# Seismic Safety and Life Safety Consideration

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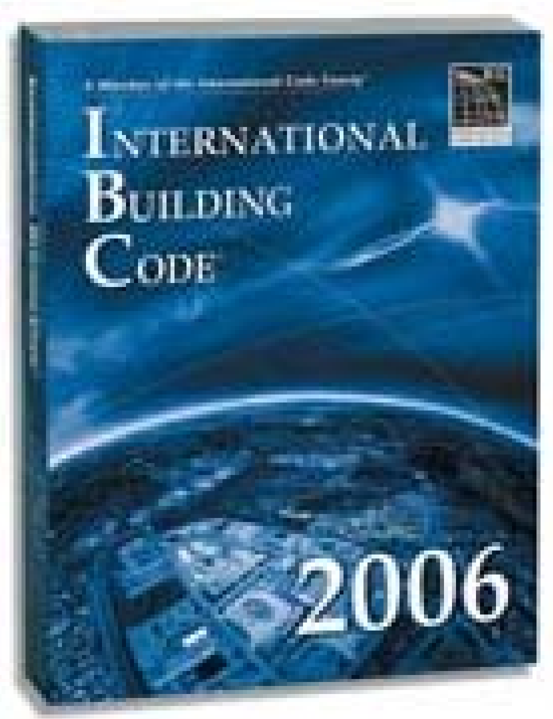
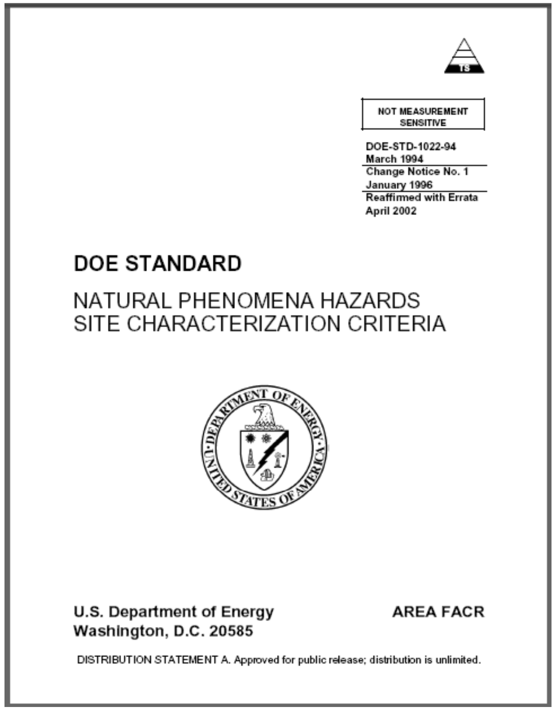
# Seismic Codes

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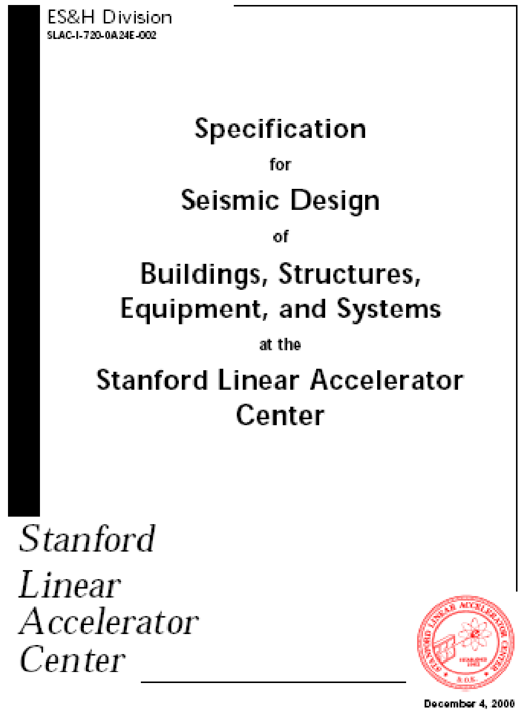
ES&H Division
SLAC-I-720-0A24E-002

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.**

# 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. Q: What set of requirement should we design to?

# 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

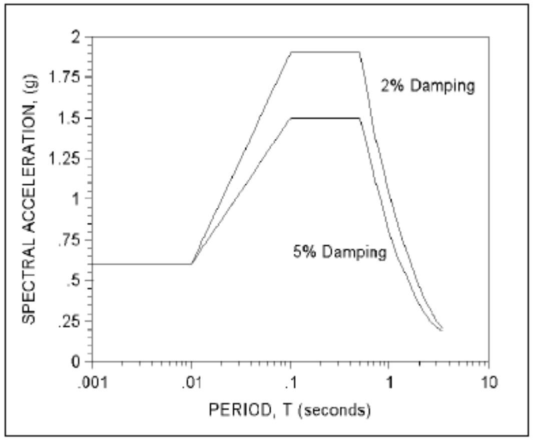


Figure 3. Response Spectra for Mechanical Systems - Horizontal Motions

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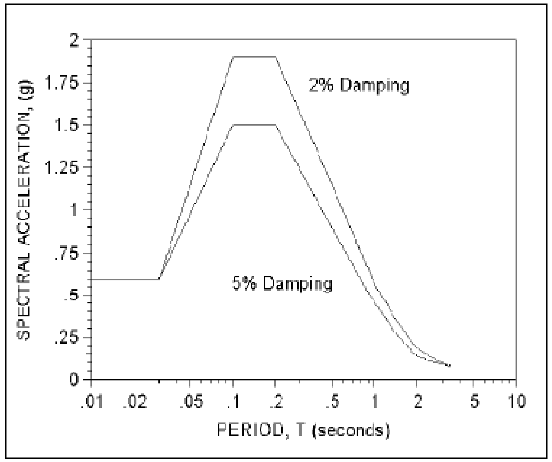



Figure 4. Response Spectra for Mechanical Systems - Vertical Motion

# Analysis Assumption

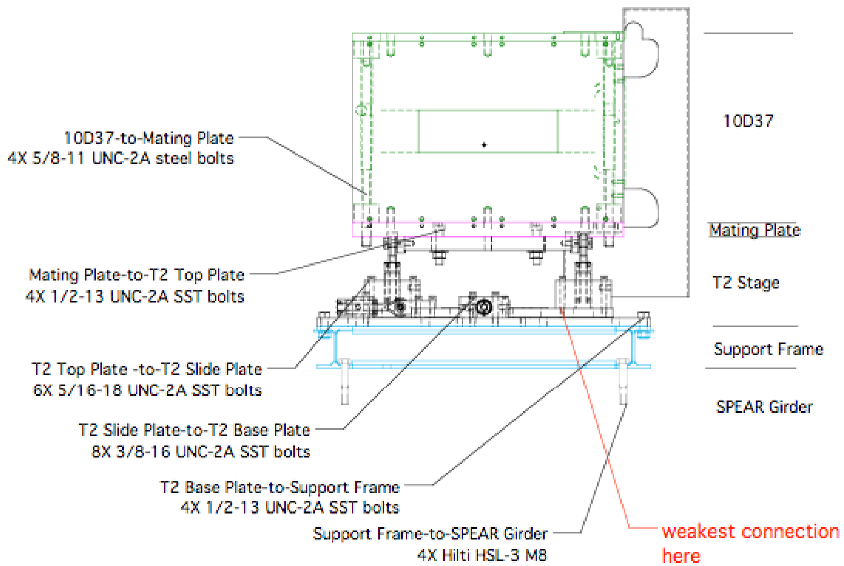
- **All support points receive identical excitation at each support**
  - This is rarely the case except for equipment having small support spacing
- **Structures founded on ground, seismic excitation is the result of propagation of seismic waves through the foundation material**
  - Implicit Assumption that Structural Foundations are Rigid and each point receives identical excitation
  - Reasonable assumption, provided structures having foundation plan dimension (L) small relative to the shear wave length ($\lambda s$)
- **When L/$\lambda$s is not small, the passage of Wave having finite wave lengths leads to support excitations differing in phase**
  - Such is the case for the ILC Beamline, Main Linac, Pipe line,

# Excerpts from ILC-ESA Seismic Analysis for 10D37 Chicane Magnets (Ray Arnold/SLAC-Nov.06)

## 1. Design Performance Requirements

The ILCESA Test Experiments T474, T475, and T480 will employ a system of magnets, microwave beam positio monitors (BPM's), wire scanners (WS and related equipment in End Statior A to perform tests of components for use in design of the planned International Linear Collider (ILC). The magnets and beamline components will be mounted on concrete girders decommissioned from SPEAR 2. The task of this analysis is to show that the design for the magnet supports satisfies the requirements.

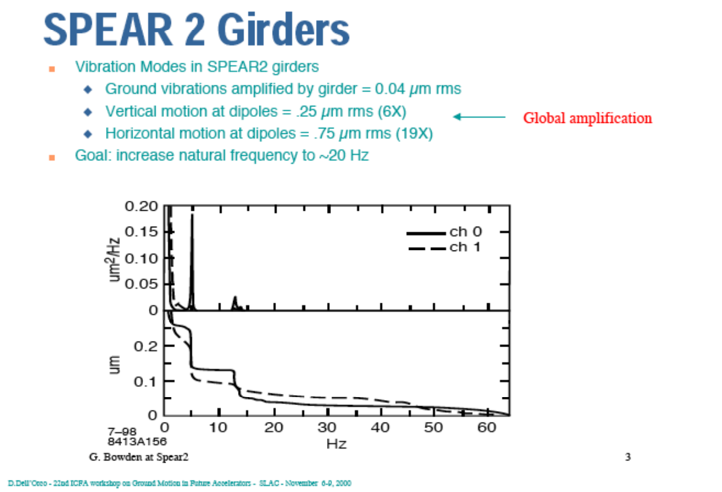
10D37 and Support -- Components and Connections

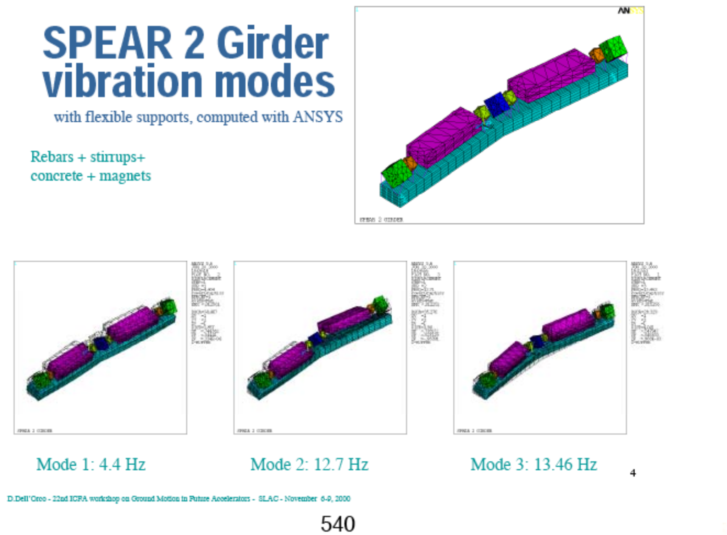


# Excerpts from ILC-ESA Seismic Analysis for 10D37 Chicane Magnets (Ray Arnold/SLAC-Nov.06)

Analysis of SPEAR 2 Girders

In preparation for design of the girder supports for the SPEAR 3 upgrade, the designers measured the vibrations in the SPEAR 2 girders and performed and analysis (Ref. 5) with ANSYS of the SPEAR 2 configuration. The SPEAR 2 configuration is similar to our design, with 10D90 dipoles (4 times the mass of the 10D37 in our design), quads and sextupoles mounted on the same type of magnet supports we plan to use. The measurements showed strong vibration modes around 4 Hz and 12 to 13 Hz, which were also found in the model. The model considered rebar, concrete, magnet mounts, and magnets, and assumed that the SPEAR girder support was flexible. In our case the girder support will be somewhat constrained to the base supports by the seismic bracing. Nevertheless it is likely that our configuration will also have significant vibration modes with T > 0.06 Sec.



# Excerpts from ILC-ESA Seismic Analysis for 10D37 Chicane Magnets (Ray Arnold/SLAC-Nov.06)

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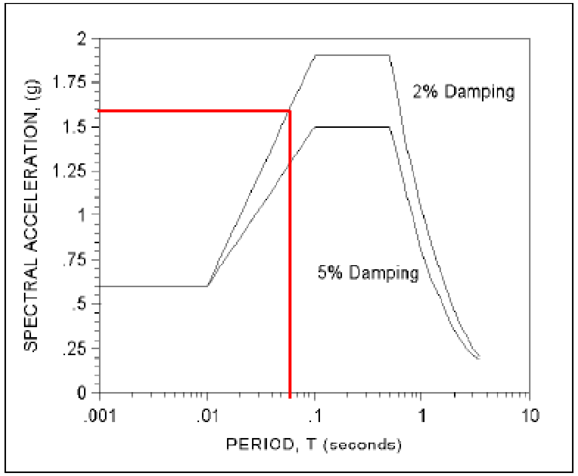


### Base Shear Stress for Horizontal Acceleration of Combinations of Components

Base shear V = 1.54Wp　　　　ga = 1.54

| Components | Mass (lbm) | Base Shear V (lbf) | Note | Anchors N | Shear per anchor Demand (lbf) | Shear per anchor Allowable (lbf) | Demand Factor Allowable/ Demand |
|---|---|---|---|---|---|---|---|
| 10D37+T2 top | 2688 | 4139.5 | 1 | 6 | 689.9 | 4456 | 6.5 |
| 10D37+Stand | 2732 | 4207.3 | 2 | 4 | 1051.8 | 3361 | 3.2 |

Notes:

1 - 5/16-18 SST bolts  Allowable shear Fv = 0.4*Fy , Fy = 4,456　　4456.0

2 - Hilti Anchors HSL-3 M8　　Maximum allowable shear (lbf) =　　3361.0
Reduction factor spacing > 6.75 in　　1.0
Reduction factor edge distance > 4.375 in　　1.0

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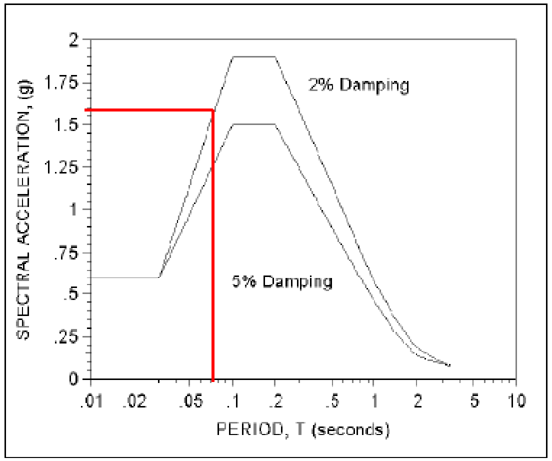



Figure 4. Response Spectra for Mechanical Systems - Vertical Motion

### Base Tension Stress for Vertical Accleration of Combinations of Components

Vertical Force = -Wp + 1.54Wp = 0.54Wp　　ga = 0.54

| Components | Mass (lbm) | Base Tension (lbf) | Note | Anchors N | Tension per anchor Demand (lbf) | Tension per anchor Allowable (lbf) | Demand Factor Allowable/ Demand |
|---|---|---|---|---|---|---|---|
| 10D37 + T2 top | 2688 | 1451.5 | 1 | 6 | 241.9 | 2228.0 | 9.2 |
| 10D37+Stand | 2732 | 1475.3 | 2 | 4 | 368.8 | 2139.0 | 5.8 |

Notes:

1 - 5/16-18 bolts　　Max Allowable tension derated x0.5 for bolt to Al　　2228.0

2 - Hilti Anchors HSL-3 M8　　Maximum allowable tension (lbf) =　　2139.0
Reduction factor spacing > 6.75 in　　1.0
Reduction factor edge distance > 4.375 in　　1.0

# Life Safety Issues

## Regulation:

- Because there are no existing laws and standards in any region which directly and comprehensively stipulate the safety measures for a facility like ILC,
- the currently planned safety measures are based on examples of existing accelerator tunnels and the regulations for buildings and underground structures of various types.
- The final plan will be subject to the approval of the competent authority that has jurisdiction over the selected site.

# Life Safety Issues

***Safety category and respective requirements:***

- Fire Safety
  - **Fire safety measures are the main subject to be considered by CFS group.**
- Radiation Safety and Safety Access Control
  - **Wall thickness for shielding radiation from Beam Tunnel is  determined according to studies by radiation control experts.**
  - **Access control equipment such as a card lock is installed at the entrances to the radiation control areas as required by the radiation safety plan.**
- Helium
  - **The helium supply system is equipped with an oxygen meter which activates an alarm and stops the gas supply in case of oxygen deficiency. Air in the Beam Tunnel is automatically pressurized.**
- Other Safety Control

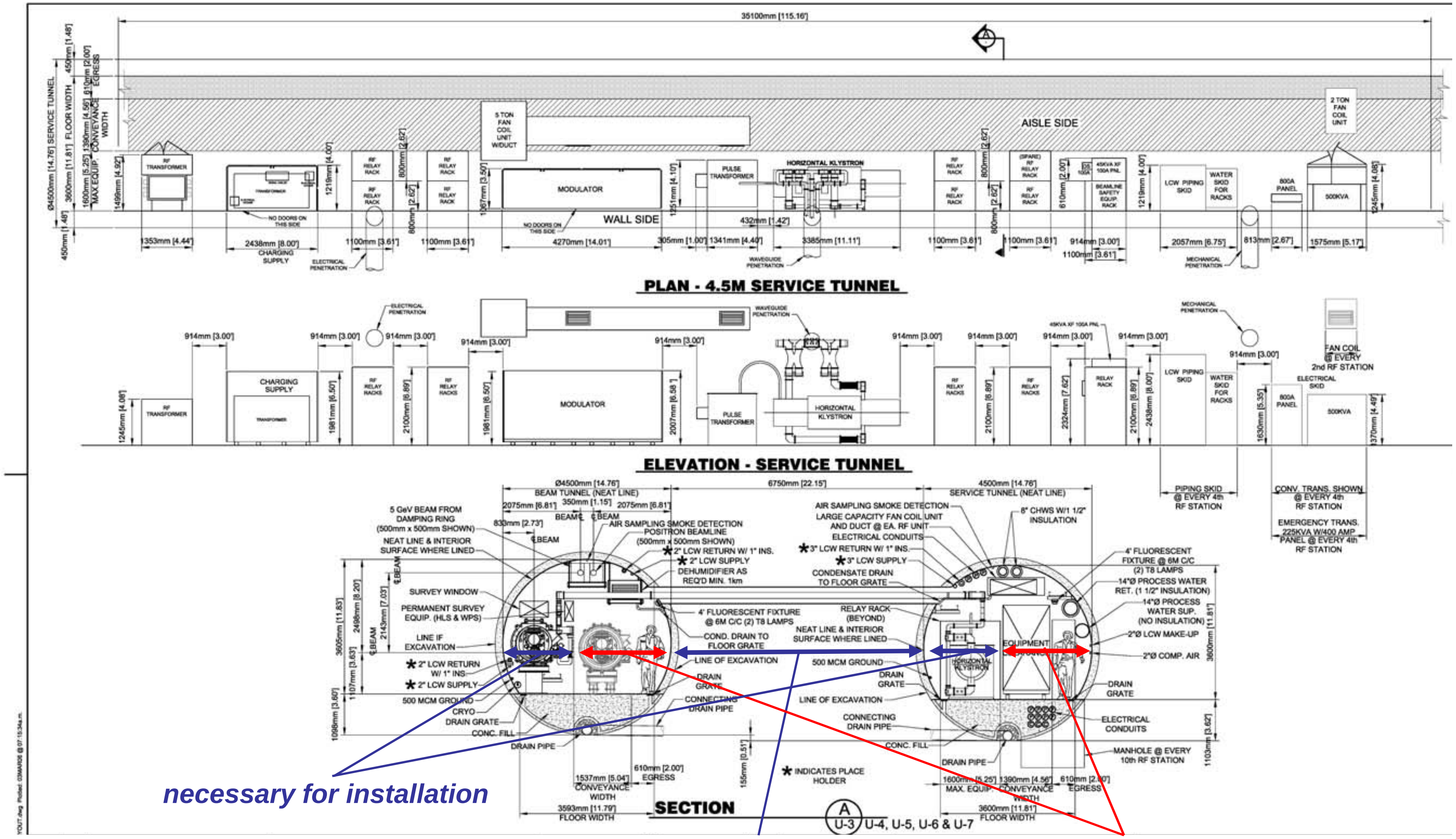
# Life Safety Issues

## *Fire Safety Requirements:*

- Structures of tunnels and caverns
  - **Primary concern. Enough space and smooth path for evacuation**
- Safety Equipments
  - **Smoke detector, fire alarm, fire extinguisher, etc.**
- Smoke Exhaust or Control
  - **To have enough time to escape**
- Materials
  - **Incombustible cable, etc., to prevent spread of fire.**

- Existing guideline and regulations of LHC will be a good example, if ILC finally takes deep tunnel scheme.
- Anyway the final plan will be subject to the approval of the competent authority that has jurisdiction over the selected site.

# Evacuation Space in Accelerator Tunnels




*necessary for installation*

*~1.5 x tunnel diameter,*
*necessary for excavation,*
*enough for radiation shield*

*necessary for maintenance,*
*emergency egress*

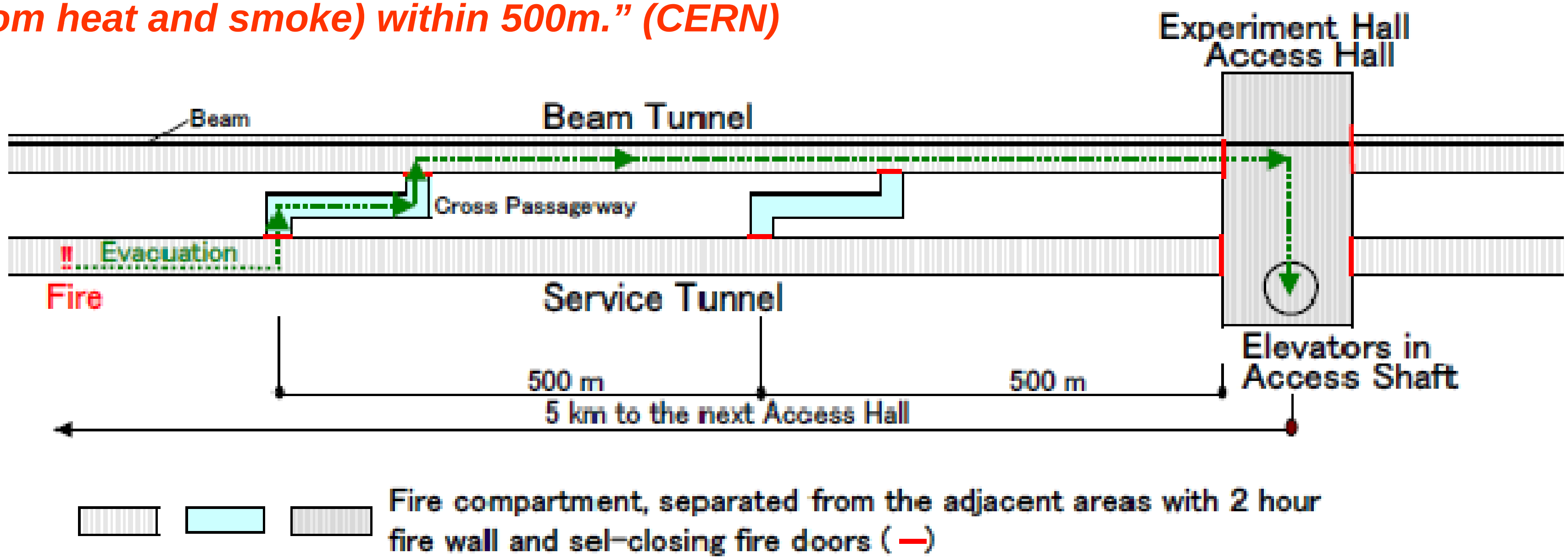
# Life Safety Issues

## Evacuation Path :

### Evacuation from Service Tunnel

1. Potencial fire origin is power cables in the Service Tunnel
2. People in the Service Tunnel evacuate to the Beam Tunnel through Cross passageway
3. Cross Passageways are provided at an interval of 500 m
4. At walking speed of 1 m/sec., he may reach to cross passageway from the furtherest point in the Service Tunnel in about 8 min., torelable evacuation time

*"Access to a different fire compartment (isolated from heat and smoke) within 500m." (CERN)*



# Summary

- Seismic Regulations are well established
- Design criteria is site specific
- Minimum design criteria are set by the authority having jurisdiction for the compliance to the governing regulations (codes)
- 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.
- CFS is not responsible for seismic design of the ILC machine nor the detector.
- CFS is responsible for providing adequate foundation for the support of the detector and the machine. Thus, we need required seismic forces from the major subsystem to design and cost it.
- CF structures for evacuation space and path will be designed based on considerations of fire safety and earthquake.
- Smoke control will be taken into account in air ventilation system.
- General safety equipment, for example, that for fire safety, is included in CFS work.
- As for other safety requirements like radiation shielding will be mitigated accordingly.