Earthquake Engineering Q&A

Almost a year on from the devastating February 22, 2011 Canterbury earthquake, the Science Media Centre put a series of questions to structural engineers on the implications for how buildings are designed, constructed and earthquake-proofed in New Zealand.

The engineers include **John Hare**, president of the Structural Engineering Society, **Win Clark**, executive officer at the New Zealand Society for Earthquake Engineering, **Mark Batchelar** a consultant engineer and earthquake engineering expert **David Hopkins**.

This Q&A was put together in association with the Institution of Professional Engineers of New Zealand (IPENZ). Feel free to use the comments below in your reports.

What is an earthquake-prone building?

Earthquake-prone is a term defined by law (in the Building Act 2002). It applies to all buildings except small residential structures of less than two stories and three household units. In broad terms, one that would collapse in ground shaking one-third as strong as that used to design a new building on the same site.

How do they vary in terms of factors causing their "prone-ness"?

Main contributors to proneness are lack of strength compared to forces likely to be induced, and brittleness, such as for brick buildings. The identification of earthquake prone buildings can be complex. This is particularly the case with non-ductile concrete buildings, where the difference may hang on some small details that may only be revealed through intensive investigation.

In the wake of the quakes and the current commission, can we expect to see the building code or enforcement changed?

It is highly likely that there will be changes to the Building Code, but it should be remembered that the Building Code is always evolving, as new research is completed and practices are amended. The Structural Engineering Society (SESOC) has issued some interim recommendations for code changes. This document is intended to allow designers some confidence in the design of new structures that should not be downgraded against future code changes.

What possible areas of the code might be focused on in future review of the legislation?

One of the founding principles of the current Building Code is to protect life safety as far as possible, but it is less concerned with damage to buildings. One of the broad philosophical questions to be reviewed is whether New Zealand as a society wishes to review this approach. New design techniques are being researched to reduce damage in the event of earthquake, but these are still in their infancy. However, even current conventional design techniques can be employed in ways that will be more resistant to damage, but possibly at the expense of some utility in the buildings, and greater construction cost.

Why does it take so long to analyse a building? What does it involve?

Analysis of a building can be more technically challenging than designing a new building.

The analysis process involves assembling all critical loading conditions that the structure is likely to be subjected to during its design life, and applying these to a theoretical model of the structure based on known material performance properties. This is often an interactive process, where the behaviour of one element may have implications for the performance of others.

What are some of the ways a building which is earthquake prone can be brought up to a higher standard?

The simplest method is to simply ignore the existing building lateral load resisting system and add a new structure capable of independently supporting the building. However, it is important to ensure that the stiffness of the new structure is reasonably close to that of the existing. Too flexible, and the existing structure will absorb the initial load, and have to fail substantially before the new structure can be effective. Too stiff, and there is a risk that it will impose greater load on the existing structure, literally shaking it to pieces.

The next approach is to enhance the ductility of the existing structure so that it behaves more like a new structure. This may be applicable to older non-ductile concrete structures, where confinement of the concrete can allow it to resist greater levels of movement. This may be done for example by wrapping column elements in fibre reinforced polymers (FRP).

At the upper limit of what may be done, it is sometimes possible to base isolate older buildings in order to reduce the seismic load demand. Base isolators work similarly to suspension and damping in a car, using the isolators instead. Forces in the structure are reduced, but a consequence of this is that the building must move greater distances, in excess of half a meter in some cases. Typically, base isolation has been used only in cases where the building has contents of great value, or is of high heritage value itself. An example of this is the Parliament buildings which was base isolated in the early 90's.

To what extent will the strong ground motions recorded in the Christchurch earthquakes lead to changes in New Zealand's building code?

The Canterbury earthquakes are hugely significant for New Zealand and worldwide practice. This is the first strong motion event in a major urban area in New Zealand in the modern building era, and has inevitably prompted research which will continue for some years. A re-evaluation of seismic loads may eventuate, but this must occur hand-in-hand with the development of our design Standards. It is vital that engineering input is obtained and taken note of at critical decision stages.

Has enough been learned in engineering terms to reduce the damage that liquefaction and lateral spreading does to foundations of structures?

It is possible, through good engineering and sound construction practices, to build on most ground. However, it is important also to consider the infrastructure necessary to sustain these areas. Where there is already considerable investment in the infrastructure, particularly damage-prone in-ground services, there may be reason to spend the extra money required to build in these areas in order to realise the current investment. However in the case of new subdivisions or cities, more careful site selection may prove a better long-term solution

And if sea levels rise 2m over the current century, will the higher water table increase the risks of liquefaction in Christchurch or Wellington?

A 2m rise in sea levels has much greater implications than simply a rise in water table, threatening the viability of coastal cities, regardless of ground conditions.
Restricting the consideration to liquefaction, it is important to note that water table is only one of the components of liquefaction issues. Liquefaction occurs generally loose sands and silts, which are prevalent around Christchurch. Other areas where the soils are of different origin may not suffer liquefaction even with a high water table, although there are many other areas in New Zealand that can liquefy with sufficient ground shaking. These areas are generally identified by the Regional Council hazard studies and the information will be recorded on LIM reports for properties.

Should households pay insurance premiums based on the perceived seismic risk of their site, the anticipated performance of their house design, and the risk that the suburb around them may be abandoned even if their specific house survives?

This may happen following the Canterbury earthquakes, at least in suburbs where issues such as rock fall or liquefaction can be identified on an area-wide basis. However, it is questionable whether the risk can be fully quantifiable for many of the more specific matters that may affect potential future claims, such as the construction of an individual home. The extent to which the insurance companies may impose such conditions will depend on their appetite for risk in the future.

It is more likely that some forms of building may become uninsurable, unless engineers are able to demonstrate adequately that the risk is not as high as perceived. An obvious category is un-reinforced masonry Buildings (URMs), which unfortunately include many of our most significant historic buildings. URMs have been recognised as a very high risk category for a long time, but have been able to be insured almost as easily as any other building. This is unlikely to be the case in the future. However, they may be strengthened successfully, as has also been demonstrated in the Canterbury earthquakes with a number of well-strengthened buildings having performed as well as much newer structures.

A more interesting question may be whether NZ will be able to afford to carry the level of earthquake insurance in the future, that it has to date. It is also relevant to consider how society may consider managing seismic risk in the future.

Risk transfer (insurance) has always been an expedient answer, but it is evident that it may not be the best way to solve the problem. Although insurance may go a long way to replacing lost assets, there are questions with respect to timeliness of the settlements and damage to the overall community from having so much of our building stock out of commission for so long.

In the future a mix of mitigation and transfer may prove a more robust policy. By more effective strengthening and replacement of the worst of the building stock, damage from a similar event may be dramatically reduced. Money saved from insurance policies over time will go a long way to offsetting the added costs of redevelopment and strengthening]

Should homeowners be rebuilding to a standard which will enable their homes to perform much better in the next big quake - such as a major shake on the Alpine Fault - rather than simply suffering exactly the same damage all over again?

There is nothing to prevent owners from building to higher standards than the minimum set. The minimums are intended to meet the basic expectations of owners in general. It is possible to make designs more conservative and thus reduce the probability of damage / collapse / business interruption, but it will be at a cost.

It takes time to change building codes and this process cannot get into full swing until the Royal Commission has published its findings. In the interim, advice is available to engineers and homeowners. Through the Department of Building and Housing (DBH), the Engineering Advisory Group has published its *Revised guidance on repairing and rebuilding houses affected by the Canterbury earthquake sequence – November 2011* .In addition, the Structural Engineering Society (SESOC) has published recommendations for interim building controls - a series of recommendations for additions to the current Building Code.

To find out more, or to talk to an expert quoted above, please contact the Science Media Centre:

Science Media Centre
04 499 5476
smc@sciencemediacentre.co.nz
www.sciencemediacentre.co.nz