Seismic matters should be discussed in a language we can all understand.

conference preview

LET'S TALK SEISMIC

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Intensity	Shaking
I	Not felt
II	Weak
III	Weak
IV	Light
V	Moderate
VI	Strong
VII	Very Strong
VIII	Severe
IX	Violent
X	Extreme

Figure 1. Classifying earthquake shaking intensity.

HAVE YOU EVER BEEN in an earthquake?

How would you describe what was going on around you during the earthquake? Would your account focus on a description of the shaking that occurred and the associated damage that was occurring as the ground shook?

Let's Talk Magnitude *and* Shaking Intensity

Engineers need to communicate seismic information to clients and the public in a way they can comprehend, but many times it is difficult to convey complicated concepts in simple language. The intent of this article is to help facilitate the discussion.

When the Earth Quakes, the Ground Shakes. After an earthquake happens, we all want to know how "big" it was, and news headlines frequently report the earthquake magnitude. And magnitude is important. The size of area affected by an earthquake and how long the shaking lasts is dependent upon magnitude. For example, a magnitude 8 earthquake can be felt over a significantly larger area than a magnitude 6 earthquake (compare Figures 2 and 3 on the next page). The shaking from a magnitude 8 earthquake also lasts longer (minutes) than the shaking from a magnitude 6 earthquake (seconds).

But just knowing the magnitude of an earthquake does not adequately tell us about the level of ground shaking intensity that occurred. It is true to say that larger-magnitude earthquakes have the potential for higher ground shaking intensity, but it does not mean that violent shaking intensity cannot occur from smaller earthquakes. For example, the ground shaking intensity from magnitude 6, 7, or 8 earthquakes can range from light to extreme.

Just as with most naturally occurring things, there is variability in the ground shaking intensity that is generated by every earthquake. The ground shaking intensity from similar magnitude earthquakes is not the same, and it can vary greatly from one earthquake to the next, or even within the same earthquake. In other words, just knowing the magnitude of an earthquake does not adequately describe the shaking that occurred. You must also know the ground shaking intensity caused by an earthquake to understand its impact.

It's All about the Shake in the Quake. A simple way of classifying ground shaking intensity is to use the following terms, Roman numerals, and colors: light (IV, blue-green), moderate (V, green), strong (VI, yellow), severe (VIII, orange), violent (IX, red) and extreme (X, dark red); see Figure 1.

Following an earthquake, the United States Geological Survey (USGS) produces maps that show the ground shaking intensity. These maps are extremely valuable to quickly see the range of ground shaking intensity. If there is red (IX, violent) shaking under a populated area, you know very quickly that it will be a very significant event. Note in Figures 2 and 3 that the magnitude 6.1 Christchurch, New Zealand, earthquake, which occurred February 21, 2011, caused red (IX, violent) shaking, but the magnitude 8.8 Bio-Bio, Chile, earthquake (February 27, 2010) caused mostly orange (VIII, severe) shaking in populated

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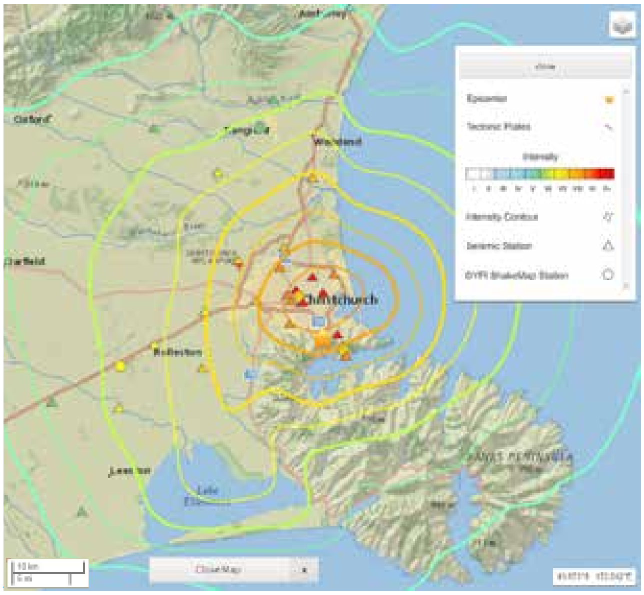

Figure 2. Magnitude 6.1 Christchurch, New Zealand, earthquake.

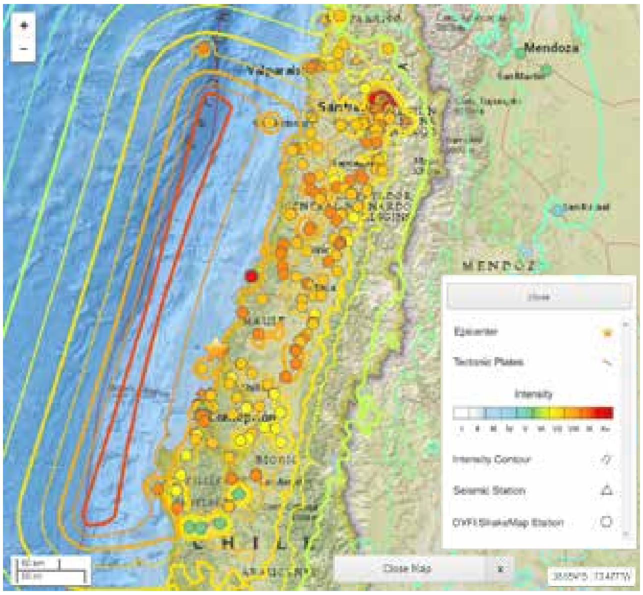

Figure 3. Magnitude 8.8 Bio-Bio, Chile, earthquake.

areas. Comparing Figures 2 and 3 also demonstrates that the magnitude 8.8 Chile earthquake was felt over a significantly larger area than the magnitude 6.1 Christchurch earthquake. (The shaking also lasted much longer in the magnitude 8.8 earthquake, but this is not captured in the map.)

For people and buildings, it is all about the shake in the quake, because they are affected more by the ground shaking intensity than by the magnitude of the earthquake. The more intense the shaking, the more damage will occur.

Consider the information contained in this hypothetical news headline: “Seattle hit with a magnitude 7.0 earthquake.” Compare that headline to the information gleaned from the following hypothetical headlines:

a. Seattle hit with a magnitude 7.0 earthquake: Large areas of extreme shaking

b. Seattle hit with a magnitude 7.0 earthquake: Most areas thankfully experience light shaking intensity

The latter headlines help you to quickly understand the impact of the earthquake much better than just knowing the magnitude.

Let’s Talk Building Codes

Since ground shaking intensity causes building damage, this is the key parameter used in the engineering design of buildings. (While many intensity factors affect building damage, engineers primarily use acceleration as the basis of design. For simplicity, this article uses “ground shaking intensity” and “ground motion” to represent all of these factors.) It is inaccurate to say that a specific building is designed for a specific magnitude earthquake, because that earthquake has a range of potential ground shaking intensities, some of which could exceed the code-prescribed ground shaking intensity.

Buildings Are Not Earthquake Proof. The code prescribes a ground shaking intensity level for every site called the maximum considered earthquake (MCE_R), but it is not an earthquake; it is a ground shaking intensity level—but not the maximum intensity possible at the site. Engineers must have a paradigm shift and consistently use phrases like “maximum considered earthquake ground shaking intensity” or “MCE_R ground motion” and never just use “maximum considered earthquake” alone. It is very unlikely that the MCE_R ground shaking intensity will ever occur, but if it does, a small number of code-conforming buildings could collapse. (A new building should have no more than a 10% probability of collapse if an earthquake causes the MCE_R ground shaking intensity.) Because it is possible for an earthquake to cause a ground shaking intensity that exceeds the MCE_R shaking intensity, the MCE_R shaking intensity should be thought of as a minimum rather than a maximum, because engineers may not consider a shaking intensity less than this level. (The MCE_R shaking intensity is set to a level where there is about a 1/5000 probability that a building will collapse in any given year.)

Buildings Will Be Damaged. Buildings that survive the MCE_R shaking intensity could be severely damaged and on the verge of collapse. Aftershocks could cause the building to collapse. Many architectural components of the building could fall, causing localized deaths or injury. The building could be a total loss. Engineers call this condition “collapse prevention.”

If an earthquake causes a lower shaking intensity ($2/3*MCE_R$, referred to as the “design earthquake ground motion”) a building could experience costly damage, but it is not expected to collapse, thus allowing occupants to safely exit the building. The building is also expected to safely experience aftershocks. Most architectural components of building should stay attached and not fall (if secured as prescribed by the code). The building, however, could be shut down for up to a year for repairs. In some cases, it may be more economical to tear the building down rather than repair it.

Let's Talk Public Expectations

The building code establishes a minimum "acceptable" standard of life safety and allows the above damage states. Unfortunately, most building owners and building occupants do not know about or understand the potential damage that could occur to their building. Many people assume minimal damage and expect to be able to reoccupy their building immediately following an earthquake.

Imagine the economic loss to a company that is not able to reoccupy their place of business for many months following an earthquake. Multiply that by the hundreds, thousands or tens of thousands of businesses in a community, and imagine the economic impact. This is not what most business owners and the public expect from their buildings.

There are ways to reduce the economic loss associated with earthquakes. Engineers can design buildings to perform better and experience less costly damage than provided by a basic code-conforming building. Engineers, architects and building owners should discuss building performance expectations prior to beginning the design of a new building.

Quantifying Building Damage. There are tools available to help building owners understand the potential repair costs and the economic loss due to business downtime caused by specific levels of ground shaking. Using these tools, engineers can make improvements to the building design and then show owners the benefits of reduced repair costs and downtime. A cost-benefit analysis will help owners decide what makes the most sense in terms of better building performance.

Common Language. We all need a paradigm shift. Engineers need to stop talking about designing buildings for "earthquakes" and start talking about designing buildings for "ground motions" or "ground shaking intensities caused by earthquakes." They also need to better educate the public about building performance and the economic impacts associated with various levels of earthquake shaking intensity, such that engineers and non-engineers alike can talk about seismic in language we can all understand. ■

This article is a preview of Session N31 "Let's Talk Seismic–In Language We Can All Understand" at NASCC: The Steel Conference, taking place April 11-13 in Baltimore. Learn more about the conference at **www.aisc.org/nascc**.