



British
Geological
Survey

The role of geology in damage limitation

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Keyword

Earthquakes cause much damage and loss of life. Often, in attempts to predict them, seismologists rely on records of past earthquakes and take little account of variations in geological conditions, particularly in alluvial basins where many of the world's vulnerable cities and structures are located. Similarly, when considering earthquake hazard resistance in their designs, engineers do not take much account of the nature of the ground at the scale used by urban planners. Geologists have much to offer in changing this situation.

It may be assumed that in earthquake prone regions, a potentially damaging earthquake will occur within the lifetime of most structures. Therefore, not only must a structure be designed to resist earthquakes, but the planning process needs to take account of the susceptibility of the ground at different places to a number of different geological hazards that are triggered by earthquakes. These secondary seismic hazards can cause extensive damage.

To reduce the risk of these hazards, it is necessary to understand the geological processes that are triggered, the local

Secondary seismic hazards

Photo courtesy of Sergio Mora.



Lateral spreading of road embankment at Cuba Creek near Limón, Costa Rica, caused when the ground below liquefied during the April 22nd, 1991 earthquake.

distribution of geological strata and their geotechnical properties. It is then possible to assess the level of hazard and build where there is least danger. If structures must be placed at specific locations then engineers can be made aware of all the potential secondary seismic hazards that may affect the structure and account for them in the design.

The BGS has recently undertaken a project funded by the UK Department for International Development (formerly the Overseas Development Administra-

tion) Technology Development and Research Programme which examined the ways in which the local geological conditions can be taken into account during the planning process so that when an earthquake occurs, injury and damage are minimised, and vital services are sustained. This work was undertaken in collaboration with organisations in Costa Rica, China and El Salvador. The project output comprises a detailed technical report, a concise guide for planners and case histories from Costa Rica and China.

Principal secondary seismic hazards

- **liquefaction** is most likely in near-surface, loose, saturated sands and silts in alluvial basins. During earthquakes, groundwater pressures can become so high that soil particles separate and the soil liquefies. Sand boils can occur if the pressure is locally relieved. Liquefied soil will flow at very low slope angles.
- **ground motion amplification** is most apparent in alluvial basins. As the earthquake disturbance passes from hard rocks to soft, unconsolidated sediments it suddenly decelerates. There is a further gradual deceleration as the disturbance travels through the sediment which becomes progressively weaker towards the surface. This causes the surface displacement to become amplified such that the ground motion is far greater on the alluvium than on the hard rock.
- **landslides** may occur on clay slopes and on jointed rock slopes. Consequently, they are mainly restricted to hilly and mountainous areas, including the margins of alluvial basins and river banks. Earthquakes increase the occurrence of landslides in ground that is already susceptible to them.
- **ground rupture and ground level change** are caused by movement along geological faults. Damage occurs by the physical tearing apart of structures. Where vertical movement takes place, ground level changes over areas of several square kilometres can occur.
- **tsunamis** are caused by offshore earthquakes when part of the sea bed changes in level. The waves may travel thousands of miles and cause most damage on arrival at low-gradient coasts.
- **ground subsidence or collapse** can be accelerated by earthquakes in regions that are already susceptible. Among these are abandoned mining districts and areas of cavernous limestones.