

SYMPOSIUM ON BUILDING DESIGN FOR SEISMIC AND SHOCK LOADING

INTRODUCTION

MR. L. J. MARKWARDT:¹

The design of buildings and structures traditionally necessitates consideration of all types of loading encountered—live loads, dead loads, wind loads, vibration, earthquake shock, and blast forces. The relative importance of the different forces varies from region to region and state to state, so that it has remained for cities and states to establish code requirements essential for regional and local conditions.

Earthquakes are encountered throughout the world, but it remained for the Long Beach shock in 1933 to dramatize the potential hazard of many types of construction and particularly school buildings. As a result of public demand, legislation was passed in California establishing design requirements to meet local conditions for school and other buildings, and procedures for design approval. As a result, the role of the structural engineer has assumed increasing importance, and California has the largest and most active Structural Engineers Association in the country.

Wood has assumed increased importance in earthquake resistant construction, but some of the problems encountered showed the need of additional design data. As a result an extensive research program was developed covering the evaluation of the strength, stiffness,

and rigidity of large diaphragms representing full-scale sections of buildings. Different types of bracing and joint details were studied. The results of these extensive studies have just recently become available. The Second Pacific Area National Meeting at Los Angeles in 1956 offered an appropriate opportunity to present a review of this subject matter. The "Symposium on Seismic and Shock Loading" was accordingly developed under the joint sponsorship of ASTM Committees D-7 on Wood and E-6 on Methods of Testing Building Constructions in carrying out the objective of the Society in furthering the promotion of knowledge of materials of engineering.

CHAIRMAN BEN BENIOFF:²

The interest in seismic or earthquake effects is not only a part of the structural engineer's problems relating to buildings, but, it is applicable to all structures—bridges, towers, aqueducts, or pipelines, to name some of the other elements effected by lateral force.

Other states have provisions in their codes for providing resistance to winds. California has provided for the lateral force, which ever is the greater—seismic or wind.

Of more concern to the structural engineer recently has come the problem of shock loading, or, in simpler terms, bomb blast. One thing that is quite sure

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in this field, in the realm of nuclear blast, is that no one is going to worry about most superstructures at the center or near the center of the target. But, at varied distances from the orbit, there are areas in which the intensity of the blast has the same effect as any other major lateral force. It is here that savings of our structures will be effected by means of adequate design. It has been stated by several well-known authorities in this field, Mr. George Housner, for one, that the design procedure used today by California engineers for design against seismic loading is probably as good an approach to the subject as any we have today. Factors will, of course, vary with the degree of resistance to be adopted. Earthquakes can, and have, occurred throughout the world. It is also known that shocks of varying intensity have occurred throughout the United States. Some have been very severe. But, it is also known that of all the heavy populated areas in this country, California is more subject to seismic disturbance.

It is recognized that a condition must be faced from which there is no escape. Earthquakes have occurred as far back as records have been kept; they will continue through our lifetime and far into the future. They are dangerous solely because buildings and houses are erected which can be shattered or shaken down. In themselves, earthquakes have little hazard to human beings. They are dangerous only when structures are poorly built so that they can be damaged or wrecked. It is just as easy to build them so they will not be shaken down. There is ample proof in the past that it can be done and is economically feasible. An earthquake can be made an interesting but not a dangerous occurrence.

As a matter of interest, some of the shocks of the past are recalled to mind. The three outstanding great shocks are:

1857, January 8-9, at Fort Tejon, northwest corner of Los Angeles County, felt from Sacramento into Mexico—probably one of the most violent earthquakes known to have occurred in California. There was visible movement on the San Andreas fault for approximately 200 miles, northwest and southwest from region of Tejon Pass.

1872, March 26, Owens Valley shock, most violent along the east base of the Sierra Nevada from Owens Lake to Mono Lake. This shock was exceedingly violent in a relatively small area, and as a moderate earthquake was one of the most widespread recorded in the state—felt from San Diego to Redding with horizontal movement up to about 18 ft at one point on the fault.

1906, April 18, San Francisco Bay Region, destructive from San Jose to Santa Rosa, with visible movement on the San Andreas Fault for 200 miles from Point Arena in Mendocino County to San Juan in San Benito County. The horizontal displacement was up to 21 ft and earthquake damage was extensive and severe.

Other great shocks might be listed as follows:

1769, July 28, Southern California, San Gabriel Mission near Los Angeles.

1812, in fall of year, San Juan Capistrano in southern California. A church was destroyed with loss of 40 lives. The mission church at Santa Ynez 170 miles from San Juan Capistrano was completely destroyed and some lives lost. It was severe at San Gabriel with damage to church and buildings.

1863, October 21, Hayward shock, San Francisco Bay area, most violent near Hayward, where every building was damaged and many wrecked. Damage done in San Francisco was considerable.

1892, February 23, San Diego County, with many strong after shocks.

1915, October 2, Pleasant Valley, Nev., about 40 miles south of Winnemucca, a very severe shock in a nearly uninhabited area. The fault was visible for about 22 miles, with vertical displacement up to 15 ft.

1932, December 20, Nevada, north of Tonopah and east of Mina, with faulting visible over an area 9 miles wide and nearly 40 miles long. There were few inhabitants or structures in the region of its epicenter, but it was felt over a large area.

Other very strong shocks but not listed as great by seismologists, from 1836 to 1933, number 22 and have occurred up and down the state of California.

But it was the earthquake of March 10, 1933, which rang the bell as far as California was concerned. The lesson of 1906 seemed to have been forgotten. Earthquakes were taking place at times most convenient to the public so that despite extensive property damage, great losses of life comparable to those in other countries had been avoided.

With an aroused public the State Legislature passed the Field Act for school buildings and the Riley Act for all buildings. The registration laws already in effect for civil engineers were amended to separate another group of

specialists in design—the structural engineers. From that day to this, every structural engineer and architect in the state of California has had to acquaint himself with the problem of design for resistance to seismic shock as well as the building codes and laws pertaining to such design. In the foreground of this campaign for more adequate construction, has been the Division of Architecture. Backed by the Legislature, the old Appendix A and the present Title 21, have been the weapon used by the Division in its enforcement. It is an act written by engineers, for engineers, and carried out by engineers.

One of the men who has come up the road in the effort to carry on this program of enforcement of sound engineering principles in school building construction and is today one of the top men in the Division of Architecture, is the chairman of this session, Ernst Maag. Mr. Maag not only has been active with the Division of Architecture, but has worked diligently with all building codes. He has also put a lot of his own time and energy in research problems pertaining to structural engineering. He has worked with others very extensively on developing standards and codes of practice now in general use by ASTM and other agencies.