THE SHAKE, RATTLE AND TOLL

Earthquake Special Report: We explore new ways architects are designing for disaster and whether fracking leads to temblor troubles. And we look at how emotion can colour our attitudes to risk, plus cutting-edge earthquake prediction technology. We also cast our eyes to the future, with forecasts for serious seismic activity

WORDS BY EDWARD MURRAY

ON EDGE: Landslides in Redcliffs near Christchurch in February 2011 leave homes teetering on the brink of disaster after a 6.3 magnitude earthquake devastates the region

EARTHQUAKES: NATURE'S MOST DESTRUCTIVE FORCE

THEY'RE A DAILY OCCURRENCE, AND WHILE THE MILDEST TREMORS GO UNNOTICED, THE MOST VIOLENT TEAR THE COUNTRYSIDE APART, REDUCE CITIES TO RUBBLE AND GENERATE TERRIBLE PERSONAL AND ECONOMIC LOSSES

Statistics show the deadliest ten earthquakes between 1980 and 2012 killed more than three quarters of a million people, while the ten costliest over this period generated losses of $557bn. Less than 15% of this was insured. What is perhaps most concerning about these figures, is the difference between where the biggest fatalities and the highest costs arise.

Although three of the costliest temblors happened in New Zealand, they resulted in relatively few fatalities. In one of the earthquakes no one died, in the second one person died, and in the third 185 people lost their lives. The 2004 earthquake in Haiti, however, saw 222,570 fatalities – but did not feature in the top ten costliest earthquakes. Not only do the least developed countries bear the heaviest human toll – they also have the least cover in place to get them back on their feet. Swiss Re estimates the insurance contribution to the Haiti quake was 1% of the total loss, while the industry covered 81% of the losses in the 2010 earthquake in New Zealand.

It is clear big improvements could be made – both in terms of the physical protection in place, as well as the insurance safety net that exists to fund rebuilding in the aftermath of disaster.

From the way we design and construct buildings to the way we seek to predict major seismic events, there is much to do. And it has already begun. In 2000, the Turkish Government created the Turkish Catastrophe Insurance Pool and insisted on mandatory cover for residential buildings in urban areas. But, the cover extends only to physical property damage and not contents, personal injury or commercial loss.

Similarly, advances have been made in the fields of architecture and engineering. But getting the latest technology implemented into construction processes in the poorest parts of the world is a difficult task.

Data from the US Geological Survey National Earthquake Information Centre shows that between 2000 and 2012, there were two earthquake deaths in the US, while globally there were 813,856. The lower fatality record was delivered on the back of better buildings, infrastructure and emergency responses. It is this level of resilience that every country in the world should be aiming for.

FEELING THE RISK

RECENT RESEARCH BY PROFESSOR HELENE JOFFE, OF UNIVERSITY COLLEGE LONDON, EXAMINES THE EMOTIONAL RESPONSES PEOPLE HAVE TO THE THREAT OF AN EARTHQUAKE. SHE TALKS TO MARKET ABOUT HER FINDINGS, WHICH WON THE 2013 LLOYD'S SCIENCE OF RISK PRIZE

MARKET: **Why do you think people in highly seismic areas do little to protect themselves against a potential earthquake?**
HELENE JOFFE: "With more regular threats like monsoons, you do find that people prepare. But when it comes to earthquakes, those in affected areas have a much more complex response. The fact that earthquakes have a very long return period, coupled with an inability to accurately predict them, means people tend to live with them as a fact of life. They refuse to let the ongoing, but non-time specific threat inhibit them. The potential scale of an earthquake also makes people feel impotent. There is a fascinating factor that, if you feel something is out of your control, you think, 'why bother?'"

MARKET: **How different were the responses from the people you spoke to in Japan, Turkey and the US?**
HJ: "In all three countries there is a sense of the potential loss following an earthquake, and the panic and anxiety that would be elicited if one strikes. But the interesting thing is that in the US there is an extra emotion of awe and excitement about potentially witnessing an earthquake. It is a minority position, but it does not exist in the other two places.

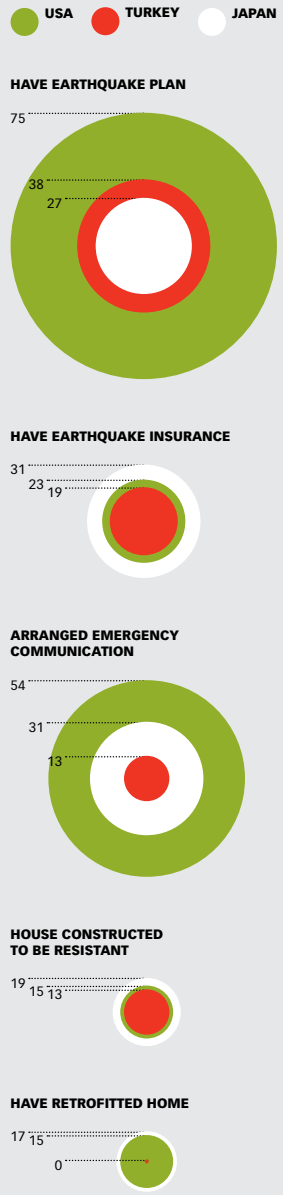
"The potential scale of an earthquake also makes people feel impotent. There is a fascinating factor that, if you feel something is out of your control, you think, 'why bother'"

Trust issues are also central. We found, particularly in Turkey, that because people do not trust their buildings to withstand any shaking, and feel they will simply crumble around them, then why do anything to prepare? Residents in Turkey feel a corrupt construction sector means the materials and techniques used often undermine the strength of their buildings, and they question the point of trying to strengthen a building weakened by poor practice.

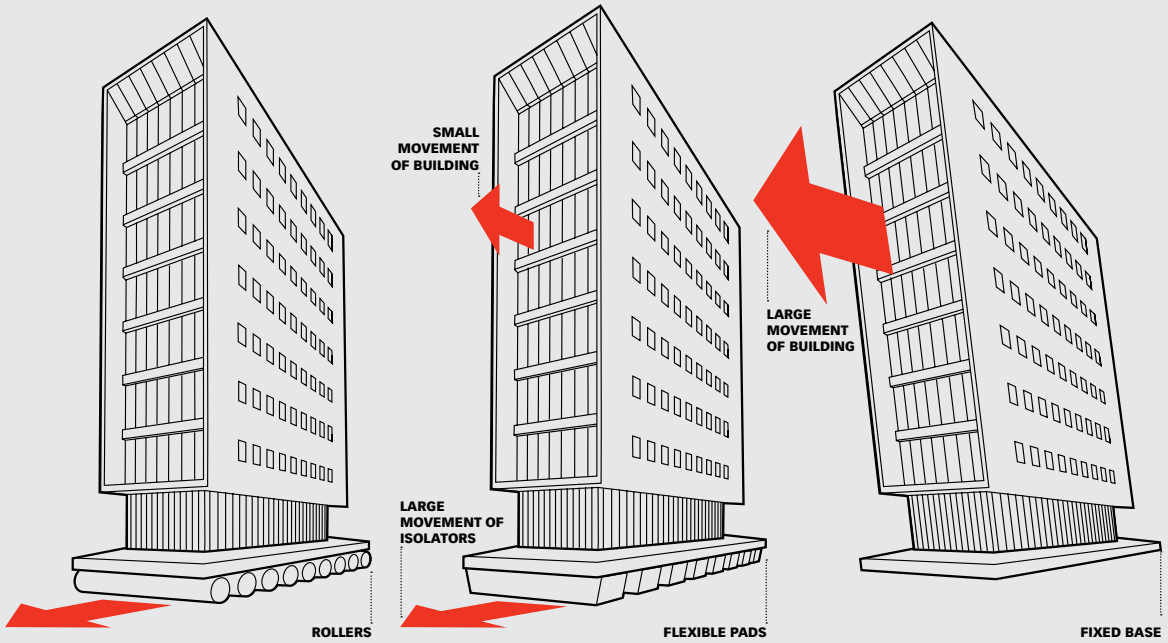
MARKET: **Many of the preparations that people make are non-earthquake specific. What can the insurance industry do to encourage people to better prepare?**
HJ: "Partly, it's people having a sense they can survive – that earthquakes are not necessarily death events. If you've retrofitted buildings, or built to code, and you take additional measures, your survival chances are quite high. So, what encourages preparedness is a sense of self efficacy – that there is something that I personally can do to mitigate impact and survive."

EARTHQUAKE PREPAREDNESS

Of the people questioned in each site in Helene Joffe's survey, what percentage adopted adjustment measures?



BASE ISOLATION, A TECHNIQUE THAT PREVENTS OR MINIMISES DAMAGE TO BUILDINGS DURING AN EARTHQUAKE, HAS BEEN USED IN NEW ZEALAND, INDIA, JAPAN, ITALY AND THE USA



ROLLERS
When a building is isolated from the ground, resting on flexible rollers (or bearings), it will only move a little or not at all during an earthquake.

RUBBER PADS
Similarly, flexible rubber pads that work like a car suspension system allow the building to adapt to tremors and ground shifts, with reduced shaking.

FIXED BASES
Superstructures that are coupled directly with the ground are more likely to experience lateral movement induced by an earthquake – and therefore to suffer extensive damage.

DESIGNING FOR DISASTER

ARCHITECTURAL AND ENGINEERING INNOVATIONS, COUPLED WITH WELL-REGULATED BUILDING CODES, COULD SAVE COUNTLESS LIVES – AND PROPERTIES

Minutes after the 2008 Sichuan earthquake struck China, the world's tallest building at the time, the Taipei 101 in Taiwan, started swaying. As it moved, a 728-ton pendulum, suspended between the 87th and 92nd floors, rocked back and forth to counteract the shockwaves and protect the building.

This counterbalancing technique is just one of the approaches that architects and engineers are evolving to enable buildings to maintain their integrity during quakes.

"Another technique is to actually isolate the buildings on foundation systems that roll with the earthquake," explains Michael Gustafson, Industry Strategy Manager for Structural Engineering at software design specialist Autodesk.

"Imagine being on top of a table with roller skates on. As somebody shifts the table back and forth, you actually stay in the same place because the skates allow the table to move underneath you. In the same way, the building does not feel all of the forces because it is moving and not subject to the full forces from the quake."

Turkey's Sabiha Gökçen International Airport, completed in 2009, is the biggest building in the world to employ seismic isolation technology, and increasingly the technique is being used in buildings across the world.

The technique has proved so successful that Kubilây Hiçyilmaz, a seismic engineer with ARUP, recently blogged: "Base isolation is seismic engineering's equivalent of seatbelts in cars – and maybe more: it's a lifesaver and possibly a property saver. That's why I believe base isolation needs to be made a legal requirement for most new non high-rise buildings in areas at risk from earthquakes."

A third technique is to incorporate 'seismic fuses' into a building. This allows some of the building to dissipate the earthquake's energy and crumple, without the integral parts of the structure being damaged.

A wide-scale adoption of these innovations would quickly drive down costs and help engineers to further develop their effectiveness. But it is unlikely wholesale take up will be made mandatory.

Instead, engineers, architects, builders and insurers must push for building codes in every location around the world to be continually and gradually improved.

Says John McAslan, of architects John McAslan and Partners: "I cannot stress enough the need for well-defined building codes when it comes to improving the global benchmark for earthquake resilience in construction. And the importance of ensuring that, while there are codes in place, people follow them."

DOES FRACKING CAUSE EARTHQUAKES?

SEISMIC ACTIVITY IN TEXAS AT THE TAIL END OF LAST YEAR HAS REIGNITED THE DEBATE. OUR EXPERTS FROM THE WORLDS OF GEOLOGY AND INSURANCE WEIGH IN…

"Pumping fluid underground to get hydrocarbons out can cause earthquakes that are felt. But if you compare fracking to other processes like mining, filling dams with water, and, ironically, conventional oil and gas extraction, it does not make it into the premier league. In the US, however, they have been injecting the waste water that returns to the surface back underground. Do that for five or ten years, with enough fluid, and it can cause larger faults to move."

PROFESSOR RICHARD DAVIES,
DURHAM ENERGY INSTITUTE

"Research suggests fracking has the potential to generate seismic activity. In the event the latter does occur, however, it can be difficult to establish a direct link between one company's fracking activity and subsequent earth tremors. It is essential, therefore, that fracking companies have robust levels of data to ensure they know immediately of any adverse effect from their operations. This will help them establish greater clarity on individual liabilities."

CHRIS JONES,
UNDERWRITER, KILN

A HEADS UP FOR INSURERS:

As the scale of fracking activity increases, there will be a greater number of claims made against the industry – and whether this relates to induced seismic activity or other issues such as environmental pollution or personal injury, insurers need to ready themselves.

FORECAST: SHAKY

FROM THE US AND EUROPE TO THE FAR EAST, EXPERTS ARE PREDICTING TEMBLOR TROUBLES IN THE NEAR FUTURE. HERE ARE THREE THAT GRABBED OUR ATTENTION

CALIFORNIA

Global Weather Oscillations Inc. (GWO) has said California is most at risk of a major earthquake in a three-year period that began in July 2012. GWO generates its predictions by combining Meteorology, Oceanography, Climatology, Geology, Seismology, Astronomy and Astrophysics to create a framework through which it observes and forecasts.

JAPAN

Russian scientist Alexei Ryubushin, of the Schmidt Institute of the Physics of the Earth, put Japan on high alert when he presented research at the European Geosciences Union Convention in Vienna in April last year that suggested the country could face an earthquake with a magnitude of 9.0 between 2013 and 2014.

GREECE, ITALY AND TURKEY

Fifty scientists working as part of the Seismic Hazard Harmonization in Europe programme have suggested countries including Greece, Italy and Turkey could bear the brunt of a major earthquake with a magnitude in the region of 9.0. Although the group of scientists gave no timeframe for this earthquake, they have produced maps detailing the most at risk areas. The research was released in September last year, but Greek scientists have questioned whether the tectonic plate structure in Greece could produce an earthquake of such intensity.

NEW PREDICTION TECHNOLOGY

TO DATE, SCIENCE HAS BEEN UNABLE TO ANTICIPATE WHERE AND WHEN THE NEXT EARTHQUAKE WILL STRIKE. THIS MAY BE ABOUT TO CHANGE

Scientists can identify earthquake signatures from electromagnetic activity prior to a major event. And they are now working to develop that understanding into a predictive capability. The UK and Russia, for example, are partnering on a joint initiative that will send satellites into orbit to monitor changes in electromagnetic activity – and hopefully enable scientists to pinpoint the location and time of a strike.

Dhiren Kataria, head of the in situ protection system at UCL Mullard Space Science Laboratory, explains the technology behind the TwinSat Project: "During the earthquake preparation phase, there are a number of things happening on the surface of the earth that propel electromagnetic signals into the environment. If you are sufficiently high you can catch these signals using plasma sensors and electromagnetic field sensors."

The challenge is then to isolate this data from similar signatures created by solar storms and human activity, and develop a communications network that can issue effective warnings to areas at risk throughout the world. The goal is to predict the occurrence of an earthquake with a magnitude upwards of six, hours and even days before it happens.

At present, however, Kataria is under no illusions: "In order to build that capability and not make false predictions, there is a considerable amount of work to be done."