Dynamics of Disasters

Earthquake disasters

Earthquakes are potentially very destructive events, yet a combination of long experience and modern research have demonstrated that disaster preparedness measures that focus on reducing people's vulnerability can make a large difference in the level of damage and in the number of deaths and injuries.

Predisposing factors for earthquake events to become disasters include the poor siting of settlements, industry, dams or roads, especially if on fault lines, ground prone to slide or the type of soils which amplify ground vibrations. Other factors involve the quality of design, planning laws, and the materials or methods used in construction, from housing to bridges.

Many of these factors are in turn determined by the level of development of the affected community, or the degree of poverty present, as *Focus* 19 comparing Turkey and California shows.

The science of predicting earthquakes is improving but is not yet very accurate. It is far easier to predict the type and extent of damage in a particular area and thus the implications of building legislation and quality.

However, the main seismic activity belts are well known, with earthquakes recurring where the stresses build up due to the movement of tectonic plates. Earthquakes occur most frequently around the Pacific Ocean and through the Himalayan-Mediterranean belt.

The trigger for an earthquake disaster is movements in the earth's crust bringing tremors (ground shaking), liquefaction (upward movement of moisture creating quicksand-like soil conditions), ground failure and ground rupture (cracks and horizontal displacement)

Earthquakes are obvious sudden impact disasters, though large events may be followed by aftershocks over several hours or days. The most common and damaging effect in inhabited areas is ground vibration.

Seismic events are measured on two scales: Richter records the energy released at the epicentre on a log scale, so that small differences in Richter figures represent very large differences in the energy involved; Mercalli measures the extent of physical damage over surface area on a linear-style scale from I to XII, I being imperceptible and XII corresponding to complete destruction.

Earthquakes cause damage and destruction of human settlements, buildings and infrastructure, including bridges, roads, railways, water treatment plants, pipelines, electrical generating equipment and transmission lines, and dams. Structures weakened by the first shocks can be further damaged by aftershocks and are vulnerable both to nearby earthquakes and to low frequency resonance from distant earthquakes if sufficiently strong.

The first impact can lead to a range of secondary effects such as fires, landslides, the release of dangerous materials, breakdown of water, gas and electricity supplies and disruption of communications

Casualty rates in earthquakes can be high, especially when they occur in areas of high population density, where streets are narrow, buildings are not earthquake-proof, the ground is sloping or unstable, or

where adobe or dry stone construction with heavy roofs and upper storeys is common.

Casualty rates are usually higher at night and lower where lightweight housing, such as wood-frame homes, is used. In the past, a rough casualty guide would have been three times as many injured survivors as dead, though this ratio has been reversing towards three times as many dead as injured survivors as building materials and methods change.

Modern materials and methods, such as pre-cast concrete structures used in both low-rise and high-rise buildings, are polarising the impact of earthquakes into those crushed and killed immediately and others who survive comparatively uninjured in the "voids" or spaces in collapsed houses and offices.

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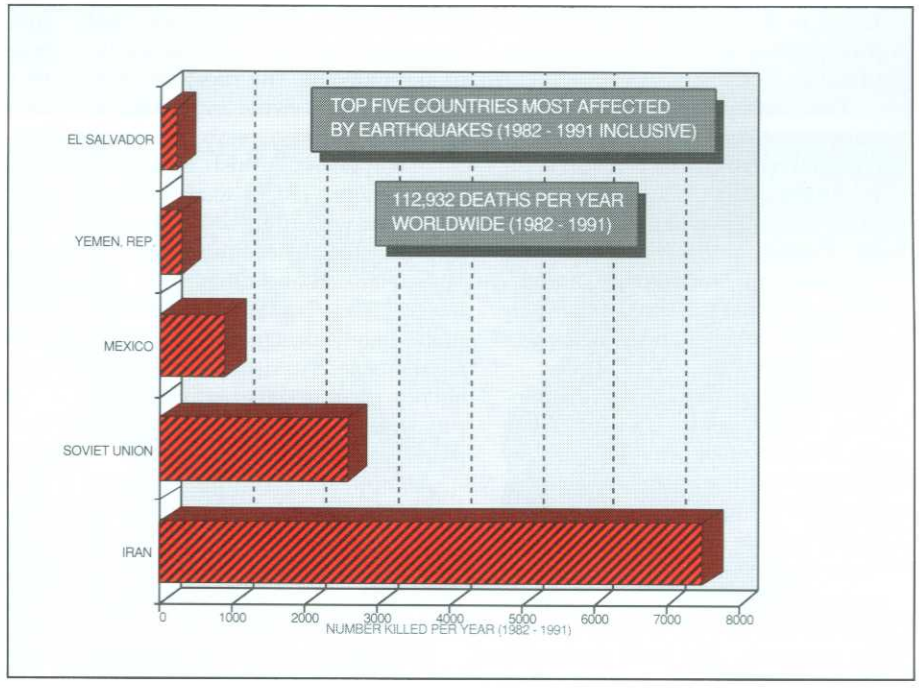

Figure 17a: Top five countries affected by earthquakes, numbers killed. Iran is hit by earthquakes almost every year, many of them severe and causing great loss of life.

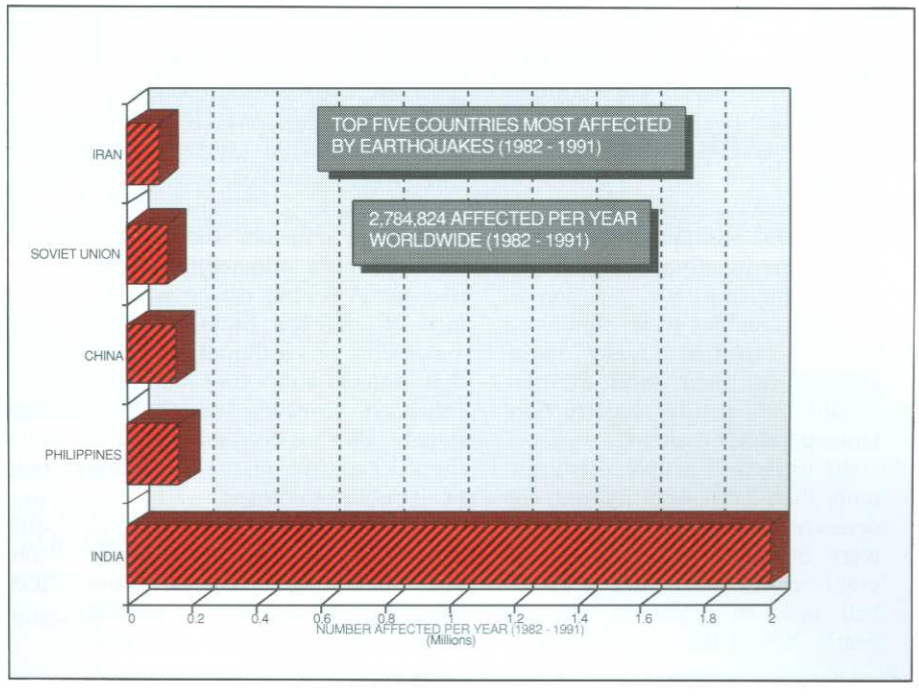

Figure 17b: Top five countries affected by earthquakes, numbers affected. India is hit by many minor earthquakes. Although they cause much property damage and affect nearly two million people a year, they rarely receive international attention because of the low loss of life.

Focus 19: Erzincan 1992 and Loma Prieta 1989

A 6.8 Richter scale earthquake hit an area in eastern Turkey for 30 seconds in the early evening of Friday 13 March 1992, just as many of the Muslim residents were either at their mosque or eating the evening meal with which they break their Ramadan daytime fast

After the shock, people rushed into the streets and began searching for relatives or friends Hours later, the survivors were still to be found in the streets, fearful of further shocks, despite temperatures of minus 10°C.

The earthquake, which had its epicentre 40km east of Erzincan a city 560km east of the Turkish capital Ankara, was the strongest shock in 50 years Disasters are common in Turkey, which is on the 1,000km-long North Anatolian seismic fault zone, the country has suffered 30 other serious disasters since 1900.

For several days many of Erzincan's 100,000 people and the 80,000 inhabitants of nearby villages refused to re-enter their homes, even those left untouched, and preferred living outside in sub-zero temperatures because they feared another and even greater shock

This was in part because in 1939 the entire city had been destroyed by an earthquake of 7.9 on the Richter scale, 50 times the energy of the 1992 disaster More than 30 aftershocks were recorded, the strongest registering 5 8 two days later. The first shock had ruptured a segment of the fault zone 80km in length; aftershocks ruptured a further 30km.

Up to 500 villages were affected by the 1992 earthquake and damage was frequently severe, in some places affecting 50% of homes, though casualties were minimised by the fact that many were gathered in their local mosque, usually of sturdy construction, when the shock occurred.

In total, 547 people died, and more than 2,000 were injured, 680 severely Five thousand buildings were destroyed or damaged beyond repair, and a further 13,500 had light to moderate damage, nearly 20% of the city's buildings, especially high-rise blocks, and nearly 40% of village mud-block and earth-roof houses.

Electricity and water supplies were cut off in the city, and communications were badly disrupted The cold brought the risk of respiratory diseases and almost all health facilities in the city were destroyed. But there were at least 100 doctors and 500 nurses in the area and the 1,000-bed hospital in Erzurum, 120km from Erzincan, was not hampered by its minimal earthquake damage. The most severely injured or sick were evacuated to Ankara.

A 60-person Turkish Red Crescent Society (TRCS) team was on the scene within 12 hours, having already dispatched thousands of tents, blankets and other relief materials. The Turkish government immediately designated the TRCS as the sole Turkish coordinating agency for international relief, and put nine Turkish military cargo planes at its disposal.

An appeal for 8 5 million Swiss francs was launched by the Federation within 24 hours and oversubscribed in a very short time, while Federation delegates assisted the work of the TRCS.

The TRCS was quick to assess the main needs in terms of shelter and cash for local purchase of supplies. It also swiftly informed potential partners worldwide what was not required, from sniffer dogs to basic drugs, usually because many short-term needs could be far more quickly and efficiently met from local resources or expertise within Turkey

A range of factors was involved in the people's vulnerability to this disaster. A central reason was the lack of enforced building codes suitable for an earthquake zone, so that houses and other buildings collapsed, crushing or trapping people. This has been addressed in the strict controls on the rebuilding of all public buildings.

The people themselves, as shown by their refusal to re-enter even undamaged homes many days after the earthquake, needed better information and education about earthquakes, preparedness and disaster management strategies, including construction techniques for traditional homes that would resist earthquake damage

The Loma Prieta earthquake happened at 5.04pm on 17 October 1989, with its epicentre 100km south of San Francisco and 10km north of Santa Cruz. It registered 7.1 on the Richter scale, but lasted just over 10 seconds, and damage was spread over a wide area. In all, 65 people died, 3,757 were injured, more than 12,000 were made homeless. In all, 18,306 homes and 2,575 businesses were damaged at a cost variously estimated at up to US$6bn. It was the strongest earthquake in the US since the 1964 Alaska earthquake and the strongest in California since the devastating 1906 earthquake in San Francisco.

Two main differences caused the far lower levels of deaths and injuries in the Loma Prieta earthquake than in Turkey, one man-made (stricter building codes) the other beyond human control (the shorter time of shaking) A third element, the regular rehearsals of the emergency services, ensured that the disaster response was effective, though communications were identified as one aspect which did require improvement following Loma Prieta.

Many recently-built homes and commercial buildings in California conform to tight planning controls The large sky-scrapers sit on seismic bearings made of layers of steel and rubber which allow buildings to shift with the ground movement Conventionally-designed buildings amplify ground movement in their upper stories; the newer blocks are reinforced with frames that absorb and redistribute energy and buildings very close to fault lines are of only a few storeys Some five years before the earthquake, even small wooden-framed houses were required to bolt the structures to the concrete foundations to prevent their being shaken off their bases.

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Earthquake disasters Those affected by earthquakes often face years of struggle to rebuild their lives. International aid soon declines, leaving people to cope on their own Armenia, 1989. Gueorgui Pinkhassov/ Magnum.

In addition to obvious injuries, such as cuts, bruising, fractures, including spinal damage, earthquakes can cause two particular types of injuries: crush syndrome, where the crushed parts of the anatomy release toxins into the blood which can cause sudden kidney failure some hours after the injury or following release, and pneumonitis from inhaling dust.

Earthquakes have limited impact on public health unless there is secondary flooding or survivors are congregated into camps. If insanitary conditions develop, the incidence of endemic diseases may increase rapidly. Interruption of water supplies leading to use of contaminated water can lead to outbreaks of water-borne diseases.

Problems with water supplies are likely because of damage to pipelines, including the possible contamination from damaged sewerage systems, damage to dams or open wells, or the impact on the water table, leading to reductions in supplies from wells or surface springs.

Unless the earthquake is linked to flooding, there is unlikely to be loss of food stocks or standing crops, although food distribution and irrigation systems may be disrupted

After initial confusion, the response of those directly affected by an earthquake usually involves searching for relatives or friends The vast majority of the injured and trapped survivors will be rescued by local people without any outside assistance. The opportunity for rescuing people alive has a short duration, the limited research suggests that of those trapped and injured, 50% die within six hours and 95% within 48 hours.

In the short term, local communities will salvage what they can from their homes and build shelters Their needs will include safe water and shelter materials. Rescue operations may require transport, appropriate heavy lifting equipment, fire fighting crews and portable communications. ■

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The short duration of the earthquake limited the damage to some buildings that might otherwise have suffered great damage and caused far greater loss of life. Many of the more vulnerable older buildings in the region, such as those in San Francisco's poorest and most densely populated inner city areas of Tenderloin and Chinatown, stayed standing because they rest on firmer soils than more recent-built homes

In Marina, the city's worst-hit area, homes were built on foundations of domestic rubbish and sandy soils, which also allowed a gas main to fracture, setting off a fire which was difficult to control since water pipes had also collapsed. Similarly, the spectacular collapses of sections of various bridges, including double-decker" highways where the top deck crushed cars on the lower deck, along the coast occurred mainly where their supports rested on soils vulnerable to liquefaction, which in some circumstances help conduct destructive shockwaves

Reports following the Loma Prieta earthquake suggest that, had it lasted even a few more seconds, the damage caused to structures on unstable soils, including far more of the bridges and double-decker highways or to the 12,000 older brick-built buildings, for example, would have been far more severe.

In the circumstances of Loma Prieta, a well-prepared and substantially better-off community in far warmer weather was able to communicate its needs and problems effectively, cooperate in relief work and share many of the burdens of assistance from its own resources.

Outside support was far more easily and quickly able to reach those in need, including the swift recovery and treatment of the injured, because of the far better communications and transportation. With its nationally-agreed role of providing immediate assistance in the aftermath of disasters, the American Red Cross was swiftly into action, helping the injured and other affected with individual help and materials in case of need.

There remains vulnerability to be identified and tackled in any disaster

San Francisco had fewer firemen at the time of Loma Prieta than it did during its devastating 1906 disaster, and many of its hospitals are sited close to earthquake fault lines. A future seismic event could trigger a far more devastating complex disaster, since the area contains a very wide range of industrial buildings containing everything from nuclear materials to rocket fuels and biotechnology laboratories.