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Safe as houses?

Clever construction can help mitigate tragedy in a natural disaster, writes Madeleine Johnson

As the 2008 hurricane season winds down, you might be wondering whether you've seen more images of families huddled on rooftops or assessing sodden piles of belongings this year than you did, say, two decades ago. The answer is yes.

According to statisticians such as insurer Munich Re and the Centre for Research on the Epidemiology of Disasters, numbers of "extreme events" such as this summer's storms, hurricane Katrina in 2005 and the 2004 tsunami in south-east Asia have quadrupled since the 1970s as a result of climate change, increased settlement in risky areas and urbanisation in the developing world. Combinations of disasters – earthquakes followed by fires or windstorms and water surges – are typical, with the after-effects often wreaking as much havoc as the main events.

On the bright side, the total death toll has gone down. But economic losses have increased 14-fold, with houses and household possessions the primary victims. Some properties, especially the ones we see on the television news, are simply flattened. But others might be damaged in smaller ways: strong winds comprise structural envelopes; pebbles blown from gravel roofs break windows; deck umbrellas and items of loose trim become wall-piercing missiles. And problems such as mould only appear after the wind has stopped and the water receded. Munich Re reports that in Thailand after the 2004 tsunami many buildings stayed standing but the "main losses involved damage to contents".

Even for those with insurance to cover repair costs, seeing one's house destroyed is a wrenching experience. For most people homes are not only a big financial asset but also expressions of taste, cultural or family heritage and identity. In poor countries stable shelter also means improved health and better-functioning societies.

Once hurricanes, earthquakes and tsunamis happen, relief money for rebuilding does typically flow in. But disaster experts agree that it is much better to pre-empt the problems – by investing in buildings that can withstand rain, flood and fire and that lessen the overall impact that such events have on a community. A roof that doesn't fly off, for example, works twice, protecting not only the people and things underneath it but also the other buildings it doesn't hit. Post-disaster, viable shelter speeds recovery by reducing economic losses, the spread of disease and social disarray. "Having a house is the most important thing for getting society back on track," says Domenico del Re, an engineer with Risk Management Solutions.

Experts say it is neither possible nor cost effective to build houses that laymen would describe as "disaster-proof". We can't live in bomb shelters. But there are effective "disaster mitigation" techniques, such as installing specially designed windows or steel roof anchors, raising buildings above expected flood levels and enforcing rigorous building code standards. "You can never be 100 per cent safe, so do what you can," says Andrew Sachs, whose title – vice-president of crisis and consequence management at "emergency preparedness" consultancy James Lee Witt – conveys the seriousness of his mission. "Many studies have found that the return for every single dollar spent on mitigation is at least four dollars."

This strategy includes adapting innovative or unconventional construction techniques as well as re-evaluating traditional practices with good survival records and making simple modifications. Sometimes it means creative destruction.

Buildings that survive disasters seem to lie at extreme ends of the cost and sophistication scale. At one end are highly engineered structures constructed by well-trained, experienced professionals using the latest technology. At the other are indigenous forms and materials employed by amateurs equipped with simple skills. The poorest-performing homes are in the middle range, where not-so-new technologies or materials are applied by not-so-skilled professionals. The most common and most tragic example is reinforced concrete used in developing countries.

Some of the most advanced disaster mitigation tools, such as base isolation systems for earthquakes, are usually reserved for big or critical projects, such as bridges, hospitals or large apartment complexes – or individual homes in the $30m range. But other new technologies are accessible to all homeowners. Sips, or stress-skin panels, which are sandwiches of structural board – wood composite or cement – and foam filling, perform well in high winds and floods. Quick

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and inexpensive to put together, Sips panels can be trimmed and shaped to blend with local architectural styles. And after a flood a cement-board Sips house can be stripped, hosed down and reconditioned in days.

Monolithic domes are another example. For these, inflated forms – often made by hot-air balloon manufacturers – are reinforced with steel, then sprayed with specially formulated concrete. Deceptively delicate, they can withstand 300mph winds and are blast- and earthquake-resistant. With no wood or porous materials, they also resist fire, floods, mildew and rot. The domed Sigler house in Pensacola, Florida, was, after hurricane Ivan in 2007, "the only thing still standing" according to David Barrett, a colleague of the late architect Jonathan Zimmerman, who designed it with a Federal Emergency Management Agency grant. "Journalists staying in the house slept through the hurricane."

Another newer construction system with proven extreme-event credentials is insulated concrete form (ICF). Concrete is poured into large-panel forms made of closed-cell insulation, such as polystyrene. The foam remains after curing, providing a nailing surface and vapour barrier. Homes constructed in this way performed well in hurricanes, such as Ivan, as well as floods and tornadoes, and their styles can be adapted for varied tastes.

At the other end of the specturm, many old construction systems do just fine and can be built by non-specialist builders (usually the homeowner) with accessible and affordable materials. From yurts in Kyrgyzstan to 18th-century apartment buildings in Lisbon to single-wall wood-board buildings in Hawaii, there are many vernacular architectural forms that incorporate millennia of first-hand disaster-mitigation research. One excellent case in point is "masonry infill" or "confined masonry" construction, in which structural elements of wood, reinforced concrete or steel surround rocks, bricks or concrete blocks. Britons know the wood version as "half timber" and there are other types in Portugal, Italy, Turkey, India and Pakistan.

"It seems counter-intuitive that simple, unsophisticated, non-engineered timber-and-masonry structures associated with the medieval rather than the modern world might be safer in large earthquakes than new structures of reinforced concrete," says Randolph Langenbach, an architect, scholar and United Nations Education, Scientific and Cultural Organisation (Unesco) consultant. But over decades of researching earthquakes' effects, he has seen the evidence first-hand.

In Turkey's 1999 earthquakes, for example, row upon row of modern, reinforced-concrete apartment houses collapsed while their traditionally constructed neighbours survived with little apparent damage. The 2005 earthquake in the Kashmir region of Pakistan and India also saw some centuries-old vernacular wood-and-masonry buildings outperform new concrete ones.

Working with Unesco, Langenbach and conservation consultant Rohit Jigyasu are now collaborating on projects to promote traditional Kashmiri building techniques. Conferences and publications encourage local residents to appreciate the advantages of their existing buildings and to adapt them for modern conveniences without undermining their disaster-resistance credentials.

Elsewhere, Sachs also advocates taking easy preventative measures. "Whenever you see wildfires in California, inevitably you see pictures in the news of one house that didn't burn. This is one where the homeowner built with fire-resistant materials or cleared brush away from the house," he says. "They did things with the design or layout that kept the home safe. Some things are really low cost. Moving a water heater to a second floor can save thousands of dollars."

Creative destruction is another approach, which works well in extreme inundation events, since little can stop a tsunami wave or rapidly flowing water. When del Re was working at Buro Happold engineers, he collaborated with Harvard University's Graduate School of Design and the Massachusetts Institute of Technology's Senseable City Laboratory to design the Safe(R) house for Sri Lankans displaced by the 2004 tsunami. Five times more wave-resistant than traditional structures, the concrete Safe(R) can be built by homeowners for $1,500. It is formed of C-shaped sections placed at each corner, leaving a corridor in the middle; bamboo or woven screens connect these and close off the exterior but give way under the force of water, letting it pass through without causing the structure to collapse or dispersing possessions stored in the concrete section. "If people are warned, they can evacuate, leaving their things safe in the concrete part. Afterwards, they can get back in in half a day," says del Re.

Whatever the building technique, the best disaster mitigation is still a good warning system and a ban on building homes in risky areas. But in settlements where this isn't possible – from undeveloped, third-world villages to unmovable cultural centres such as New Orleans – an extreme event can sometimes be an opportunity to reconstruct well.

"The recovery period is a key time to promote mitigation," Sachs says. After hurricane Andrew hit Miami in 1992, for example, Florida implemented "aggressive" testing procedures, building codes and financial incentives, which resulted in significantly fewer damages from 2004 storms. "There is enormous psychological pressure to want to get everything back to normal. But instead this is the time make the minimal extra effort to think what they can do to keep it from happening again."

And then a disaster is not a tragedy.

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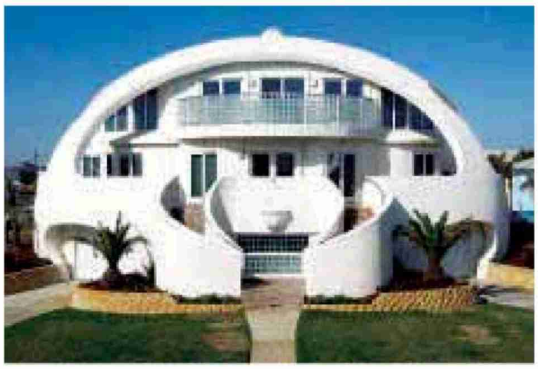

Aftermath Clockwise from top, earthquake damage in Turkey in 1999, the Sigler house, Safe(R)'s shelter

Jeremy Horner/Panos/ Bruce Graner/Safe(R)