STATEMENT
By
DR. GEORGE W. HOUSNER
PROFESSOR OF CIVIL ENGINEERING
AND APPLIED MECHANICS
CALIFORNIA INSTITUTE OF TECHNOLOGY

MAY 19, 1964

My name is George W. Housner and my business address is 1201 East California Boulevard, Pasadena, California. I am Professor of Civil Engineering and Applied Mechanics at the California Institute of Technology. I received a Bachelor of Science degree from the University of Michigan in 1933, a Master of Science degree from the California Institute of Technology in 1934, and the Doctor of Philosophy degree from the California Institute of Technology in 1941. I have been on the staff of the California Institute of Technology since 1945.

I am a member of the following scientific and professional organizations: Seismological Society of America, American Geophysical Union, Earthquake Engineering Research Institute, International Association of Earthquake Engineering, Mexican Association of Earthquake Engineering, Structural Engineers Association of California, American Society of Civil Engineers, and others.

I hold the following positions of responsibility relating to earthquake engineering: President of the Earthquake Engineering Research Institute; Member of Board of Directors of the International Association of Earthquake Engineering; Member of Board of Directors of the International Institute of Seismology and Earthquake Engineering in Tokyo; Member of the Consulting Board for Earthquake Problems for the California State Department of Water Resources. I was formerly a member of the Advisory Panel on

Safety Against Groundshock for the U. S. Atomic Energy Commission and a member of the Scientific Council of the Seismological Society of America.

I am, or have been, a consultant on the following projects concerned with earthquakes, bombshock, or other vibratory excitations: preparation of handbook "Nuclear Reactors and Earthquakes" for the Atomic Energy Commission; earthquake design of nine nuclear power plants in different parts of the United States; design of nuclear power plant for Japan Atomic Power Company; earthquake design of suspension bridge over the Tagus River in Lisbon, Portugal; design of the San Francisco Bay Area Rapid Transit System; design of Titan missile bases for Space Technology Laboratory; design of Saturn Missile Test Facilities, and others. I have also served as consultant to the following organizations: General Electric Company, Westinghouse Corporation, Allis-Chalmers Corporation, Rocketdyne; Bechtel Corporation, Ralph M. Parsons Company, Sverdrup & Parcel and Associates, Los Angeles Department of Water and Power, Humble Oil Company, Standard Oil of California, Aerojet-General Corporation, General Telephone Company, Hancock Oil Company, and others.

I am the author of forty technical papers and books, most of which deal with problems of earthquakes.

I have been asked by the Pacific Gas and Electric Company to present my opinion as to the earthquake resistant design of the

proposed nuclear reactor power plant to be located on Bodega Head.

Northern California is in an active seismic region, as is most of the western United States. Strong earthquakes have also occurred in the midwestern and eastern United States but with less frequency than in the western parts of the country. That California is subject to earthquakes has long been recognized by seismologists and engineers, and much research has been done on the problems posed by their occurrence. The frequency of occurrence of earthquakes of various Magnitudes have been analyzed[1], the locations of epicenters have been determined[1], the potentially damaging ground motions during earthquakes have been recorded[2]; spectral analyses of these ground motions have been made[3], studies have been made of the behavior of structures during earthquakes[4]; the motions of buildings have been measured during

---

1. B. Gutenberg and C. F. Richter, Seismicity of the Earth, Princeton University Press, 1954.

2. "U. S. Earthquakes 1928-63," U. S. Department of Commerce, Washington, D. C.

3. G. W. Housner, J. L. Alford and R. R. Martel, "Spectrum Analyses of Strong-Motion Earthquakes", Bull. Seismological Soc. Am., Vol. 43, No. 2, 1953.

4. "Proceedings of the World Conference on Earthquake Engineering", Earthquake Engineering Research Institute, Berkeley, 1956; and "Proceedings of the Second World Conference on Earthquake Engineering", Tokyo, 1960.

earthquakes[5], and methods of analysis and design of structures to resist earthquakes have been developed[6]. The results of these studies are reflected in the building codes that govern the earthquake-resistant design of buildings and schools in our communities. The forces induced by earthquakes can be taken into account in the design of a structure in the same way that wind forces and other types of forces are taken into account, and any desired degree of safety can be incorporated in the structure.

No movement on faults is expected to occur on the site of the plant, but the design will be such that fault movement could be accommodated without damage to the functional integrity of the plant.

The motion of the ground during strong earthquakes in California is recorded by a network of special accelerographs that are maintained by the Seismological Field Survey of the U. S. Coast and Geodetic Survey[8]. The characteristics of strong earthquake ground motion and the behavior of structures subjected to

---

5. C. M. Duke and R. A. Brisbane, "Earthquake Strain Measurements in a Reinforced Concrete Building", Bull. Seism. Soc. Am., Vol. 45, 1955.

6. G. W. Housner and D. E. Hudson, "Vibrations of Structures Induced by Seismic Waves", Chapter 50, Shock and Vibration Handbook, McGraw-Hill, 1961.

7. "Report of the State Earthquake Investigation Commission", Carnegie Institution of Washington, Vol. 1, 1908; Vol. 2, 1910.

8. The data are published in the series of booklets, "U. S. Earthquakes 1928-63, "U. S. Dept. of Commerce, Washington, D.C.

this ground motion have been analyzed[9]. Methods of design of ordinary structures to resist earthquakes have been presented in detail[10]. The design of nuclear reactors to resist earthquakes has also been described[11]. An extensive discussion of the design of nuclear reactors to resist earthquakes is presented in an Atomic Energy Commission Handbook[12].

The design of the Bodega Bay power plant is based on the expectation that there will be a repetition of the 1906 earthquake. There is a very complete report on this earthquake that describes the slip on the fault and the damage to buildings[7]. In particular, there are photographs and descriptions of structures close to the surface trace of the fault which give a good indication of the severity of ground shaking. The design of the plant is such that in the event of a repetition of the 1906 shock the stresses induced will be less than the allowable working stresses for the materials. This means that the buildings and equipment could withstand a repetition of the 1906 shock every week without

---

9. G. W. Housner, "The Behavior of Structures During Earthquakes", Proc. Amer. Soc. Civ. Engnrs., Vol. 85, EM4, October, 1959.

10. J. A. Blume, L. H. Corning, N. M. Newmark, "Design of Multistory Reinforced Concrete Buildings for Earthquake Motions", Portland Cement Assn., 1961.

11. G. W. Housner, "Design of Nuclear Reactors to Resist Earthquakes", Proc. Second World Conference on Earthquake Engineering, Tokyo, 1960.

12. U. S. Atomic Energy Commission, "Nuclear Reactors and Earthquakes", 1963.

ill effect. The design will incorporate a large factor of safety so that the reactor structure could withstand, without damage, ground motion twice as severe as that during the 1906 shock. The earthquake forces used in the design of the reactor building are more than five times the values required by the Building Codes of San Francisco and Los Angeles. The plant will be able to withstand the maximum credible ground shaking as estimated by seismologists with ample factor of safety.

In summary, the plant can be designed to withstand[13/] ground shaking and to accommodate fault movement without jeopardizing its integrity.

---

13. P. Byerly, "Seismicity of the Western United States", Proc. World Conference on Earthquake Engineering, Earthquake Engineering Research Institute, 1956; G. D. Louderback, "Faults and Earthquakes", Bull. Seism. Soc. Am., Vol. 32, No. 4, 1942; W. K. Cloud, "Maximum Accelerations During Earthquakes, "First Chilean Conference on Seismology and Earthquake Engineering, Santiago, Chile, July, 1963.