Seismic Consideration Discussion for The Interaction Region

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Seismic Consideration

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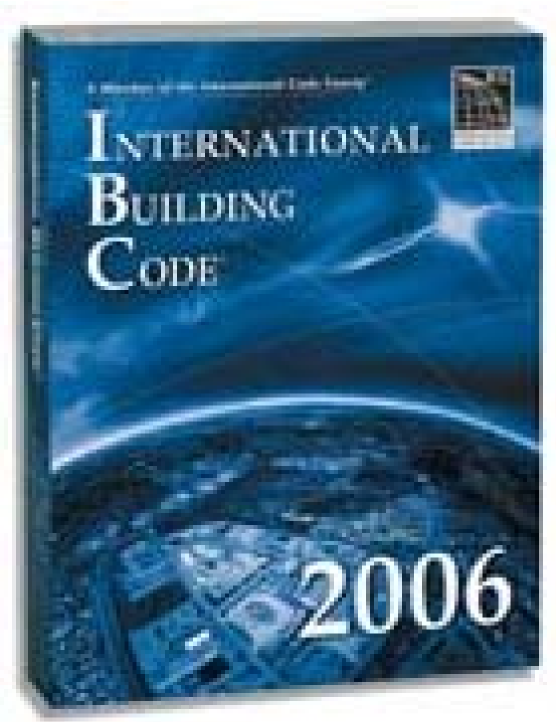
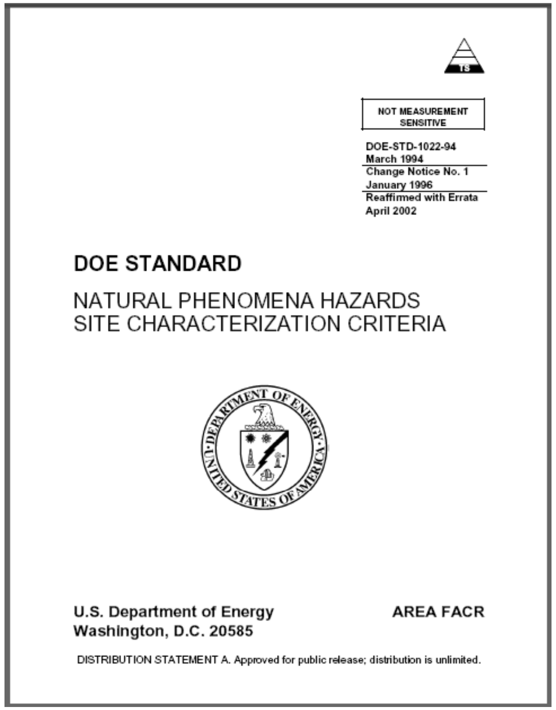
Seismic Consideration

- Design and construction of permanent Buildings, Structures, Equipment, and System are governed by provision of the National, State and Local Codes
- Design document shall be submitted to the authority having jurisdiction for compliance with these provisions




NOT MEASUREMENT SENSITIVE

DOE-STD-1022-94
March 1994
Change Notice No. 1
January 1996
Reaffirmed with Errata
April 2002

DOE STANDARD

NATURAL PHENOMENA HAZARDS
SITE CHARACTERIZATION CRITERIA

U.S. Department of Energy
Washington, D.C. 20585

AREA FACR

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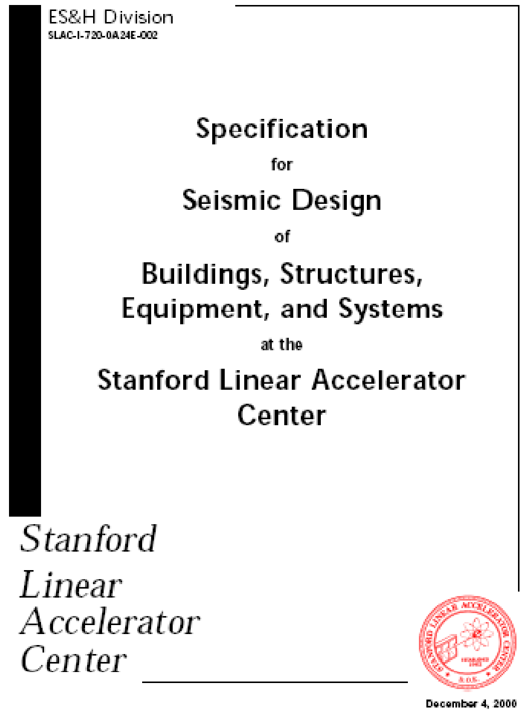

ES&H Division
SLAC-I-720-0A24E-002

Specification
for
Seismic Design
of
Buildings, Structures,
Equipment, and Systems
at the
Stanford Linear Accelerator
Center

Stanford
Linear
Accelerator
Center

December 4, 2000

Purpose

- **Main Purposes of the Seismic Regulations provides in these codes are:**
  1. **To provide minimum design criteria for structures appropriate to their primary function and use considering the need to protect the health, safety, and welfare of the general public/its citizen by minimizing the earthquake-related risk to life and**
  2. **To improve the capability of essential facilities and structures containing substantial quantities of hazardous materials to function during and after design earthquakes.**

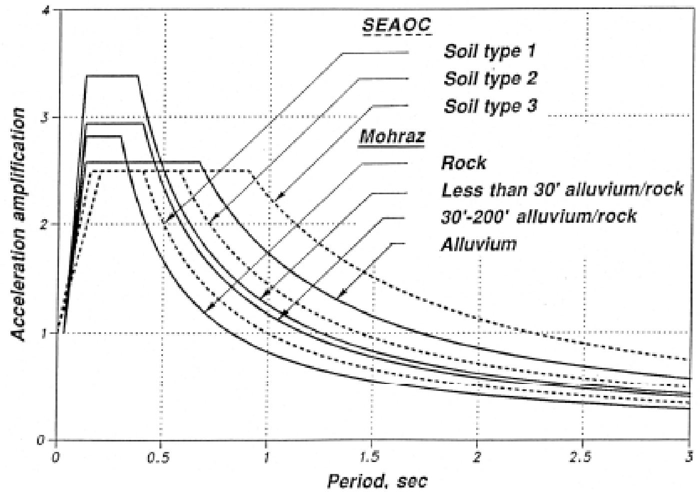
Intent

- Modal Codes provide minimum seismic requirement to safeguard against the loss of life and to maintain the function of facilities required for post earthquake recovery
  - **e.g. Every structure, and equipment, including components that are permanently attached to structures and their supports and attachments, shall be designed and constructed to resist the effects of seismic ground motion specific to the construction site**
- The owner or the user of the facility sets the limit for the extent of the acceptable damage
  - **e.g. The SLAC Earthquake Design Specification requires that building, structures, equipment, and systems should suffer very little damage from a moment magnitude 7.0 earthquake and should be "life safe" for moment magnitude for 7.5. Also, SLAC should be able to operate within a few months of the magnitude 7.0 events.**

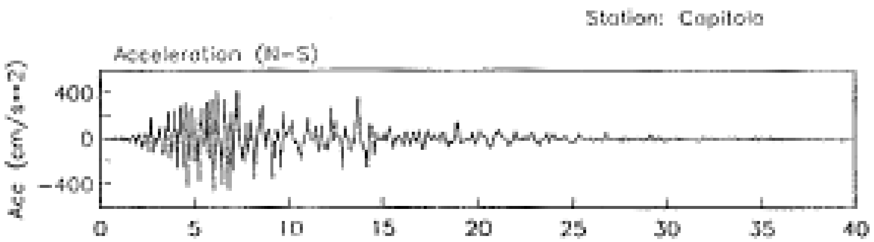
Method

- Two basic methods are widely used for dynamic seismic analysis, namely, Response Spectrum and Time History methods

1. Response Spectrum methods allows determination of maximum modal response of a singly supported structural system or a multiple supported system where all supports receive the same excitation.



2. Time History method of analysis permits the simultaneous application of different excitations at each support point of uncoupled model of the system of interest .



Time History of recorded ground acceleration at Capitola, California in the 1989 Loma Prieta earthquake 1989

Approach

- **It is a relatively straight forward matter to assess design criteria for seismic load for structure or equipment at rest, but it is quite a different matter to come-up with criteria for equipment during the move.**
  - **Following are excerpts from SLAC seismic requirement**

This Design Specification assumes that buildings, structures, equipment, and systems should suffer very little damage from a moment magnitude (M_w) 7.0 earthquake on the proximate section of the San Andreas Fault, and should be "life safe" for M_w 7.5. These two earthquake standards currently are required for Stanford University design and analysis of construction projects. SLAC should be able to operate within a few months of the magnitude 7.0 event if its buildings and structures meet these Specifications and appropriate budget and manpower are available for recovery. A much greater amount of work and funding would be required to regain operational status after a M_w 7.5 event.

Finally, a comment must be made about the relative sizes and effects of the 1906 San Francisco and the 1989 Loma Prieta earthquakes. The 1906 earthquake was M_w 7.9, the Loma Prieta 6.9. The duration of the 1906 earthquake was 45 to 60 seconds, the Loma Prieta, 15 seconds. The length of the rupture for the 1906 event was 430 km from San Juan Bautista to Cape Mendocino. The length of rupture for the Loma Prieta was 40 km centered in a forested and mountainous region east of Santa Cruz and 120 km south of San Francisco. The energy release by the 1906 earthquake was more than 16 times greater than the Loma Prieta.

The seismic design requirement for SLAC is amongst the most stringent and out of the three reference sites only the site in Japan could come close it.

Analysis

- **The critical parameter is the Spectral acceleration expected for the components of the system during the design earthquake**
  - Determine natural modes of vibration for major components of the system (Numerous computer programs available)
  - Determine from the site specific spectral (e.g. SLAC Response Spectra acceleration shown below) the design forces acting on the center of gravity of the system component
  - Provide a complete load path (by physical means) capable of transferring all loads and forces from their point of origin to the load-resisting elements (foundation)

Specification for Seismic Design of Buildings, Structures, Equipment and Systems at the Stanford Linear Accelerator Center

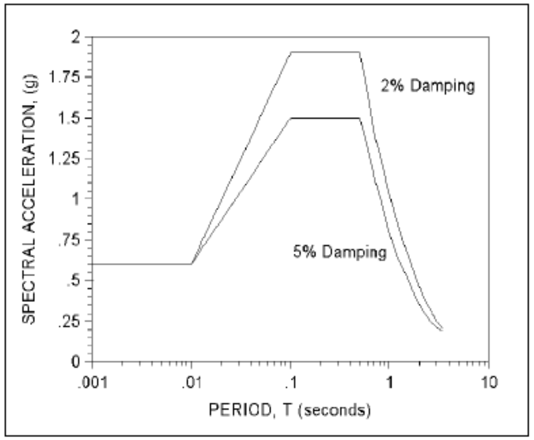


Figure 3. Response Spectra for Mechanical Systems - Horizontal Motions

Specification for Seismic Design of Buildings, Structures, Equipment and Systems at the Stanford Linear Accelerator Center

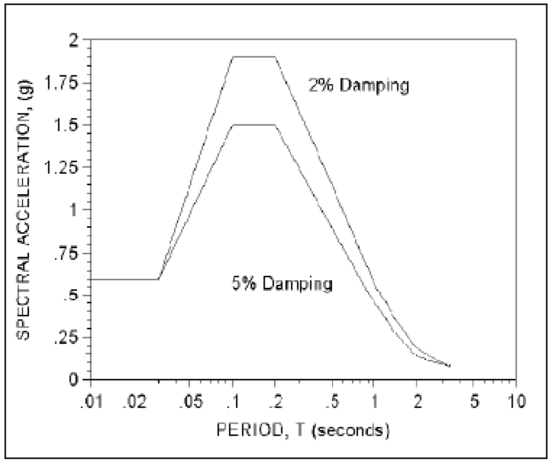


Figure 4. Response Spectra for Mechanical Systems - Vertical Motion

Excerpts from SLAC BABAR Detector Site-Specific Design Response Spectra

Introduction

The studies presented in this report were carried out by ESA Consultants Inc. (ESA) in order to develop site-specific design response spectra, as well as peak ground accelerations, for a seismic retrofit design of the Babar Detector which is presently being assembled at the Stanford Linear Accelerator Center (SLAC) located in Menlo Park, California. This facility is owned by the Department of Energy (DOE) and operated by Stanford University. The seismic design criteria were developed taking into consideration the geologic, tectonic, seismologic and soil characteristics associated with the specific local site conditions.

Site-specific response spectra were developed for the following two earthquake scenarios which could affect the facility:

- A moment magnitude (M_W) 7 event on the nearby Peninsula segment of the San Andreas fault - this event has been assigned a 23% probability of occurrence within the next 30 years by the USGS Working Group on California Earthquake Probabilities (Schwartz, 1994).

- A moment magnitude 7.7-7.9 event which corresponds to the Maximum Credible Earthquake (MCE) which can occur on the San Andreas fault. This event is comparable to the surface wave magnitude (M_S) 8.3 earthquake which ruptured this portion of the fault in 1906. This event has been assigned a recurrence interval on the order of 138 years or less based on slip rate measurement by various investigators.

The site-specific response spectra were developed using a deterministic approach taking into account the local site conditions and the seismic environment of the site. Design spectra were developed for each earthquake scenario for damping values of 2%, 5% and 10% up to a maximum period of 5 seconds.

Excerpts from SLAC BABAR Detector Site-Specific Design Response Spectra

- **Field investigation conducted in order to establish the subsurface geologic conditions in the immediate vicinity of the Detector location**

LR Hall consists mainly of dense to very dense poorly cemented sands with Standard Penetration Test (SPT) blow counts in the range of 75 to 100 blows per foot. In addition, results of a geophysical crosshole survey conducted in Borings 3-5-1, 3-5-2 , and 3-5-3 by Dames & Moore in 1977 are also included in Appendix A together with the boring logs for these holes. Review of these logs indicate that the materials at this location are classified as poorly cemented sandstones with SPT blow counts somewhat greater than those measured in Boring 2-2 drilled right at the LR Hall location. A profile of shear and compressional wave velocities versus depth developed from the crosshole survey is included in Appendix A. This plot indicates that at the depths corresponding to the elevation of the LR Hall floor, values of shear wave velocities are on the order of 2000 ft/sec. Thus, one would expect somewhat similar velocities below the foundation of the LR Hall. On the basis of this information we have classified the site as a soft rock site from the standpoint of seismic response and local site effects.

Excerpts from SLAC BABAR Detector Site-Specific Design Response Spectra

- **Established Peak Horizontal and vertical ground acceleration**

Peak horizontal ground accelerations were estimated using a number of attenuation relationships proposed by several investigators (Campbell, 1988; Joyner and Boore, 1993, 1994; Sadigh and others, 1993; Idriss, 1985), and are presented in Table 1. Values obtained from the Joyner and Boore relationship correspond to both a soft rock site with an average shear wave velocity (V_s) within the upper 100 feet of 750 m/sec (2500 ft/sec), and a hard to stiff soil site with an average shear wave velocity ranging between 360 m/sec (1200 ft/sec) and 750 m/sec. The other relationships apply to rock and rock-like sites without any consideration of the shear wave velocity characteristics of the site. Mean and mean plus one standard deviation values of acceleration were computed for both a M7 and M7.7-7.9 event on the nearby San Andreas fault zone (distance = 4.75 km). For the rock and rock-like site conditions the mean values of acceleration range between 0.43 g to 0.56 g. Based on the ratios of peak horizontal to peak vertical accelerations recorded on rock sites during both the 1989 Loma Prieta and the 1994 Northridge earthquakes, values of peak vertical accelerations can be taken as two-thirds of the peak horizontal values.

Excerpts from SLAC BABAR Detector Site-Specific Design Response Spectra

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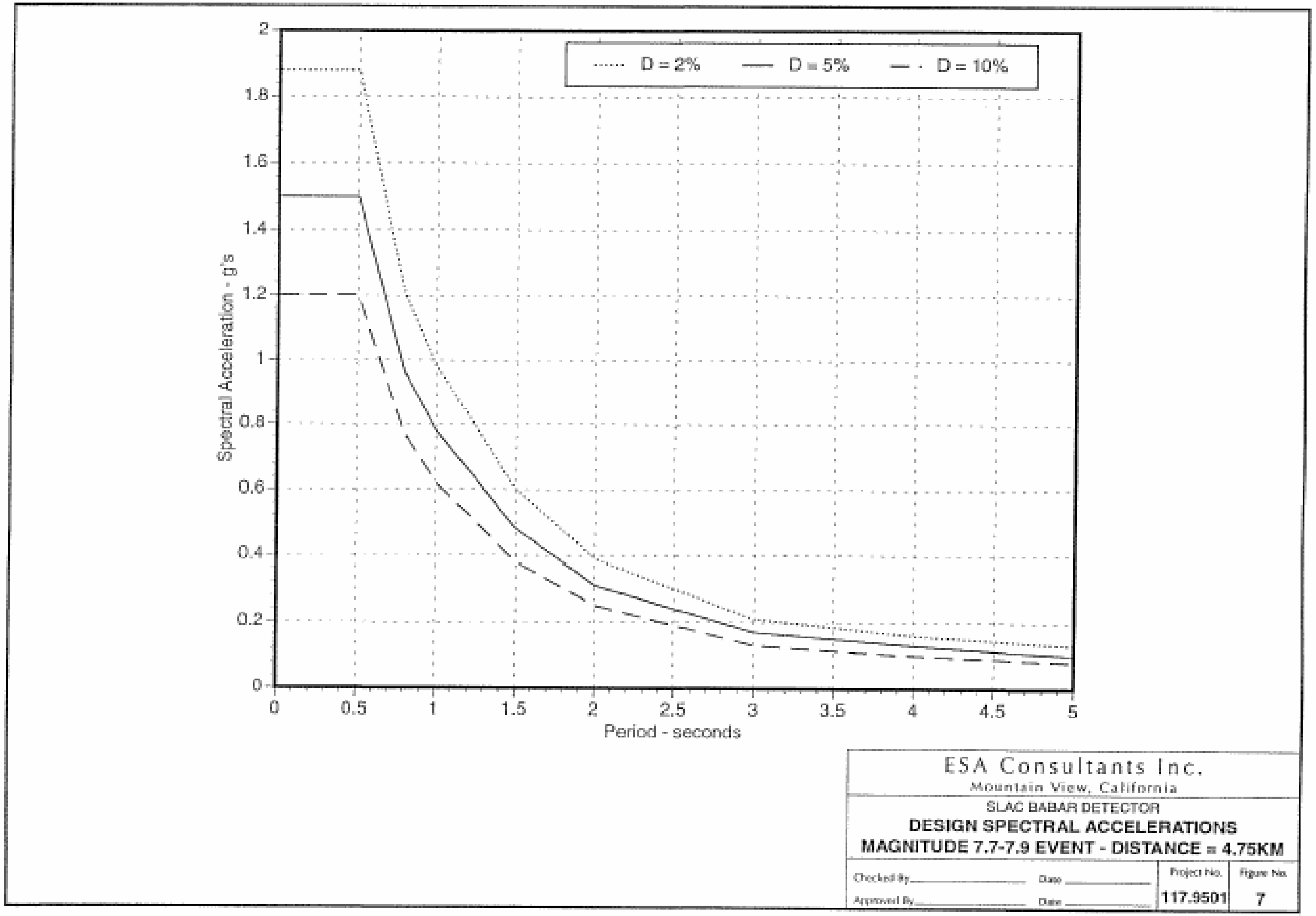
Excerpts from SLAC BABAR Detector Site-Specific Design Response Spectra

- **Recommended Plots of spectral accelerations versus period for use in seismic design of the Babar Detector**

Plots of recommended spectral accelerations versus period for use in seismic design of the Babar Detector, for damping values of 2 %, 5 % and 10 %, are plotted in Figures 6 and 7 for both earthquake magnitudes considered. Similar plots of pseudo-relative velocity versus period are also presented in Figures 8 and 9. Finally, tabulated values of spectral acceleration, pseudo-relative velocity and pseudo-relative displacement are tabulated on Tables 2 and 3 for periods ranging from 0.10 to 5 seconds for all three damping ratios of interest.

Review of historical earthquake data indicates that for strike-slip faulting vertical ground motions usually contain much higher frequencies than corresponding horizontal ground motions. In addition, for any given earthquake record the peak horizontal acceleration recorded at any given site is generally greater than the corresponding vertical acceleration, with the peak values occurring at different times. As previously indicated use of a two-thirds ratio between the two components of acceleration is appropriate. This ratio is also recommended for establishing spectral values for the vertical component of ground motion for use in design.

Excerpts from SLAC BABAR Detector Site-Specific Design Response Spectra



Summary

- **Seismic Regulations are well established**
- **Design criteria is site specific**

1. **Minimum design criteria are set by the authority having jurisdiction for the compliance to the governing regulations (codes)**
2. It is a relatively straight forward matter to assess design criteria for seismic load for structure or equipment at rest, but it is quite a different matter to come-up with criteria for equipment during the move.

- **Question:**

Which set of criteria should we adopt for design of the detector, the most stringent criteria or the least ?