SEISMIC EVALUATION OF CRITICAL FACILITIES
AT THE LAWRENCE LIVERMORE LABORATORY

by

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SYNOPSIS

The performance of critical facilities at the Lawrence Livermore Laboratory (LLL) are being evaluated for severe earthquake loading. Facilities at Livermore, Site-300 and the Nevada Test Site are included in this study. These facilities are identified, the seismic criteria used for the analysis are indicated, the various methods used for structural analysis are discussed and a summary of the results of facilities analyzed to date are presented.

INTRODUCTION

The San Francisco Operations Office of the U.S. Energy Research and Development Administration has requested LLL to investigate the earthquake hazard associated with its critical facilities at its three sites. These sites include the main Laboratory complex in Livermore, California, the High Explosive Test Complex (Site-300), near Tracy, California, and the 410 area of the Nevada Test Site, outside of Las Vegas, Nevada.

The approach taken to determine the seismic hazard associated with these critical facilities has been divided into five main areas: 1) selection of critical facilities for evaluation, 2) a geological and seismological review to determine the potential seismic hazard at each site, 3) an estimate of the ground motion that could result at each site. This ground motion is expressed as a free field peak acceleration and a response spectra. 4) A structural analysis of each facility, and 5) an assessment of the structural integrity of each facility with recommendations for modifications if necessary.

All of the information generated by this study is being incorporated into Safety Analysis Reports[1] which are being prepared for each facility.

SELECTION OF CRITICAL FACILITIES

Critical facilities are defined as those facilities which have a potential for release of radioactive materials. The safety criteria used for selecting these facilities is based on that established by the U.S. Nuclear Regulatory Commission for power reactors[2] and the U.S. Energy Research and Development Administration for plutonium facilities.[3] Table 1 lists the facilities being reviewed at each site. All these facilities except the firehouses contain radioactive experiments where damage resulting from an earthquake could involve the exposure of a large number of people to excessive radioactive hazard. The integrity of these facilities is essential to the health and safety of the public.

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GEOLOGICAL AND SEISMOLOGICAL REVIEW

The location of potential earthquakes that could affect a given site in the western U.S. is usually associated with active faults. Active fault locations at LLL sites were determined by a thorough review of both the geology and seismicity of the area surrounding the sites.[4,5,6]

Determination of potential earthquake magnitude is based primarily on empirical correlations. The complete characterization of earthquake sources involves parameters such as length of rupture, offset, area of faulting surface, stress drop, and rock strength. In practice, correlations between rupture length and earthquake magnitude are usually emphasized. Using such correlations the earthquake magnitudes and associated active faults for the three sites are summarized in Table 2.

GROUND MOTION ESTIMATES

Three methods are usually used to specify the ground motion resulting at a given site. The first uses recorded surface motions from past earthquakes to extrapolate directly surface motions at some epicentral distance. Such extrapolated motions are sometimes modified to account for local site conditions. The second method estimates the bedrock motion underlying the site of interest and then uses detailed site properties to compute the surface motion. The third method, used for shorter epicentral distances, makes estimates directly from empirical correlations.

All three methods were used to determine design earthquakes for the sites. Figure 1 shows the response spectra for the design earthquakes selected, and are referred to as safe shutdown earthquakes (SSE). These earthquakes estimate the most severe horizontal ground motion for the sites. The SSE is intended for the design and investigation of critical structures, associated equipment, and ventilation, fire protection, and utility systems. Vertical ground motions are considered to be two-thirds of the horizontal SSE values.

STRUCTURAL ANALYSIS

Our structural analysis generally involves three steps: selection of the method of analysis, development of a calculational model, and analysis and interpretation of results. The method of analysis chosen requires consideration of the nature and importance of the structure, the consequence of failure, and the type of structural system being analyzed. Because seismic damage could result in the exposure of a large number of people to an excessive radioactive hazard, safety is of paramount importance. Therefore, our analysis must be as reliable and accurate as possible. In addition, the different facilities being analyzed have a great variety of structural systems: rigid frame, braced frame, shear wall, arch and shell. Some structures are embedded or fully-buried. The calculational model must be capable of capturing the response characteristics of these structures. This is done through an accurate representation of the structural stiffness and mass distribution with damping and application of exciting forces properly handled.

Methods of analysis that we normally employ include equivalent static, spectral response, and time history analyses. These latter two methods are dynamic and therefore include possible amplification effects of the input ground motions. They can also include inelastic effects if desirable. For very stiff structures (period < 0.1 sec), the equivalent static approach is usually adequate. For more flexible structural systems (period 0.1 to 2.0 sec), possible dynamic amplification effects must be examined.

ASSESSMENT OF STRUCTURAL INTEGRITY

Analysis of approximately 50% of these facilities is complete (refer to Table 1 and references 7-14). These structures were typically designed by the Uniform Building Code (seismic coefficient = ZKC = 0.133 to 0.20) and performed well when subjected to the more severe seismic motion imposed.

Most of the inadequacys observed to date were found in connection details. Typically problems occurred in roof-to-wall connections. Careful design of these connections had not been done. Another common occurrence was the increase in roof loading due to the addition of mechanical and electrical equipment. In many cases the roof mass was increased without consideration of the effect of earthquake loading.

REFERENCES

1. Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants, USNRC, Washington, D. C. 1972.

2. Appendix A of 10 CFR Part 100, "Seismic and Geologic Siting Criteria for Nuclear Power Plants" U.S. Nuclear Regulatory Commission, Washington, D. C.

3. ERDA Manual Appendix 6301, General Design Criteria, Engineering Handbook., U.S. Energy Research and Development Administration, Division of Construction.

4. L. H. Wight,"A Geological and Seismological Investigation of the Lawrence Livermore Laboratory Site," Lawrence Livermore Laboratory Report UCRL-51592, June 1974.

5. R. K. Thorpe and L. H. Wight, "A Geological and Seismological Investigation for the 834, 836, and 854 Building Complexes at LLL's Site-300, Lawrence Livermore Laboratory Report UCRL-52006, Jan. 1976.

6. W. J. Hannon and H. L. McKague, "An Examination of the Geology and Seismology Associated with Area 410 at the Nevada Test Site," Lawrence Livermore Laboratory Report UCRL-51830, May 23, 1975.

7. F. J. Tokarz, Earthquake Analysis of the Diagnostic Chemistry Building, Lawrence Livermore Laboratory, Lawrence Livermore Laboratory Report UCRL-51192, May 1972.

8. R. C. Murray and F. J. Tokarz, Seismic Analysis - Livermore Pool Type Reactor Facility, Lawrence Livermore Laboratory, Lawrence Livermore Laboratory Report UCRL-51507, Nov. 1973.

9. Safety Analysis Report for Building 332 - Metallurgical Chemistry, Lawrence Livermore Laboratory Report UCRL-51590, June 1974.

10. Safety Analysis Report - Livermore Pool Type Reactor, Lawrence Livermore Laboratory Report UCRL-51423, Nov. 1974.

11. Safety Analysis Report for Building 251 - Diagnostic Chemistry, Lawrence Livermore Laboratory Report UCRL-51690, Nov. 1974.

12. Safety Analysis Report for Building 231 - Central Vault, Lawrence Livermore Laboratory Report UCRL-51815, Aug. 1975.

13. Safety Analysis Report for Building 331 - Gaseous Chemistry, Lawrence Livermore Laboratory Report UCRL-51816, Oct. 1975.

14. Safety Analysis Report for the 5300 Complex (Baker Site) Located in Area 27 (410 Area) of the Nevada Test Site, Lawrence Livermore Laboratory Report UCRL in preparation.

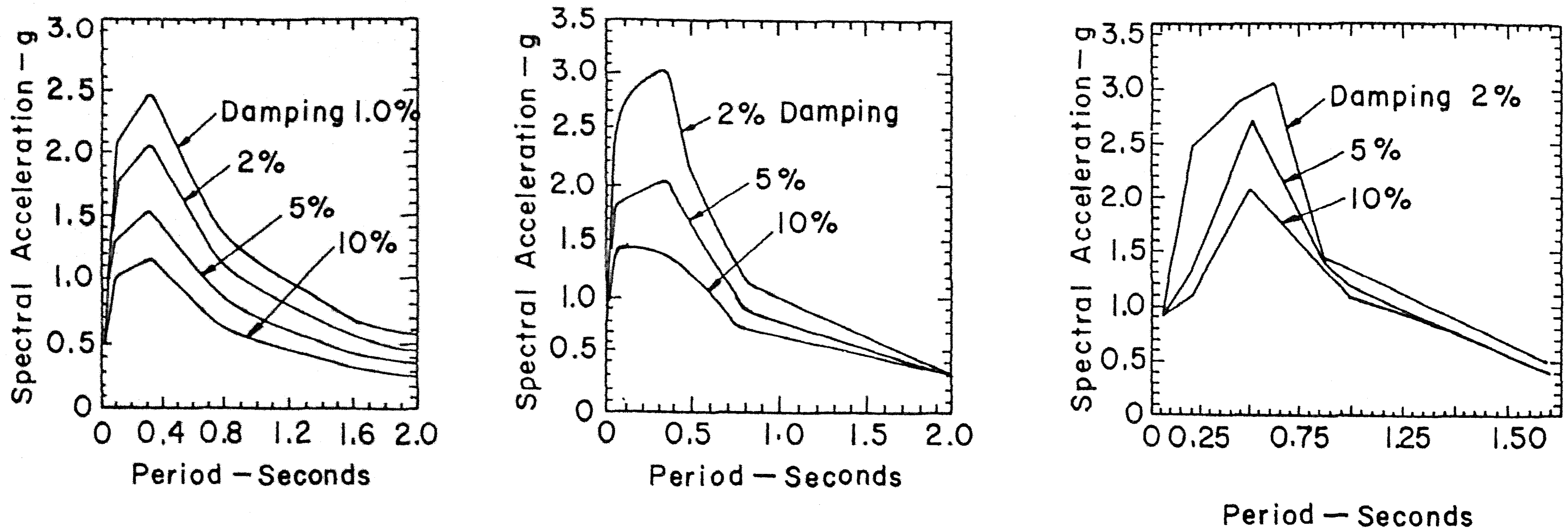
Table 1. List of Critical Facilities Being Reviewed

LOCATION	BUILDING DESIGNATION
Livermore	Pool-type reactor*
	Metallurgical Chemistry*
	Gaseous Chemistry*
	Diagnostic Chemistry*
	Development and Assembly
	Central Vault*
	Classified Storage
	Hot Cell Area
	Dry Waste Disposal
	Radio Chemistry
	Fire Department
Site-300	Environmental Test Complex
	Dynamic Test Complex #1
	Dynamic Test Complex #2
	Fire Department
410 Area of Nevada Test Site	Technical Laboratory and Storage*
	Technical Bunkers and Storage
	Super Kukla Reactor

*Structural Analysis Complete

Table 2. Magnitude of Faults Surrounding the Sites

FAULT	RICHTER MAGNITUDE	DISTANCE TO FAULT(km)
Livermore and Site-300		
San Andreas	8.3	58.0-65.0
Calaveras	7.5	17.0-29.0
Hayward	7.5	37.0-42.0
Greenville-Riggs Canyon	6.7	10.0
Black Butte	6.5	$\leq$ 5.0
Livermore	6.5	20.0
Mocho	6.5	10.0
Tesla	6.5	$\leq$ 5.0
Carnegie	6.4	$\leq$ 5.0
Corral Hollow	6.4	$\leq$ 5.0
Valle	6.3	13.0
Williams	6.3	14.0
Ramp Thrust	6.2	10.0
Patterson Pass	6.1	$\leq$ 5.0
Callahan	5.9	$\leq$ 5.0
Doutherty	5.8	10.0
Midway	5.8	$\leq$ 5.0
410 Area of Nevada Test Site		
Owens Valley	8.3	160.0
San Andreas	8.3	310.0
Furnace Creek-Death Valley	7.5	64.0
Garlock	7.4	130.0
White Wolf	7.2	260.0
Las Vegas	7.0	16.0
Yucca	6.5	14.0
Cane Spring	5.8	0.2
Massachusetts Mountain	5.3	9.0



a) Livermore Site (0.5g Earthquake on Local Fault)

b) Site 300 (0.8g Earthquake on Local Faults)

c) 410 Area of Nevada Test Site (0.9g Earthquake on Local Spring Fault)

Figure 1. SAFE SHUTDOWN EARTHQUAKE RESPONSE SPECTRA — HORIZONTAL COMPONENT

DISCUSSION

H. Shibata (Japan)

In Japan we think that strength or intensity of earthquake should be expressed in the maximum ground velocity instead of the maximum ground acceleration.

How much the maximum ground velocity of the cases of site 300 and 410 Area of Nevada Test Site ?

Some geologist said the upper bounded value of the maximum ground velocity might be 40 cm/sec. On the rock surface, otherwise that of Pacoima Dam is estimated over 100 cm/sec by the group of cal. tech.

Author's Closure

Not received.