Development of the Design of Earthquake Resisting Structures in Greece

By Panos Moliotis*

Greece has been subjected to frequent and severe earthquakes. The main cause of these earthquakes is the Geotectonic faults of the Aegean and Ionian Seas. The regions of Greece subject to earthquakes and the relative earthquake intensities are illustrated on the Technical Seismic Map prepared by Professor A. Roussopoulos, edit 1949, revised in 1956.

The more recent strong and disasterous earthquakes in Greece have occurred at the areas listed below:

1. Corinth (1928)
2. Calkidiki (1935)
3. Leucas (1937)
4. Attica-Oropos (1938)
5. Leucas (1948)
6. Iouian Islands (Chephalonia. ZZante Ithaca) (1953)
7. Magnissia (Volos) (1955)

Until the year 1932 the design of earthquake resisting structures in Greece was based on the following two methods:

(1) A method developed and used in Italy. This method is based on the analysis of the structure as vertical plane frames. These members consist of single or multistory frames. Each frame is designed individually according to the loads acting upon it, these loads depending on the part of the mass contributing to the particular frame.

(2) A method developed in Japan by Professor Tachu Naito which is based on the following two assumptions:

a. There is no deformation of the horizontal slabs parallel to their plane.

b. The horizontal seismic loads are distributed in two directions so as to be proportional to the rigidity of each member connecting either the slab with the foundation or two consecutive slabs.

This method can be applied when the slab has two axes of symmetry and the rigidity of the supporting members are also symmetrical about the same axes.

*Doctor of Civil Engineering, National Technical University, Athens, Greece.

DEVELOPMENT OF ASEISMIC CONSTRUCTION

Since 1932, the design of antiearthquake structures has been based on a theory developed by Professor A. Roussopoulos of the Technical University, Athens, Greece.

The method of Professor Roussopoulos deals with the investigation of the effect of earthquakes on buildings, the investigation of the seismic forces acting upon the buildings, and the design of the structures to resist these forces.

The above mentioned analysis is based on the methods of statics, which are sufficiently accurate for buildings of low or medium height and consisting of rigid members, which is the common case in Greece.

In the analysis of the earthquake resisting problem by the methods of statics the earthquake loads can be substituted, according to D'Alembert's principle, by an equivalent static force. These forces have vertical and horizontal components. Both are considered applied to the center of gravity of each member of the structure and they are of varying direction.

The vertical component of the earthquake forces is superimposed to the vertical loads of the structure. Therefore, the stresses due to the vertical components are computed in the same way as for ordinary vertical loads.

The horizontal component of the seismic forces is resisted by the vertical supporting members of the structure, i.e., columns, walls and frames which we call the "elastic supports."

According to D'Alembert's principle, the horizontal components are equal to the product of the weight of each member times the ratio of the horizontal component of the earthquake acceleration to the acceleration of gravity. A horizontal force $F = CW$ is thus acting at any level of the structure, where W is the weight of the structure above the considered level and C is the earthquake coefficient or the ratio of the horizontal component of the earthquake acceleration to the acceleration of gravity. The range of the earthquake coefficient C for the Corinthe area is between 0.10 and 0.15.

The general case of the earthquake structure has been solved by Professor Roussopoulos in two papers.

The first paper has been published in the magazine "Technica Chronica" in 1932 and it covers the cases of the single story and the simple multistory building.

The substantial difference between this method and the onces mentioned above is the following: From the arrangement and the dimensions of the elastic supports of a rigid horizontal slab, the principal axes of translation are determined, as well as the center of the elastic rotation of the system. The stresses and strains of the structures are computed by the elastic system so determined.

The properties of the equivalent elastic support are as follows:

1. If a force F acting upon the slab goes through the center of the elastic rotation, the slab is subject to a simple translation.

2. If the force F acts upon the slab in the direction of the principal axes, the slab is subject to simple translations of a direction parallel to the axes.

3. If the force F rotates about any point on the slab such that the terminus of its vector describes a circle, then all points of the slab describe ellipses. The major and minor axes and the orientation of these ellipses vary at each point. The ellipses mentioned above are called ellipses of motion of the points of the slab.

4. Since the direction of the horizontal seismic load is random, the most severe loading conditions of the elastic supports can be found with the help of the ellipses of motion.

The second paper of Dr. Roussopoulos' has also been published in the magazine "Technics Chromica" in 1949. It mainly investigates the case of the complex and multistory buildings. The copies in Greek and the French translation of the book by Professor Roussopoulos titled "Earthquake Resisting Structures" has been handed to the Secretary of the conference. This book covers the entire theory for all cases, a brief outline of which has just been presented.