

SENDAI MEDIATHEQUE, SENDAI, JAPAN

Toyo Ito designed a state-of-the-art public library in Sendai in 2001. Built like a transparent cube, its lattice design is composed of tubes and platforms that mimic trees and tall grasses. The building survived the 2010 earthquake.



BUILDING UNSHAKEABLE STRUCTURES

An ongoing exhibition at the National Building Museum in Washington DC titled *Designing For Disaster* drives home an important point – natural disasters can affect anyone, anywhere. It examines disaster mitigation and how to create design solutions for safer and disaster-resilient communities. It also showcases innovative research, cutting-edge materials and technologies, new thinking about how to work with natural systems and the environment, and presents a range of viable responses.

In Taiwan, the 921 Earthquake Museum is a poignant reminder of the September 1999 quake that registered 7.3 on the Richter scale and caused fatalities and property destruction in central Taiwan. In light of the recent earthquakes in Nepal and Malaysia, which also resulted in massive loss of life and, in the case of Nepal, irreparable damage to



CCTV HEADQUARTERS, BEIJING, CHINA
Not wanting to compromise on the desired architectural form of the CCTV building in favour of structure, architectural firm OMA engaged the facade structure and created an external continuous tube system. This gave the building the largest possible dimensions with which to resist the bending forces generated by its cranked, leaning form – and external pressure from wind and earthquakes.

WITH NATURAL DISASTERS SUCH AS EARTHQUAKES POSING GREAT RISK TO HUMAN LIFE AND ECONOMIC PROGRESS, ACADEMICIANS, ARCHITECTS AND ENGINEERS ARE JOINING HANDS TO FIND SUSTAINABLE AND TECHNOLOGICAL SOLUTIONS WHILE DESIGNING SAFER AND MORE RESILIENT BUILDINGS.

ancient heritage structures, building for earthquake-prone zones is becoming a critical concern.

Notably, Japan, located along the Ring of Fire, an arc of seismic activity that surrounds the Pacific Ocean, is the world's best-prepared country in terms of civilian alertness as well as the strict building codes it adheres to. In 1981, Japan revised its building standards in accordance with earthquake science. Since then, Japanese authorities have updated the guidelines, and mandatory checks are carried out at frequent intervals, especially at hospitals, schools and public welfare facilities.

ARCHITECTURAL RESPONSE TO EARTHQUAKES

The Great East Japan Earthquake of 2011 became the subject of an exhibition – *Groundswell: Guerilla Architecture In Response To The Great East Japan Earthquake* – held last year at The Schindler House, California. Following the catastrophe, a number of architects took it upon themselves to address the area residents' rebuilding needs. *Groundswell* presented a selection of their efforts while engaging the ongoing conversation on how architecture can serve communities following a natural disaster.

Ziggy Lubkowski, seismic specialist and associate director at Arup, a global authority on structural engineering, says that the developed world has a significant advantage, and that we can see that in recent earthquakes, for example Christchurch's in 2011, in which the number of lives lost was relatively small. "Japan, which has good understanding of earthquake risk, has separate issues of population density and usable land which bring on alternative considerations. In contrast, earthquakes

in China (2008) and Turkey (1999) have led to much higher loss of life," he says.

Having realised that government-initiated civic solutions are often inadequate, experts are collaborating in a new effort to engineer earthquake-ready buildings. The 2010 Haiti earthquake prompted architectural analysis of buildings there and in megacities around the world. It was concluded that without competent planning and stricter building codes, most of the biggest cities on earth are disaster zones in waiting.

While most developing nations are fraught with deficient measures, Chile has shown remarkable progress. Measuring 8.8 on the Richter scale, 500 times as strong as the one in Haiti, the 2010 Chilean quake was devastating, but not nearly as catastrophic as it could have been had the country not been expecting it for more than 50 years. After the strongest earthquake ever recorded (9.5) hit the country in 1960, followed by another major quake in 1985, Chile started following a seismic design code for new buildings.

Speaking to National Public Radio, Eduardo Kausel, a professor in the Massachusetts Institute of Technology's civil and environmental engineering faculty, explained that Chile's codes were set up not only to save lives, but also to keep buildings and urban infrastructure in one piece. One of its building systems is the strong column/weak beam principle – reinforced concrete in buildings is designed to break in certain spots along horizontal beams, dissipating some of a quake's intensity and preserving the vertical columns, thus keeping a building standing.

Lubkowski notes several technical challenges, such as the potential size of an

earthquake, its impact on founding soils, and a building's ability to resist ground motion. "The intent of most codes of practice is for buildings to be designed such that people will be safe even if the structures are damaged. For hospitals, schools and power stations, the intent is for them to be able to continue to operate even after an earthquake."

Mehmet Ozcanli, general manager and structural and earthquake engineer at Emke, a Turkish firm specialising in seismic structural technologies, concurs. "If your buildings are strategic structures such as hospitals, nuclear power plants, data centres, fire stations, emergency management centres and viaducts, and located on highly seismic areas, your structures must be operational after an earthquake. The only way to sustain operations after an earthquake is to apply seismic isolation," Ozcanli adds.

TECHNOLOGICAL ADVANCES

Ozcanli shares that lead rubber bearings are the best suited devices to mitigate earthquake hazards; they have been tried and tested during the Northridge, USA (1994), Kobe, Japan (1995) and Christchurch, New Zealand (2011) earthquakes. "As they reduce floor acceleration, building elements can be elastic during an earthquake without sustaining any damage, and the contents of the building will not be damaged during the earthquake," he says.

Sustainability is intertwined with seismic architecture, well beyond the principles of building a sound and safe structure. Underscoring this, Lubkowski says: "Buildings that survive earthquakes are by their very nature sustainable. We do not want to be rebuilding after every earthquake. To address this, Arup has developed the REDi initiative, which is all about promoting 'seismic resilience' rather than the traditional 'life safety' only objective."

Thanks to advanced material research and innovation, experts are in a better

MAISON HERMES, TOKYO, JAPAN

Italian architect **Renzo Piano** and structural engineering firm **Arup** designed a jewel box of glass blocks inspired by Japan's traditional pagodas, which have been known to be highly resilient to earthquakes. Instead of resisting seismic forces, the blocks can move with a quake and the columns can realign.



BEIJING NATIONAL AQUATICS CENTRE, BEIJING, CHINA

Designed by architect **Zaha Hadid**, the bubble wrap-inspired form of the 2008 Beijing Olympic swimming venue is that of a highly innovative seismic sponge. Running among all those plastic globules is a large network of steel members designed in such a manner that that if any of the members fail, the others can hold strong.

position today to build with sustainable and ecological materials that are able to withstand natural seismic shifts. "Ductile or flexible materials are the best," says Lubkowski. "You want a building to respond to ground motion, not resist it."

He gives an example to illustrate this point: "Consider a tall tree in a windstorm; it will survive up to a certain level, then fall in a brittle manner. This is unacceptable. In contrast, bamboo will flex in the wind, but after the event will regain its original position. In simple terms, reinforced concrete, steel, reinforced masonry and timber can all be made to be ductile. Masonry is almost always brittle, but poorly designed and constructed reinforced concrete, steel, reinforced masonry and timber can also be brittle." He emphasises that with the wrong details, a building performs badly, regardless of the materials used in its construction.

REBUILDING VS RESTORATION

This subtopic within the discourse on sustainable and earthquake-resistant building is hugely debatable, not least because of economic considerations. Both Ozcanli and Lubkowski prefer to strike a balance between pragmatism and cultural value. "For historical buildings, restoration is a must. However, if normal structural retrofit cost is more than 40 per cent of the total cost of the building, you should rebuild it," says Ozcanli.

For Lubkowski, this is a philosophical challenge, focused on the importance of culture and heritage as well as on seismic safety. "Should we knock down the Tower of Pisa because it leans? I think we have a duty to preserve history, but in some cases this may not be possible. We should ensure that risks are evaluated, and appropriate measures taken to retain our heritage, with the knowledge that we are in a safe environment." ●