

ON THE PREDICTION OF EARTHQUAKES
BY AN ELECTRICAL METHOD

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SUMMARY

From the experiments conducted over the last thirty five years, it is found that the changes in the electric charge in the atmosphere can be correlated to the occurrence of earthquakes. Generally, a drop in the electrical charge with a following slight increase is followed by an earthquake in about up to three days. Results show that this information can be used in earthquake prediction. An earthquake source model is suggested, in which earthquakes can be generated by the triggering of accumulated stresses in the ground by underground electrical discharges.

INTRODUCTION

In the recent years, research on the prediction of earthquakes has increased with the view of trying to save people's lives and reduce the damage to their property. This research also helps to develop the models of earthquake source and therefore is very helpful in the understanding of the earthquake mechanisms. Theories of plate tectonics show that, the surface of the earth consists of about a dozen large plates which move slowly with respect to each other, accumulating stress due to the stored strain energy. Earthquakes are claimed to be caused by a sudden release of this stress in the ground.

From observations and experiments in the past, it has been found that there are certain precursory changes in the region of impending earthquakes [1,2,3] such as in electrical conductivity and generation of electrical potentials in the ground, in magnetic and atmospheric electric fields, in the quality or level of groundwater, and in the emission of various gases such as radon in well water or in soil. Changes in seismic measurements and in animal behaviour are also recorded.

A POSSIBLE EARTHQUAKE MODEL

It is known that an electrical energy with 700 MW power is continuously pumped into the atmosphere by cosmic rays, which gradually is transmitted into the ground [4]. This charge in the atmosphere causes thunderstorms, lightnings and other events. Since the same charge is transmitted into the ground, it may accumulate in certain regions depending on their degree of

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conductivity and at may be discharged underground with resulting shock-waves. These waves may generate a triggering action to set free the large strain energy which is stored in the crust of earth as explained by the theory of plate tectonics.

There can be a secondary electrical effect that when the stress in the earth's crust increases, it can cause electrical currents due to the piezo-electric effect, which would also contribute to the accumulated electric charge and would affect the atmospheric electric field.

Based on such a model for the source of an earthquake, it may then be reasonable to measure the changes in the atmospheric electric field and use it as a precursor for the prediction of earthquakes.

EXPERIMENTS

Based on the above model, the senior author has started experiments on the measurement of atmospheric electrical charge since 1945 [5]. He constructed an apparatus consisting of an electromotor driving an insulated pulley by means of a leather belt as seen in Fig.1. It is found that

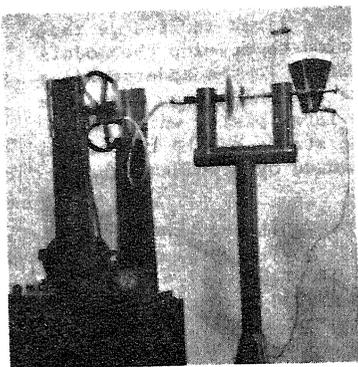


FIG-1: APPARATUS

charged ions in the atmosphere are accumulated in the pulley and the strength of the charge can be measured by the length of the spark which jumps between the electrodes of the measuring device attached to the bearing of the pulley. The apparatus and the early results are reported in an earlier paper by the authors [6]. Since 1974 the experiments are also continued and daily readings on atmospheric electric charge has been communicated to the Earthquake Research Institute in Ankara. It is found that after reaching a peak and with a decrease of the electrical charge and with a following rise, there is a high probability of an earthquake occurring within three days. The magnitude is also roughly proportional to the amount of decrease of the electrical charge. It is also observed that winds causing rains increase the electrical charge. This charge when discharged in the atmosphere, thunder or rain is generated, otherwise it may discharge in the ground resulting in earthquakes. The similarity of maps showing the rainfall and the distributions of epicenters of earthquakes support this argument.

Fig.2 shows a typical period in 1975. Earthquake numbers are given on the day of occurrence of earthquakes based on Kandilli Earthquake Catalogue with most references being due to ISC. Earthquakes whose magnitudes are not given in the catalogue are not marked. It is felt that the magnitudes and locations can be predicted better if a network of such apparatus and continuous recording of data can be realized.

In the laboratory, when two separated metal plates are charged by the same apparatus, the plates separate more and when the system reaches saturation discharge between plates takes place with following vibrations simulating the triggering action explained above.

It is also found that the same electrical charge when it comes close to a free water surface, creates pressure and drives the water away to greater heights in the neighbouring connected containers. This way such changes in underground water level can be explained before the earthquakes. The pressure of water may also ease the underground discharges, since it increases the conductivity of the ground.

CONCLUSION

The investigations show that there is a strong correlation between the drop in the electrical charge and the occurrence of earthquakes and this may be used as a prediction technique. The present results can serve as introductory information which provide certain hints, and much more research into this area needs to be done to uncover the many unknowns.

ACKNOWLEDGEMENT

The authors would like to thank the staff of the Earthquake Research Institute for providing the Earthquake Catalogue and for the helpful cooperation on the subject.

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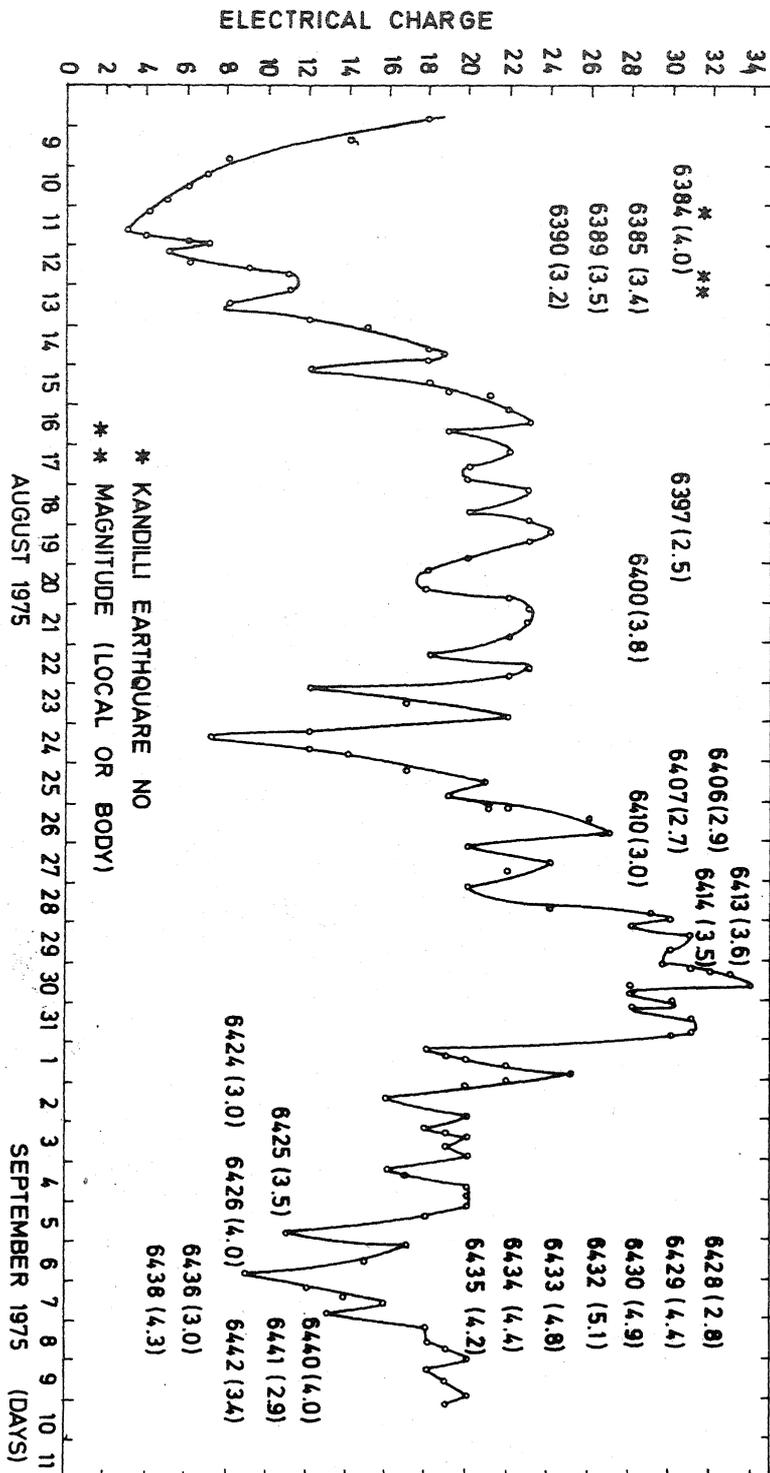


FIG. 2: VARIATION OF ELECTRICAL CHARGE WITH TIME

REPORT ON THE ACTIVITIES OF
EARTHQUAKE ENGINEERING RESEARCH INSTITUTE
MIDDLE EAST TECHNICAL UNIVERSITY, ANKARA, TURKEY

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INTRODUCTION

The Earthquake Engineering Research Institute (EERI), Middle East Technical University (METU), Ankara, Turkey, was established in 1977 to coordinate and promote research and education in earthquake engineering at METU. Although it is still in a development stage, EERI has already contributed significantly to the earthquake engineering research and practice in Turkey. This report is an overview of the activities of EERI in its first three years.

FACILITIES OF EERI

Presently EERI utilizes the research facilities available at various departments of the Middle East Technical University, namely, the structures, soil mechanics, engineering geology and rock mechanics laboratories and the computer center. All of these facilities are fully developed and contain modern equipment for research and teaching. Partly through its cooperation program with the Earthquake Research Institute of the Ministry of Reconstruction and Resettlement, and partly through other sources, EERI constantly expands and improves its own research laboratories.

The laboratories under development are the structural dynamics, soil dynamics, and engineering seismology. These facilities contain, presently, a vibration generator system for testing full scale structures under forced vibration, a vibration triaxial apparatus for cyclic testing of soils, and a small vibrating table.

STAFF OF EERI

The staff of EERI consists of researchers from various departments of the Middle East Technical University, including Civil Engineering, Engineering Sciences, Engineering Geology, and Applied Statistics. Formal membership to the staff of EERI is associated with involvement in a current research project.

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The present members are Professors B. Atalay, M. Erdik, P. Gülkan, Ç. Yılmaz, S. Yüceci, and Ö. Yüzügüllü. Earlier and potential future members include Prof. A. Gürpınar, the former director of EERI (now on leave), and Professors A. Birand, V. Doyuran, Y. Mengi, T. Norman, İ. Ordemir, Y. Özkan, M. Tokay, E.R. Tuncer, T. Wasti, Y. Wasti, and K. Yaşar.

EERI provides financial support to graduate students and other individuals who contribute to the research efforts of the institute.

FIELDS OF STUDY AND RESEARCH PROGRAMS

The major fields of study of EERI may be classified as (1) Seismic hazard assessment studies, (2) Structural analysis and testing, (3) Geotechnical engineering, and (4) Engineering seismology. In the past three years, EERI has published some fourty research reports on these topics, in Turkish and English.

(1) Seismic Hazard Assessment Studies

EERI collects historic, geologic and seismologic data for identification of seismotectonic regions in Turkey and assessment of the parameters describing the seismic sources. Attenuation relationships are developed for various geologic regions of Turkey based on isoseismal maps available. These data are utilized in analyses of the seismic hazard at the proposed sites for important facilities such as nuclear and fossil fuel power plants, large dams, major industrial and public facilities, and important structures.

(2) Structural Engineering

A continuing research program in structural engineering at EERI is dynamic testing of various real structures. Natural frequencies and mode shapes are determined from these forced vibration tests, and these are compared with the results of dynamic response analyses. Structures usually remain in the linear range in these tests though slight nonlinearity is sometimes observed. Tests performed until recently have demonstrated that significant soil-structure interaction occurs in reinforced concrete frame buildings, but especially in prefabricated panel structures where the motion of the building is almost solely due to the deformation of the foundation soil.

EERI has the necessary computer software for linear and nonlinear earthquake response analyses of various types of structures, including finite element analysis of arch dams and composite bridges.

A new research project under preparation involves cyclic testing of masonry walls. This project aims at determination of cyclic load deformation behavior of masonry walls, development and propagation of cracks, and failure mechanisms. It is believed that the results of these studies will lead to a better understanding of the earthquake damage on the rural buildings in Turkey and consequently will provide useful data for improving the design and construction of such structures.

(3) Geotechnical engineering

One of the major research programs at EERI is related to embankment dams. Forced vibration tests are performed on existing dams and the results are compared with analytical predictions. Methods of analyzing the embankment dams in three dimensions have been developed with the objective of studying the effect of the size and shape of the valley on dynamic behavior. These effects are neglected in practice by performing a plane strain analysis. EERI studies have shown that the effect of the "third dimension" is not negligible for embankments with a crest length less than about four to five times the height. It has also been established that through a conventional plane strain analysis one may reach seriously unsafe results by underestimated stresses, deformations and inertia forces, for typical sizes, shapes and material properties of embankment dams.

Another research area at EERI related to geotechnical field is on realistic and practical representation of foundation soil in soil structure interaction analyses. Tests on structures, foundations and specialized finite element analyses are incorporated in this research program.

(4) Strong Motion Seismology

Strong motion instrument network in Turkey is developed and operated by the Earthquake Research Institute of the Ministry of Reconstruction and Resettlement. The network currently consists of 46 SMA-1 type accelerographs and 40 Wilmot type seismoscopes. In addition to this network other state organizations have installed accelerographs at important structures.

Through its cooperation program with the Ministry, METU/EERI augments the studies on strong motion field in the areas of (1) network design, (2) instrument development, and (3) accelerogram processing procedures.

A dense array has been designed on the eastern section of the North Anatolian fault, a location which is estimated to provide the highest potential yield for the investment required.

EERI currently experimenting on an accelerograph newly developed at METU. The instrument has a high resolution, a wide dynamic range, and a precision timing system. Recording is digital.

EERI has developed the necessary computational "accelerometer correction" procedures and the associated software.



Figure 1. A view on the crest of 165 m high Keban rockfill dam during the forced vibration test.

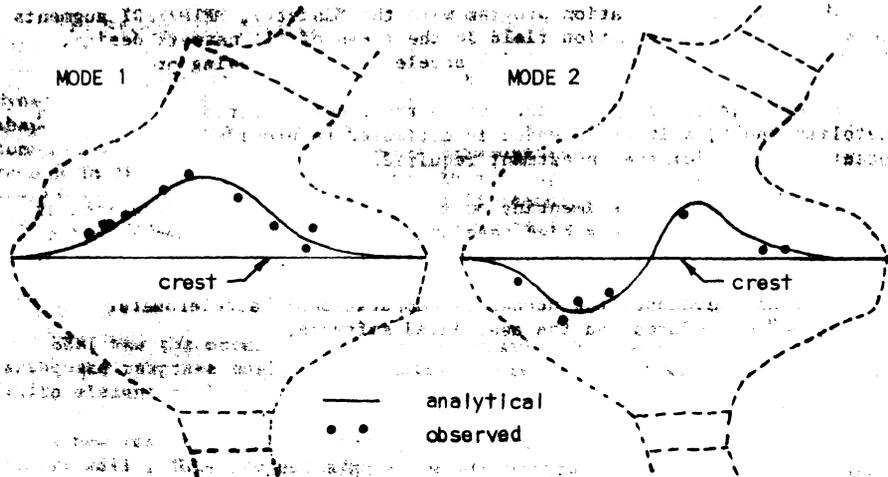


Figure 2. Measured and predicted mode shapes of Keban dam (plan view, horizontal displacements along the crest are shown).

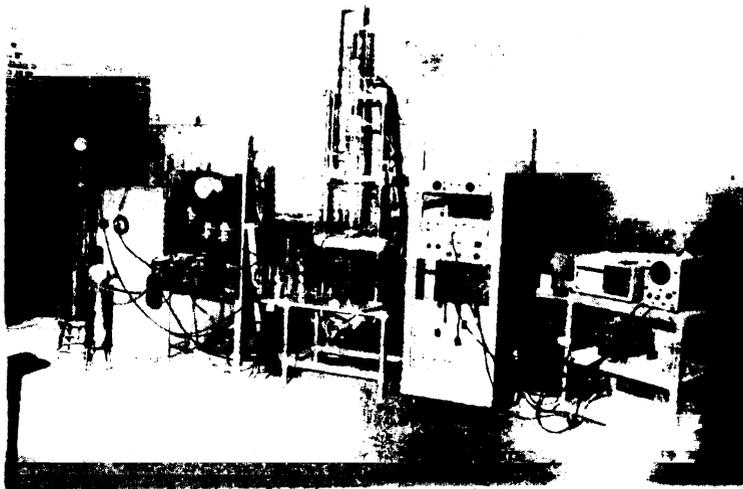


Figure 3. Vibration triaxial apparatus and its peripheral instruments in Soil Dynamics Laboratory.

... D-direction ... P-direction

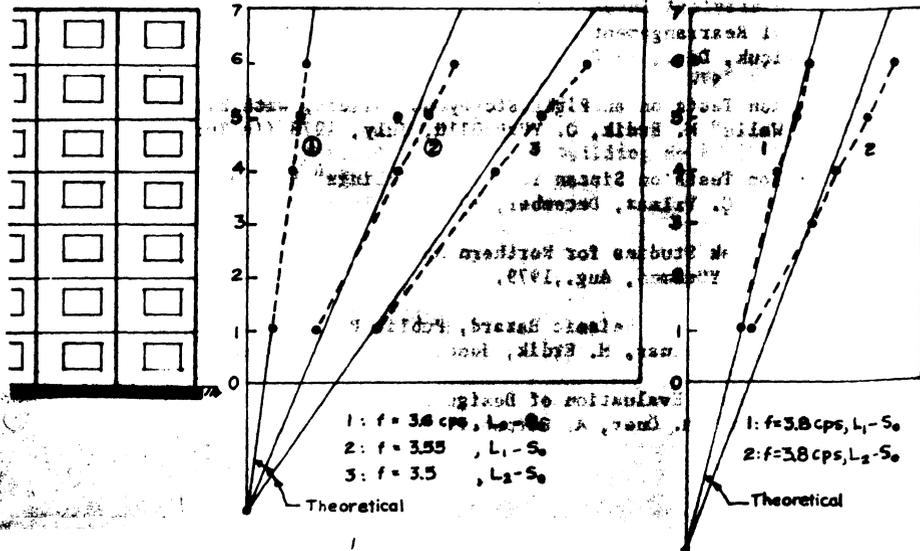


Figure 4. Observed soil-structure interaction in a prefabricated panel building under forced vibrations.

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