SELECTION OF SEISMIC DESIGN PARAMETERS FOR A NUCLEAR FACILITY

by

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INTRODUCTION

Much of the recent controversy concerning seismic hazards to proposed nuclear facilities has centered not on the complexities of dynamic structural design but with the difference of opinion as to the maximum credible earthquake to be specified for a given area. Occasionally, some very legitimate geological-seismological questions have been raised during those controversies by those who tend to underestimate the overall safety aspects of the site. This has had in general a positive effect. Present day investigations for the earthquake design of nuclear facilities require increasingly more extensive and more precise geologic and seismologic data.

SITE DESCRIPTION

The site is located near West Valley in the Cattaraugus County in western New York. The construction consists of Process Units, Service Structures, a receiving Area, Waste Tanks, and Lagoon and Sludge Ponds. The heaviest structures on the site are the Process Mechanical Cell, the Chemical Cell and Extraction Cell. These are massive reinforced concrete structures varying from 30 to 50 feet in height above the ground and 3 to 8 feet deep in the ground, and which impose pressures of 3000 to 4000 pounds per square foot over their base area.

REGIONAL GEOLOGY

The site is located in the glaciated Allegheny Plateau Section of the Appalachian Plateau Physiographic Province. This province is bounded on the north and west by the Erie-Ontario Lowlands Section of the Central Lowlands Physiographic Province. The region surrounding the site is generally characterized by the effects of glaciation, both in erosional and depositional features.

Bedrock in the area is generally near flat and quite undeformed. The rock strata in the region slope gently south about 30 to 40 feet per mile. To the north, into the Central Lowlands Province and into Canada, the underlying formations continue relatively undeformed and lap onto the seismically stable Canadian Shield.

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REGIONAL TECTONICS

Authors such as Richter, (1959); Woolard, (1958); and Algermissen, (1969) have postulated a seismic trend from the region of Intensity X* shocks in the lower St. Lawrence into the Buffalo, New York-Hamilton, Ontario region. On Algermissen's 1969 Seismic Risk Map of the U.S., the West Valley area is in UBC Zone 3. Studies by Canadian seismologists (Milne and Davenport 1969) in the adjacent areas have not supported any such trends. The results of many investigations in northern New York State (Fischer and McWhorter 1972) did not indicate any regional trend of northeast-southwest trend. However, the site was close to a zone of seismic activity in western New York. It thus became important to more precisely define the zones of weakness within the earth's crust which had localized shocks in the general area of the site.

The only known geologic structure of significance in the area is the north-south trending Clarendon-Linden feature. The Clarendon-Linden was originally described by Chadwick (1920) as a normal fault believed to extend from the Niagara escarpment near Clarendon, New York on the north, to Linden, New York on the south, a distance of some 25 miles. Chadwick found displacement of the Onondaga and Niagara escarpments with the western side displaced farther north relative to the eastern side. In the vicinity of Linden, New York he discovered that the formations to the west were at a much lower elevation than the same formations on the east. Thus, Chadwick was led to believe that the structure was a fault with the downthrown side on the west. After further study, Chadwick (1932) termed the feature a monocline at the Linden end and a fault at the Clarendon end. He called the whole structure the Clarendon-Linden Displacement.

Thus, this structure became the focus of the regional seismotectonic investigation performed for the West Valley site.

STUDIES OF THE CLARENDON-LINDEN FEATURE

Initially it was believed that the only possible source of significant earthquake motion would come from the occurrence of shocks along the Clarendon-Linden feature to the north and east of the site. Earthquake activity in the past has been centered near Attica, New York adjacent to a faulted portion of the Clarendon-Linden feature.

The initial interpretation of the Clarendon-Linden feature postulated a bifurcation south of Batavia (but north of Attica) trending in a southwestern direction past Attica to the Java area. This initial interpretation was based on the data available to that date.

Detailed studies of the Medina Formation indicated quite conclusively that the originally postulated southwestward extension does not exist much beyond the Attica area and that the closest approach of the Clarendon-Linden Structure or associated displacements is some 23 miles due east of the site.

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* All intensities in this paper refer to the Modified Mercalli Scale as abridged by Richter in 1956.

Based upon this detailed study, it was concluded that there is no geologic structure in the area that would adversely affect the proposed expansion and that there is no reason to postulate an extension of the bifurcation any closer to the site than the immediate vicinity of Attica.

SELECTION OF MAXIMUM CREDIBLE (SAFE SHUTDOWN) EARTHQUAKE

The procedures used in this analyses were reported in Fischer and Murphy (1969). Input data consisted of regional seismicity, regional geologic history and an evaluation of the seismic response of the on site soil column.

Studies of regional and local seismicity indicated that there is history of minor earthquake activity in the area, the most significant of which are shocks near Attica and Buffalo. The Attica shocks appear to be related to the Clarendon-Linden Structure, an isolated geologic feature trending north-south. Although the significant portion of the structure is to the north-east of the site the easterly branch approaches to within about 23 miles east of the site. As previously indicated, it is believed that the earthquake activity in the vicinity of Attica, New York is associated with crustal readjustment along the Clarendon-Linden Structure. Thus for the Safe Shutdown Earthquake it was conservatively hypothesized that a shock similar to the largest of the Attica series, the 1929 Intensity VII-VIII shock, could occur at the closest approach to the site of this branch of the Clarendon-Linden Structure.

Based on the foregoing conservative assumptions, the Safe Shutdown Earthquake was considered to be an Intensity VII-VIII earthquake with its epicenter about 23 miles from the site. It was estimated that the maximum horizontal ground acceleration at foundation level within the overburden soil at the site due to such a shock would be 12 percent of gravity. It was recommended, therefore, that critical structures be designed for safe shutdown for this horizontal acceleration. The recommended degree of vertical motion for the design basis earthquake was an acceleration of 8 percent of gravity.

DYNAMIC SOIL PARAMETERS

A soil structure interaction analysis was required to evaluated the the stress-strain behavior of the interface of these structures with the surrounding soils. To provide the necessary soil stratigraphy information and samples suitable for testing, a field program including borings, sampling and geophysical profiling were undertaken.

A variety of procedures, including laboratory and field tests were used to evaluate the elastic moduli, the shear moduli and the damping characteristics of the various soil layers. The main laboratory procedures include constant rate of strain triaxial compression tests, cyclic triaxial tests, shockscope tests and resonant column tests. Triaxial tests are useful in measuring moduli under moderate to relatively high strain (10^{-2} to 10^{-1}). The shockscope and resonant column tests are useful in evaluating properties at relatively low to moderate strain levels (10^{-4} to 10^{-3}).

Geophysical surveys were used to measure the velocity of propagation of compression waves, shear waves and Raleigh waves from which values of soil moduli were evaluated for low strain conditions (10^{-5} to 10^{-4}).

The elastic properties of the soil will depend on the magnitude of the strain and therefore the moduli and damping factors to be used in the analysis were determined as a function of the induced strain. In the analysis it was assumed that the strain level which would be encountered during the earthquake would be on the order of 10^{-3} to 10^{-2}.

The moduli and damping values compared favorably with empirical relationships, such as those proposed by Hardin and Black (1968) and Seed and Idriss (1969).

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