

U.S. DEPARTMENT OF ENERGY
OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT

**NUCLEAR WASTE TECHNICAL REVIEW BOARD
PANEL ON STRUCTURAL GEOLOGY & GEOENGINEERING**

**SUBJECT: SEISMIC VULNERABILITIES
AND SEISMIC DESIGN ISSUES
SURFACE FACILITIES**

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Seismic Vulnerabilities and Seismic Design Issues Surface Facilities

- **Background/objective**
- **Scope of presentation**
 - **Seismic design considerations - general**
 - **Waste handling building concept**
 - **Design criteria issues**
 - **WHB design for vibratory ground motions**
 - **WHB design for fault rupture**
 - **Summary and conclusions**
- **Perspective - design vs. scenario development**

Seismic Design Considerations General

- **Design approach**
- **Design process**
- **Structural systems**
- **Earthquake response**
- **Earthquake effects**

Design Approach/Philosophy

- **Normal industrial facilities**
 - **Level of protection**
 - **Expected behavior**
- **Special/safety related facilities**
 - **Level of protection**
 - **Expected behavior**

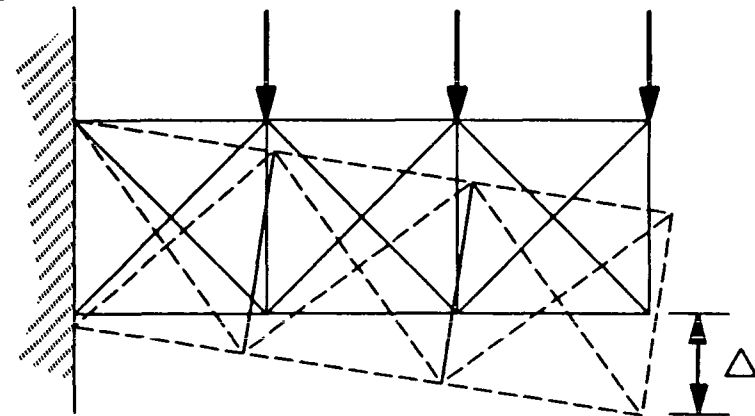
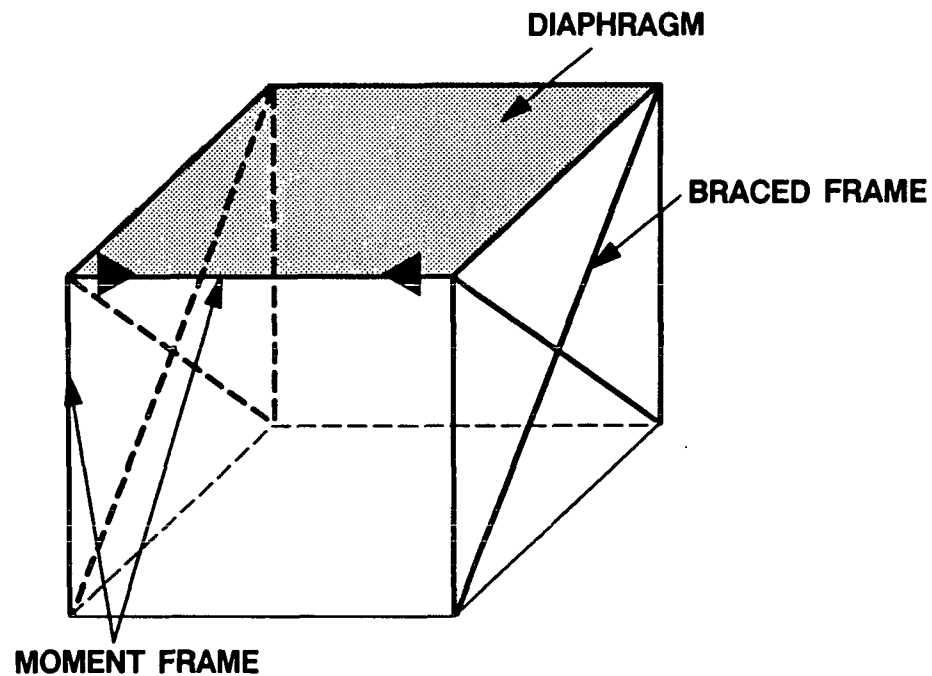
Design Process

- **Establishing risk levels**
- **Defining inputs/loads/forcing functions**
- **Selecting acceptable levels of response**
- **Choosing structural systems/materials/
configuration/sizes**
- **Determining response: structural analysis**
- **Iterating on initial design**
- **Non structural systems and components**
- **Other issues**

Structural Systems

- **Vertical**
 - **Space frames**
 - **Columns/beams/trusses**
 - **Walls/slabs/floors**
 - **Foundations**
- **Lateral**
 - **Frames**
 - * **Moment**
 - * **Braced**
 - **Shear walls**
 - **Diaphragms**

Lateral Force Resisting System Concepts



- **Box like action/shear beam**
- **Building - story to story distortion**

Steel Moment Frame Construction

Steel Braced Frame Construction

Concrete Shear Wall Construction

Structural/Nonstructural Systems

Earthquake Response

- **Elastic response**
 - **Modes of vibration**
 - **Ground motion input**
 - **Amplification**
 - **Damping**
- **Inelastic response**
 - **Ductility**
 - **Distortion/hinging**
 - **Permanent deformation**

Earthquake Effects Beam Hinging Model

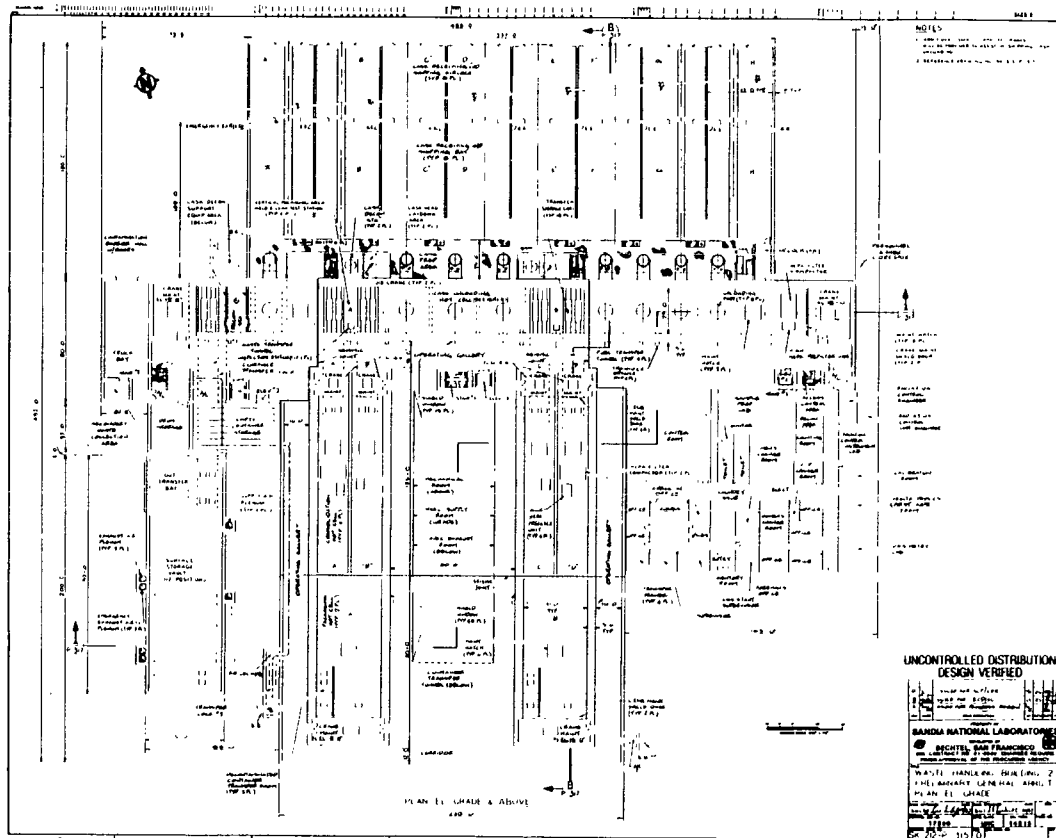
Beam Hinging Damage

Shear Wall Damage

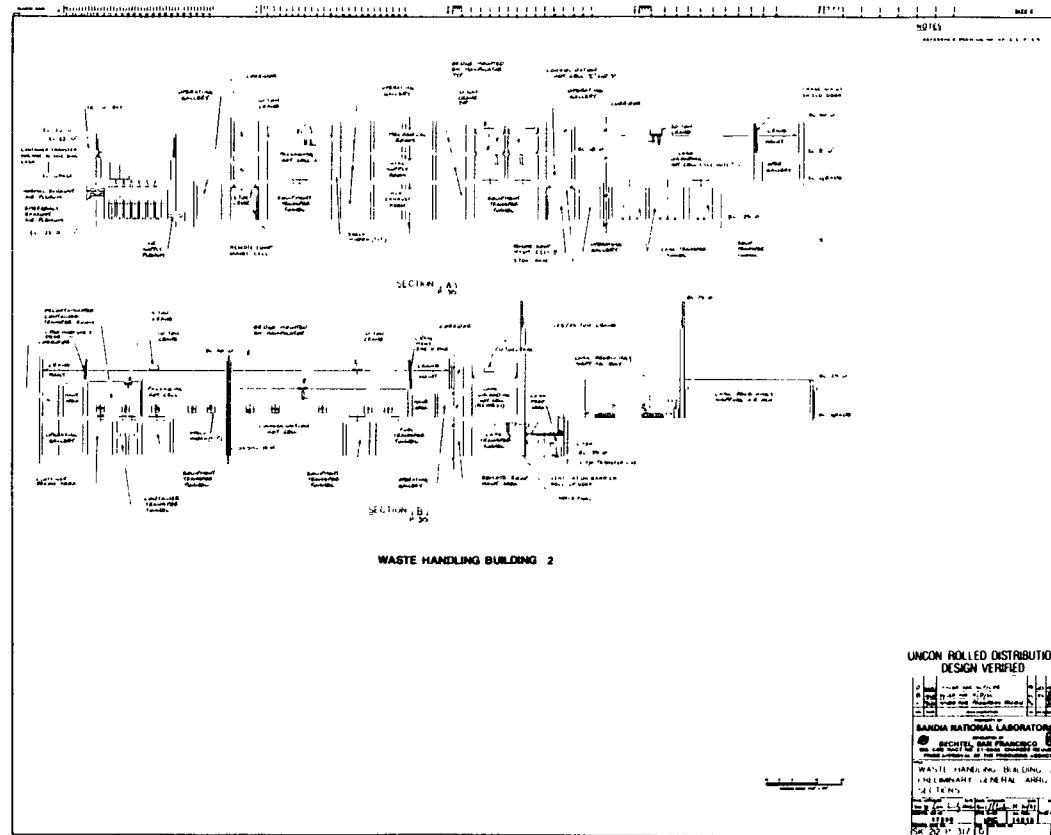
Waste Handling Building Concept

- **Three story reinforced concrete shear wall building**
- **Partially buried**

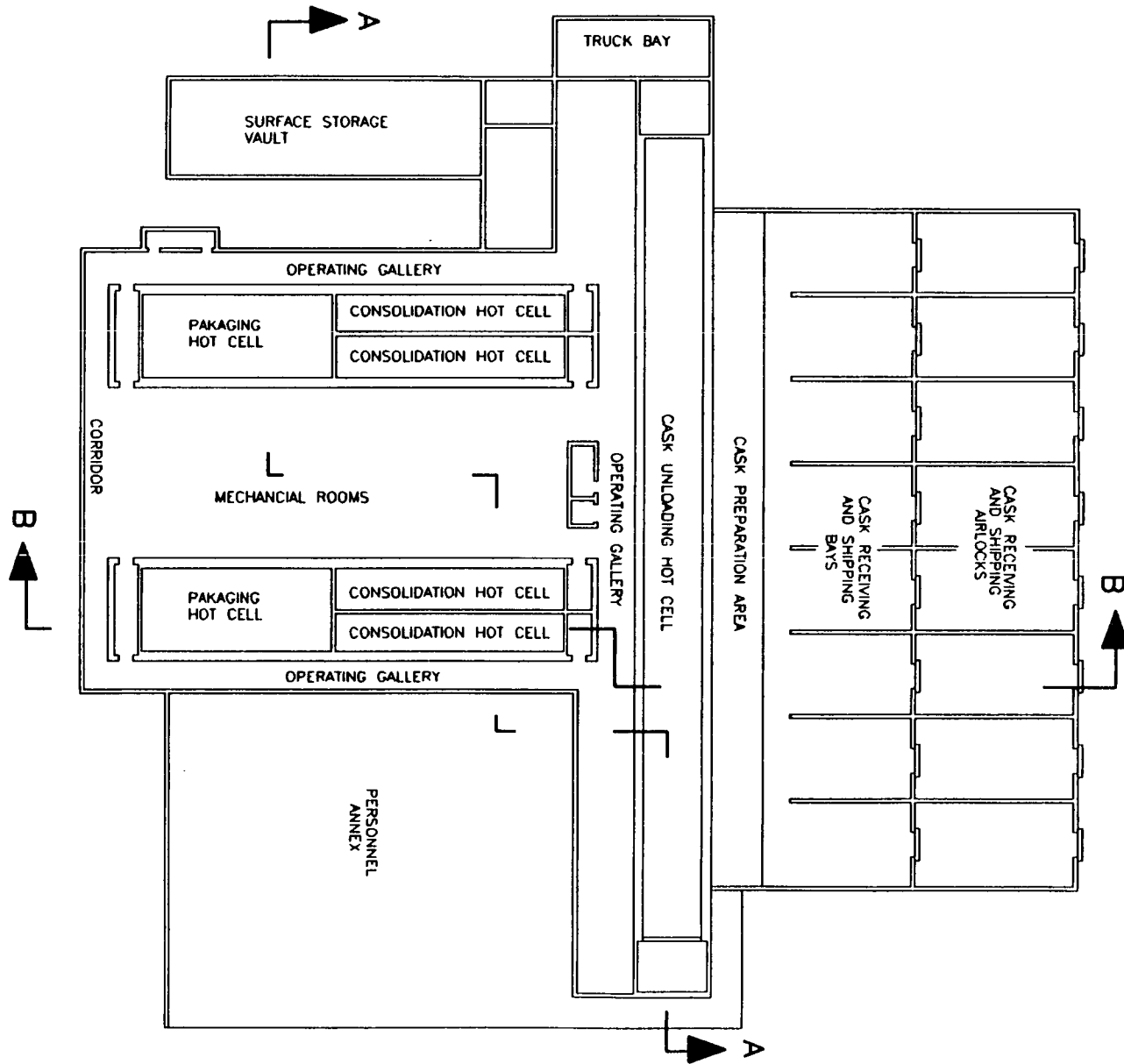
WHB 2 - Plan

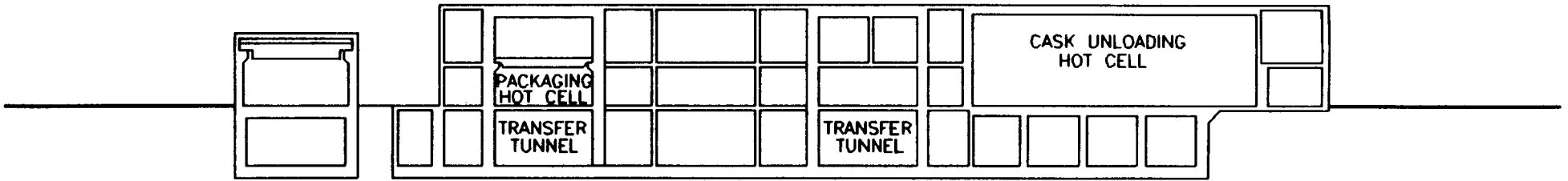


WHB 2 - Sections

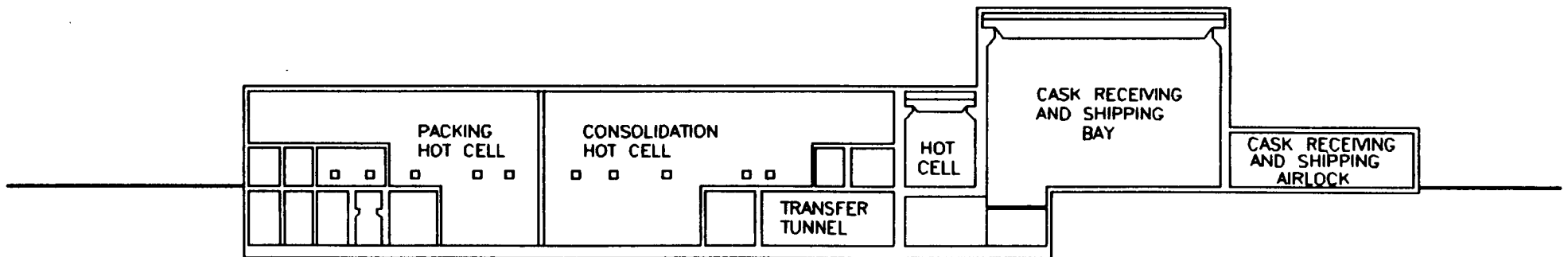


Waste Handling Building 2





SECTION A-A



SECTION B-B

Design Criteria Issues/ Current DOE Practice

- **Categorization/classification of buildings**
 - **Use/occupancy**
- **Risk levels**
 - **Input**
 - **Resistance**
- **Analysis Requirements**
 - **Elastic analysis**
 - **Soil-structure interaction**
- **Documentation**

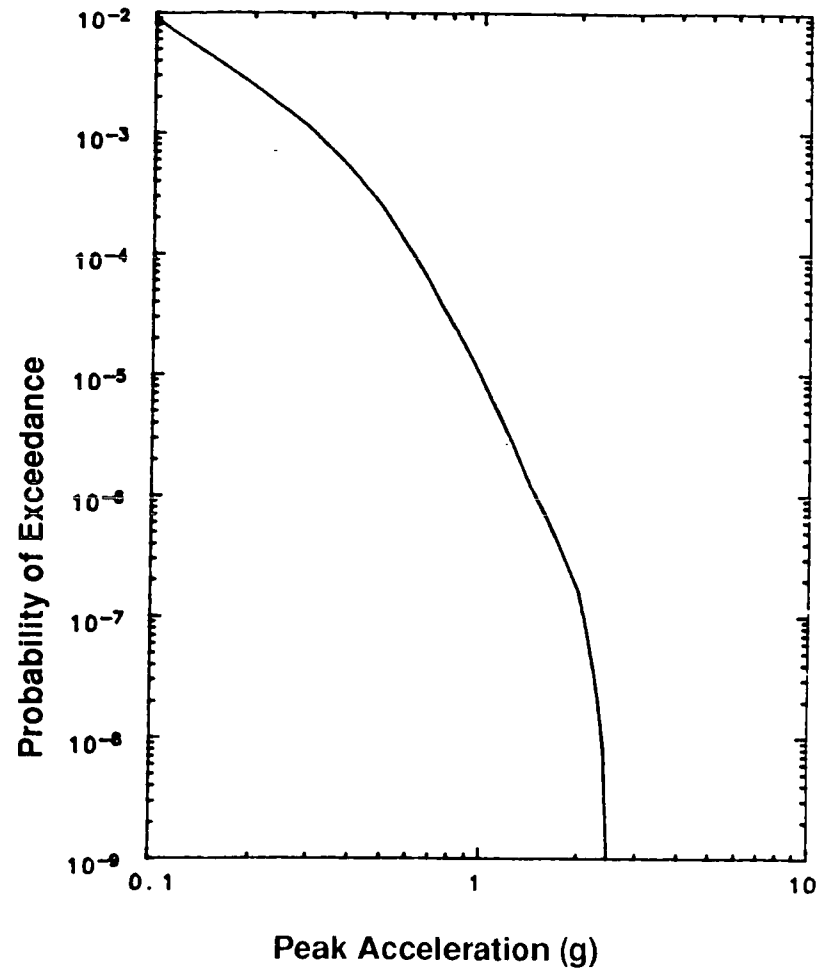
DOE Practice Performance Goals

Usage Category	Performance Goal	Hazard Exceedence Probability	Ratio of Hazard to Performance Probability
General Use	1×10^{-3}	2×10^{-3}	2
Important or Low Hazard	5×10^{-4}	1×10^{-3}	2
Moderate Hazard	1×10^{-4}	1×10^{-3}	10
High Hazard	1×10^{-5}	2×10^{-4}	20

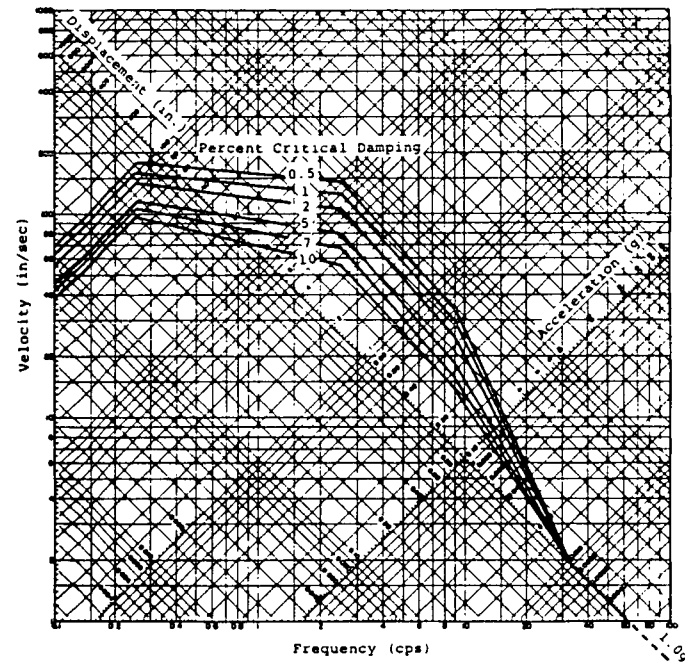
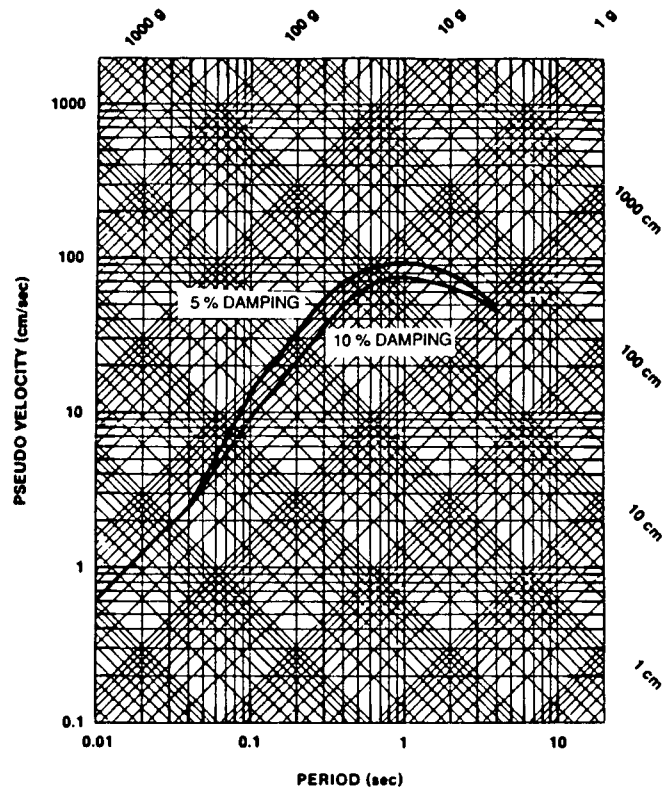
Site Specific Input

- **Probability of peak ground acceleration**
- **Design response spectra**
- **Definition of vertical ground motion**
- **Underground nuclear explosions**
- **Effects of local fault rupture**

Risk of Ground Shaking Peak Horizontal Acceleration

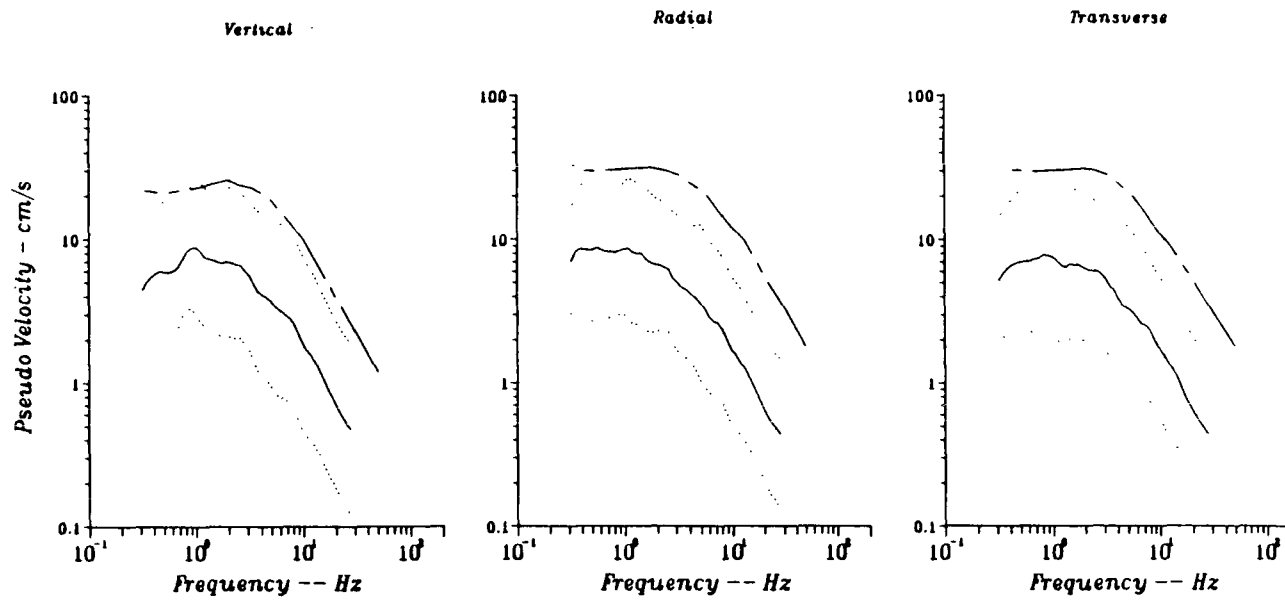


Design Response Spectra



UNE Vibratory Ground Motion

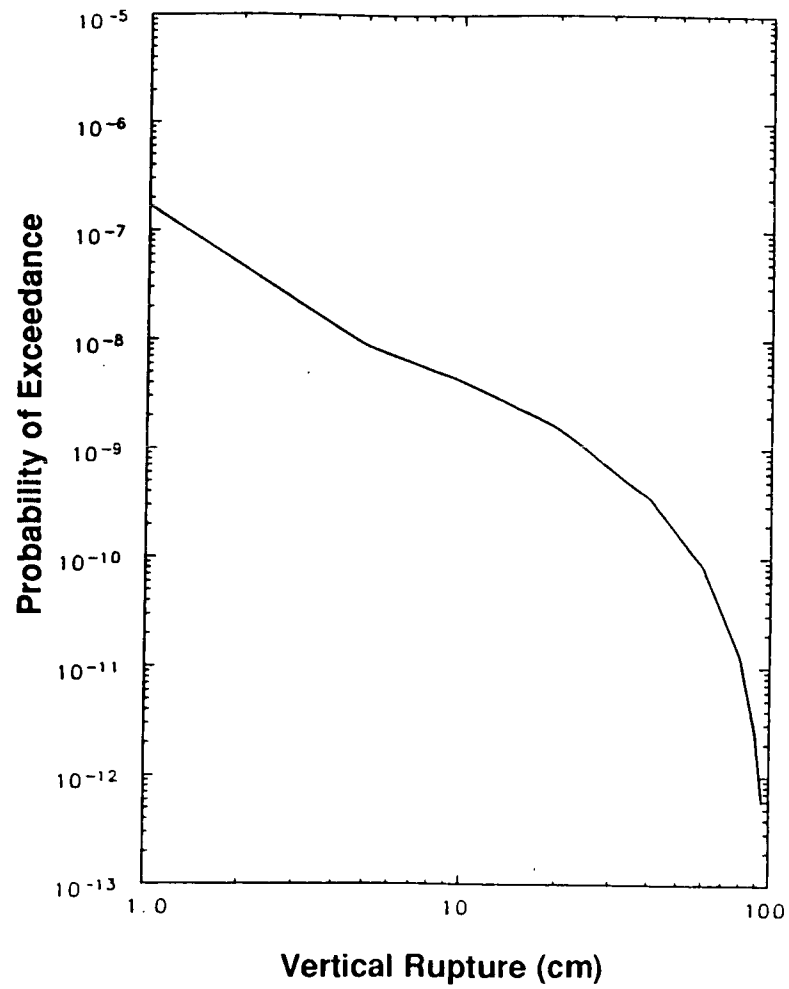
RADIOACTIVE WASTE MANAGEMENT



LEGEND

- UNE Best Estimate
- UNE 2σ Bounds
- URS/Blume Earthquake Estimate

Risk of Faulting



WHB Design for Vibratory Ground Motion

- **Design criteria vs. level of conservatism**
- **Analysis**
- **Structural resistance**
- **Ductility issues**
- **Regularity**
- **Effects of embedment**

Design for Local Fault Rupture

- **Issues**
 - **Displacement**
 - **Strength**
 - **Limiting force**
 - **Effect of embedment**
- **Estimated level of resistance**
 - **Vertical 1.0 to 2.5 inches**
 - **Horizontal 5 to 15 inches**
- **Mitigative measures**

Mitigative Measures in Design for Local Fault Rupture

- **Direct approach**
 - **Determination of orientation/ limiting forces**
 - **Strength**
 - **Ductility**
- **Modularization of Structure**
 - **Location/orientation of joints**
 - **Design details for joints**
- **Isolation Techniques**
 - **Granular bedding**
 - **Crushable bedding**
 - **Trenches/clearance**
 - **Mechanical isolation**

Overview of Experience - Heavy Industrial Facilities in Past Seismic Events

- **Ferndale/Eureka** 1954
- **El Centro** 1979
- **Borah Peak** 1983
- **Chile** 1985
- **Armenia** 1988
- **Loma Prieta** 1989

Summary and Conclusions

- **Seismic environment issues**
 - Data needs
 - Conservatism in current reports
- **Current concept**
- **Design approach**
- **Design issues**
 - Design for vibratory ground motion - analysis vs. conservatism
 - Design for fault rupture