



SATELITE IMAGE OF CYPRUS SHOWING THE MICROZONATION STUDY AREAS

PARTICIPANTS IN MICROZONATION STUDIES

For the Nicosia study

- Geological Survey Department
- Turkish-Cypriot Geologists
- United Nations Office for Project Services (UNOPS)
- United States Geological Survey
- Technical Chamber of Cyprus (ETEK)

For the Limassol and Paphos studies

- Geological Survey Department
- Aristotle University of Thessalonica
- Institute of Technology and Anti-Seismic Structures (I.T.S.A.K.)

For the Larnaca Study

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- Geophysics Institute of Hamburg

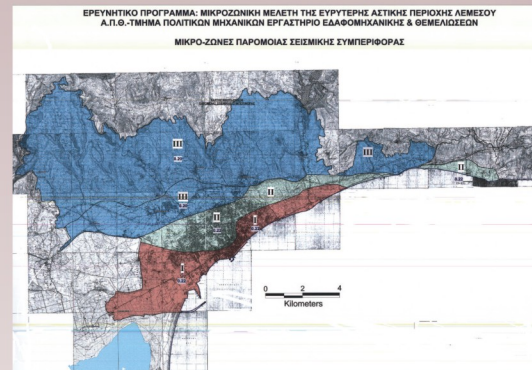
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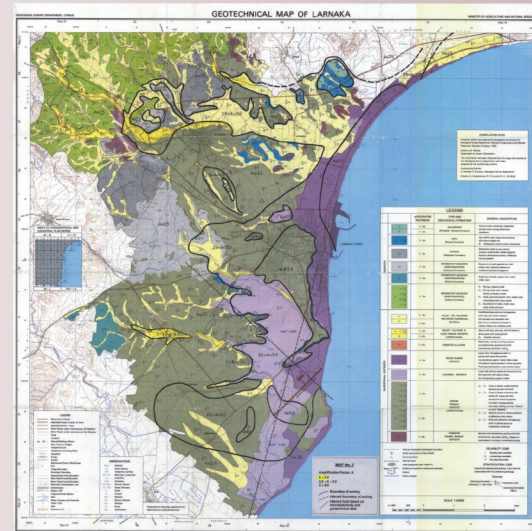
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Microzonation Map of the greater Limassol town planning area



Microzonation Map of the greater Larnaca town planning area



Polemidia Overbridge on Limassol Bypass. Deep foundation of the piers on reinforced concrete piles



New Paphos District Offices. Deep foundation to avoid clayey deposits

THE MICROZONATION STUDIES

The Microzonation Studies represent specific studies that aim at defining zones within an area, which have their own characteristics and generally the same soil behavior under seismic conditions. The zone characteristics mainly involve the peak ground acceleration, the velocities and the magnitude of the soil displacement, as well as the frequency of the seismic motion and the ground response spectra.

The geological tectonic structure, as well as the mechanical properties of the strata are important factors that control the behaviour of each zone under seismic tremors. These factors fall in to the scope and field of activities of engineering geologists. Beside the engineering geologist the involvement of other scientists, such as Geophysicists, seismologists, Earthquake Engineers and Geotechnical engineers is needed for the contact of Microzonation Studies.

The main final product of the Microzonation Studies is the Microzoning Maps, in which the peak value of the expected strong ground motion, as well as other valuable parameters are given for each zone, such as:

- The peak ground acceleration values
- The expected ground deformations
- The elastic response spectra
- The predominant period and amplification of the various geological formations and
- The seismic design response spectra.

THEIR SIGNIFICANCE

The findings of the Microzonation Studies constitute the basis for a more comprehensive anti-seismic design of the built environment development. Overall design also has to consider the impact of seismic tremors on areas susceptible to problems, such as potential liquefaction phenomena, possible landslides, ground settlements and karstic subsidence. These natural phenomena inevitably increase the potential for damage and human losses as a result of seismic risk.

Taking into consideration the results of the Microzonation Studies. It is possible for the engineers to design structures that are more resistant to seismic events and simultaneously to contribute to the strengthening of existing weak and problematic structures, in terms of their seismic resistance.

Microzonation Studies are essential tools in the elaboration, as well as the modification and improvement of the Seismic Code of a broader area. The objective of the above actions is to decrease the consequences of seismic risk on the built environment or, in other words, to increase the seismic resistance of the structures.

THE SIGNIFICANCE OF MICROZONATION STUDIES ON THE SEISMIC RISK ASSESSMENT

BACKGROUND OF MICROZONATION STUDIES IN CYPRUS

Cyprus is in the eastern Mediterranean Basin, which is characterized by relative intense seismic activity. This has troubled the island from antiquity to the present day. The great earthquakes of AD 76 that have resulted in the destruction of Salamina, Curium and Amathus are well known from hisoric sources. More recently, the 1953 earthquake had disastrous effects in the wider area of Paphos. Folloeing the independence of Cyprus in 1960 and in particular the last two decades, the Government of Cyprus has invested heavily in the development of projects and other works, such as ports, airports, highways, bridges, public buildings and refugee settlements. Continuous development in an environment susceptible to intense seismicicity has led the Government to develop a strategy to limit and minimize earthquake related damage. This has been the motivation for the Geological Survey Department (GSD) to undertake microzonation Studies. The GSD has undertaken these studies in collaboration with foreign consultants and Universities, e.g. the Aristotle University of Thessalonica, the Geophysics Institute of Hamburg and the United States Geological Survey.

The first Microzonation Study in Cyprus took place during 1995-1997 and covered the greater town planning area of Larnaca. this study was a pilot project for subsequent studies. It was followed by the Microzonation Study of the urban Limassol area during 1998-2000 and the study of the greater urban area of Nicosia between 2000 and 2003. The later study was within the frame work of bi-communal programme under the auspices of the United Nations Office for Project Services (UNOPS). In 2002 the Microzonation Study for the greater Paphos area commenced and is expected to be completed in 2005. In the foreseeable future these specialized studies are expected also to cover the free region of Famagusta as well as the greater area of Polis tis Chrysochous in the Paphos region.

The undertaking of Microzonation Studies requires an important financial commitment, the participants of multidisciplinary research groups and a relatively long period (usually 2-3 years). These constraints are determined by the size of the study area, the complexity and non homogeneity of the geological and seismotectonic environment and the required detail. At the same time these studies take into consideration the plans for future development including the magnitude of further works by the public and private sectors.



PAPHOS Earthquake 23/2/1995. Two deaths at Miliou village caused by the collapse of a roof. Severe damages on the church steeple at Arodhes village.



Building development at Pentakomo village in unstable clayey soils

- Landslide due to a deep excavation on a hill slope
- Remedial measures-Construction of a retaining wall with deep foundation (piles) and deep anchoring at the face of the excavation



TYPE OF INVESTIGATION WORKS

During the implementation of Microzonation Studies the most important type of investigations are the following:

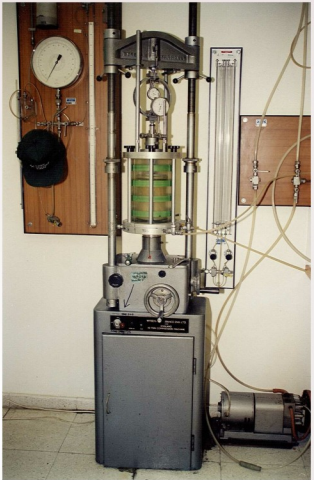
Geological and Geotechnical Investigations

This investigations include detailed geological and geotechnical mapping of the superficial deposits and bedrock. An integral part of these investigations is

drilling, during which various insitu tests are performed, e.g. the Standard Penetration Test (SPT). Exploratory boreholes facilitate also the necessary sampling for laboratory tests and analysis.

The basic objective of these studies is to establish the stratigraphy of the ground and the geological and tectonic structure. Furthermore, the geomechanical and geodynamic characteristics of the strata, the seismic sources and particularly the seismogenetic active faults, constitute another field of investigation, thet of Neotectonics.

The laboratory trials aim at defining the physical and mechanical properties of the various geological formations under both static and dynamic conditions. These results are essential in evaluating the ground response under seismic loads.



Insitu exploratory drilling and laboratory tests



Geophysical Investigations

The geophysical investigations are insitu field surveys that aim at the identification of the stratigraphic boundaries in depth and the estimation of seismic shear and primary wave velocities of the different strata. these investigations include geoseismic surveys, geoelectrical soundings, geoelectrical tomography, microtremor measurements and cross hole/down hole measurements.



Down-hole seismic survey

Seismological Investigations

These investigations focus on the study of the grater area seismicity, which is controlled by the frequency, the magnitude and the intensity of the earthquakes. For this, the potential seismic sources are defined along with the epicenters of historical as well as recorded data on more recent earthquakes. These data used along with the macrotectonic structure of the greater area define the seismotectonic model of the area. This in turn facilitates the definition of he seismic zones (the microzones), which is the primary objective of the study.

Useful tools in a seismological study are accelerographs that are installed in the area under investigation. These record all earthquakes for the duration of the study and allow fo their evaluation in respect to the ground motion and behaviour in the affected area.



Assessment of Structures for Seismic Vulnerability

In parallel with investigations for the evaluation of seismic risk quite often further studies are undertaken for the assessment of the seismic vulnerability resistance of structures. These studies aim at establishing which structures need to be reinforced. The following factors are taken into consideration for this type of study :

- Earthquake parameters and characteristics (magnitude, orientation of the seismogenetic fault, depth of seismic source, etc)
- The distance of a structure from the earthquake epicenter and consequently the degree of seismic wave attenuation
- The type of foundation strata and their geomechanical properties and Structure properties and characteristics, such as the natural period of the structure, the form (shape) of the structure, the foundation type, the quality of the construction materials and the orientation of the structure in respect to the direction of the seismic waves propagation.



Nicosia traditional and contemporary buildings

