1. General aspects of earthquakes

1.1 Location, magnitude, intensity

An earthquake is produced either by movement of tectonic plates or by volcanic activity. The areas of the world that are most earthquake-prone are shown in Fig. 1-1. Earthquakes of intensity 8 on the Richter scale have been recorded in Asia and of up to 8.7 in the Andes . Nearly a hundred earthquakes of intensity higher than 6 and twenty of intensity higher than 7 on the Richter scale are recorded annually. Several thousand people are affected by earthquakes every year.

The magnitude (M) of an earthquake usually is measured on the Richter scale, which is logarithmic with an open end. It is a measure of the energy produced in the epicenter, the place where the earthquake is generated. The Mescali scale, on the other hand, is divided into 12 grades and indicates the intensity of the local impact.

The local impacts on a structure depend not only by the magnitude of the earthquake, but also on the depth of and distance from the epicenter, the geology and topography, the kind of local soil and last but not least on the duration, frequency and acceleration of the impacts.

1.2 Structural aspects

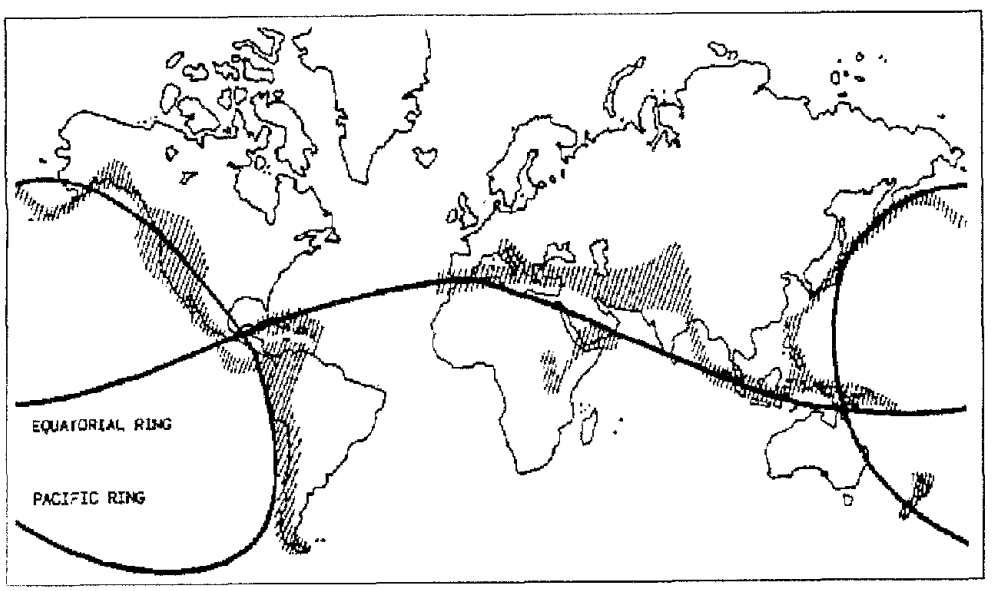
Structures are mainly affected by the horizontal forces created by the earthquake. The vertical forces are usually less than 50% of the horizontal ones.

The main danger due to horizontal movements of the earth is that the walls of buildings might fall outwards and consequently the roofs collapse. The main aim of building earthquake-resistant houses, therefore, is to avoid walls being able to fall outwards and to ensure that the roofs are fixed well to the walls, or even better that they stand on a system of posts separated from the wall, so that the roof system and the walls can swing independently due to their differing frequency.

With a "medium" earthquake the following measures have to be taken into account:

horizontal deformation: h = 0.1 to 0.3 m
horizontal velocity: v = 0.1 to 0.3 m/s
horizontal acceleration: a = 0.1 to 0.3 m/s^2 = 0.15 to 0.30 g

A horizontal acceleration of 0.3 g means that 30% of the dead load of the structural elements acts as horizontal force against the structure ("equivalent force"). Usually simple structures are calculated by the method of "equivalent



1-1
Earthquake zones (Houben, Guillaud 1984)

force", in which the horizontal impact is taken as a static force and not as a dynamic one. However, the higher the ductility, the capacity for deformation without structural failure, the lower the equivalent force is and the lower the structural resistance must be.

The quality of an earthquake-resistant structure can be expressed in the formula

structural quality = resistance x ductility

This means the lower the resistance of the structure is, the higher the flexibility must be, and the higher the flexibility is, the lower the resistance must be (Grohmann, 1998).

The historical rammed earth houses with walls of 60 to 100 cm thick had enough resistance to withstand earthquakes and did not need to be flexible. For instance in Mendoza, Argentina, these houses withstood all earthquakes of the last centuries, whereas all modern buildings built of adobe or bricks collapsed. However, these structures are not economic nowadays. Economic solutions have less rigidity, therefore they must allow deformation during seismic shocks without collapse.