurring hazards through Internet searches and by viewing fly-overs using Google Earth, Schuknecht explains.

"The other five percent you get by getting in a car with a handheld GPS device and driving a five-mile radius around the site," Schuknecht says. "I have found things no one thought of, such as underground pipelines, just by driving around the location."

With risks collected, Schuknecht puts them all, categorized by exposure type (bodies of water, weather, hurricanes, typhoons, and seismic activity) and risk type (floods, structural failures) into a matrix, weighting them based on the business objectives the data center must meet. He then uses the matrix to evaluate the proximity and severity of the risks. Using this information, the data center design and construction team and the enterprise determine the risks they need to mitigate, to what degree, and how.

Using the Old For the New in Santa Clara and Tokyo

When rebuilding a chip factory into a new data center in Santa Clara, CA, 45 miles from the San Andreas Fault, Server Farm Realty, Inc (SFRI) of El Segundo, CA, considered the clearly high risk of seismic activity in the area. "The specification we looked at the closest was the Seismic Importance Factor (SIF)," says Bob Glavan, vice-president of operations at SFRI.

The purpose of the SIF or I-factor is to increase the probability of a building's functionality after an earthquake, given the requirements necessary to meet the SIF at the location in question. "If the building has an SIF of 1, you will be able to get out of the building though it could be heavily damaged. At an SIF of 1.25, the building remains intact, can have some damage, but is inhabitable. At an SIF of 1.5, the building, infrastructure and people inside remain completely operational," says Glavan.

To meet their SIF requirements, SFRI reinforced the building columns, used lateral cross beams to eliminate the lateral sway of the building, reinforced the roof with additional beams along side the existing roof joists, and installed joist hardware at each joist junction. Data center leaders would do well to mimic their efforts.

"When we select the buildings for our data centers," says Kei Furuta, managing director, Equinix Japan, Tokyo, "we ensure that they pass the Japanese Earthquake Codes." Japan made the last major change to the building regulations that contain these codes in 1981. Equinix locates its data centers only in buildings built after that year.

"The roof design for those buildings is meant to resist a 1.5G to 2G horizontal acceleration in the event of an earthquake. All the electrical panels are designated to support 0.5 to 1G horizontal accelerations, which is why steel panels in the buildings are usually thicker than those made outside Japan," Furuta explains.

Addressing Codes, Calculations, and Zones

"Enterprises that build data centers must adhere to the building codes of all applicable jurisdictions, including codes that address seismic activity, at the national, state and local level," says Kris Domich, principal data center consultant, Dimension Data Americas.

These include the Uniform Building Codes (UBC). Regulations base codes for earthquake readiness in a given geographical area on the seismic zone the location falls into. Engineers refer to these seismic zones, labeled 1 through 4, which describe the differing levels of seismic activity experienced from one location to another.

Zone 1 designates a low level of activity while zone 4 designates the highest. "If you look at a seismic zone map of the US, you will generally find areas of low seismic activity in the center of the country and areas of higher activity at the edges of the coast areas and on the West Coast in particular," Domich says.

While building codes require engineers to build data centers to meet requirements for the given zone, Domich advises clients to build data centers to withstand earthquakes of one zone higher than that. "If you are building in seismic zone 2 your data center should be built to withstand seismic zone 3 earthquakes, and so on."

The reasoning behind this is worthy of discussion. Structural engineers should always consider the Peak Horizontal Acceleration (PHA) or the likely movement of the earth during a tremor, according to Domich. Engineers calculate the PHA value, which is a computation of G forces acting on the earth or anything on the earth. Building regulations factor this into the building codes. Following those codes should automatically account for PHA. So building for zone 2 quakes in zone 2 should suffice.

But structural engineers must also consider the probability of excedence, the probability that seismic activity may exceed that PHA value in the next 50 to 100 years. If a seismic event that exceeds PHA could occur during the life of the building, building up to the requirements of the next highest zone will help to address this.

"The quake in Japan, however, was a 1-in-500-years event," says Domich. It is difficult to predict these by any science.

Base Isolation Systems, Safe From the Bottom Up

A firm yet flexible foundation will assure data center managers that servers will not go flying when the earth starts moving. Rolling base isolation systems are available to stabilize building foundations for new building construction in high earthquake zones. "A base isolation system is a collection of elements used in structure construction to separate a building from its foundation," says Dr. Mickey S. Zandi, managing director, SunGard Availability Services, Wayne, PA. These systems enable the building to absorb shock from earthquakes in order to withstand the horizontal movement caused by the quake.

One type of base isolation system uses rubber bearings. The bearings are made of layers of rubber and steel. "This is the most common type of base isolation system," says Dr. Zandi. The second type are the spherical sliding isolation systems, which support the building on bearing pads that have curved surfaces and experience low friction. "During a quake, the building slides on the bearings to minimize damage," Dr. Zandi explains.

"We built a building on base isolation systems," says Mark Evanko, founder, BRUNS-PAK, Edison, NJ. "The entire building and all of its electro-mechanical support systems can move two feet in either direction." A tour of the structure's basement reveals the rubber base isolation systems that suspend the building. Data center managers should consider such a tour if the opportunity presents itself.

Equipment Stabilization and Isolation

The data center industry often refers to the Telecommunications Industry Association (TIA) Telecommunications Infrastructure Standard for Data Centers, or TIA-942. The standard consists of requirements for telecom infrastructure used in data centers. Based on the TIA-942 and the GR-63-CORE, Domich advises clients and data center managers about how to bolt down racks to the floor.

Most racks have the option to use seismic anchors or adapters, which add reinforcement so the racks will stay in the same place. But if you have a structural failure of the building or floor, it will not matter. And even minor movement of the racks can sever data connections or injure people. "The best practice," says Domich, "is to use rails to slide the system into the rack and lock them in place."

But the best practice in the US may not be enough in Japan. "We install our equipment on earthquake frames," says Furuta. Rather than mount racks on a raised floor, Equinix uses an earthquake frame, which is a rigid steel frame that they bolt directly to the floor while mounting the racks and other equipment on top of that. This provides the racks with better lateral support and avoids the collapsing domino effect that can occur when racks are fixed to the raised floor. "Our earthquake bracing frames are tested and approved for seismic zone 4," says Furuta.

There are also seismic isolation systems for equipment that roll on bearings that separate the hardware from the floor. Some of these systems re-center the equipment squarely after the quake. Some also offer noise filtering so that vibrations do not transfer from the floor to the hardware, causing damage. These systems enable the equipment to keep on running through and after a quake unharmed. Some of these systems exceed seismic zone 4 requirements.

The Active-Active Data Center Operation Model

In the event of a damaging quake that takes out the data center, the enterprise should be prepared to shift data traffic quickly out of the affected geographical location to another facility. Enterprises can do this by mirroring the first data center at another. This is the active-active approach, Dr. Zandi explains, in which both facilities carry live production traffic and are supported by either a disaster recovery or cloud-based site as well.

"That way, if there is an earthquake at one site, the second site assumes all production operations. And if there is an issue at the second site, the disaster recovery or cloud site becomes active," Dr. Zandi says. Some enterprises, such as one that Evanko worked with, go so far as to build out three or more redundant data centers in dissimilar regions to further minimize their risks.

By carefully assessing earthquake risk at new and existing sites, building beyond code and zone requirements from the foundation up, securing systems internally with equal care, and preparing for disaster with redundant sites, the enterprise can thrive in a world that rocks its own foundations from time to time.