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

NUCLEAR WASTE TECHNICAL REVIEW BOARD
PANEL ON STRUCTURAL GEOLOGY & GEOENGINEERING

SUBJECT: EFFECTS OF NUCLEAR TESTS ON TUNNELS

PRESENTER: JAMES S. PHILLIPS

PRESENTER'S TITLE AND ORGANIZATION: SENIOR MEMBER OF TECHNICAL STAFF
SPECIAL PROJECTS DIVISION
SANDIA NATIONAL LABORATORIES

PRESENTER'S TELEPHONE NUMBER: (505) 844-7275

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Tunnel Dynamics Experiment Objective

To correlate measured ground motions with observed tunnel damage

Description of the Tunnel Dynamics Experiment Tunnel

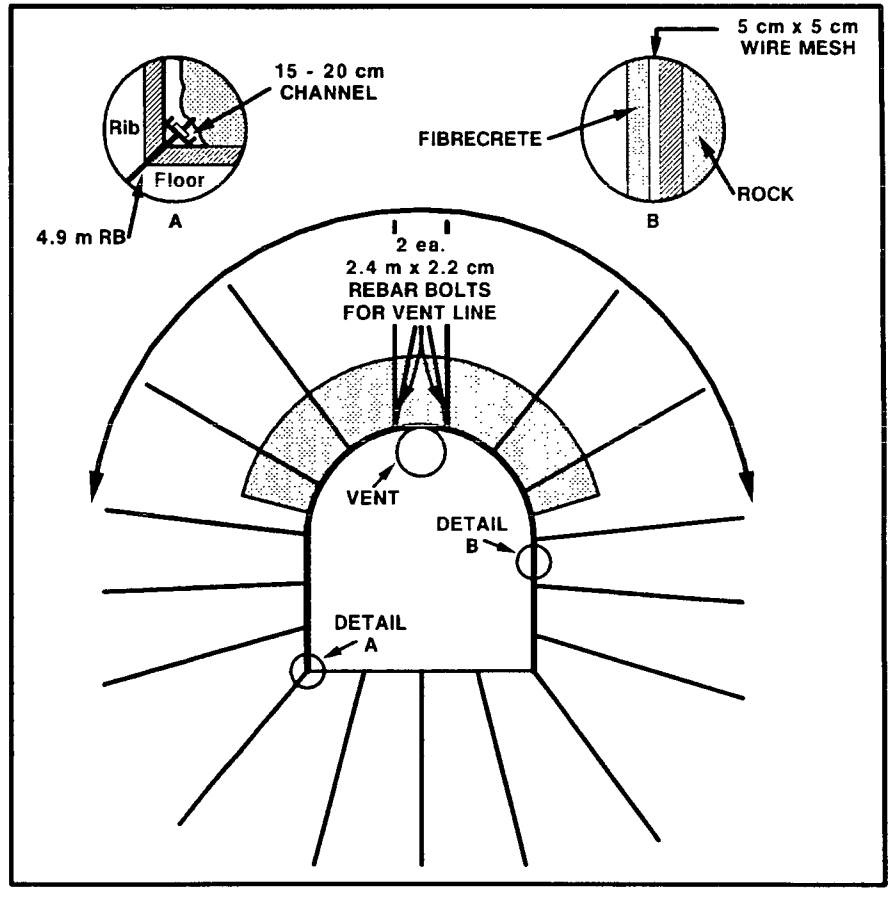
Dimensions - 6 m high x 5.8 m wide

4.9 m Lg x 2.9 cm ϕ RB's nominally spaced on 1.2 m centers

4 to 10 cm of fibercrete lining

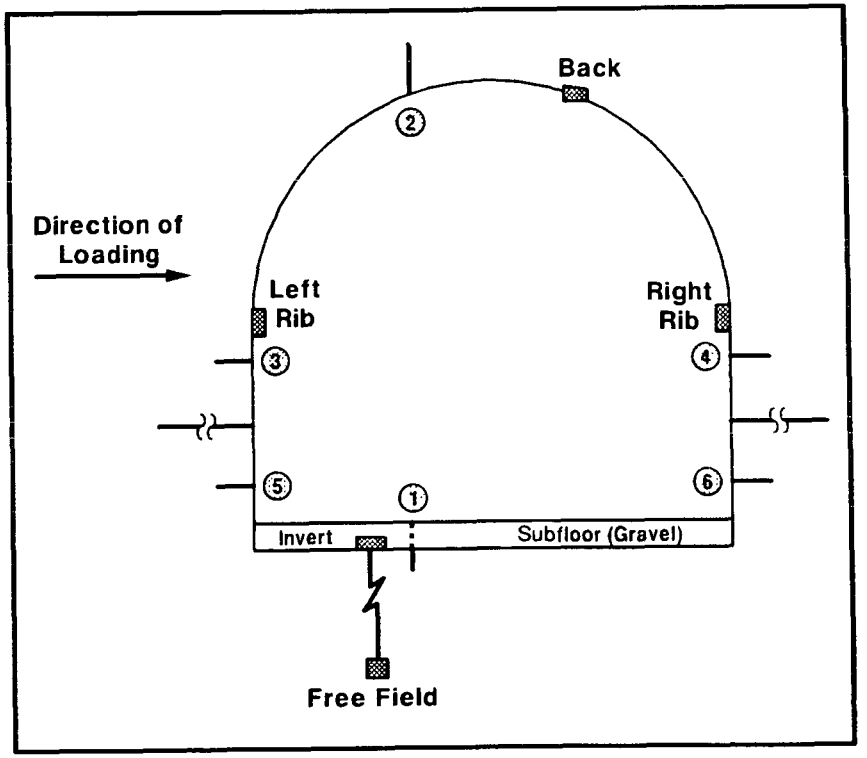
Host rock - nonwelded ashfall tuff-rock mass rating of 57

Tunnel axis approximately perpendicular to direction of loading



Description of the Tunnel Dynamics Experiment Measurements

12 m tunnel section
Triaxial acceleration measurements
Permanent displacements
Tunnel convergence
Borehole observations
Still & high-speed photography



Pre-test View Looking Toward Portal

SVNTJP5P.125.NWTRB/1-22/23-92

Post-test View Looking Toward Portal

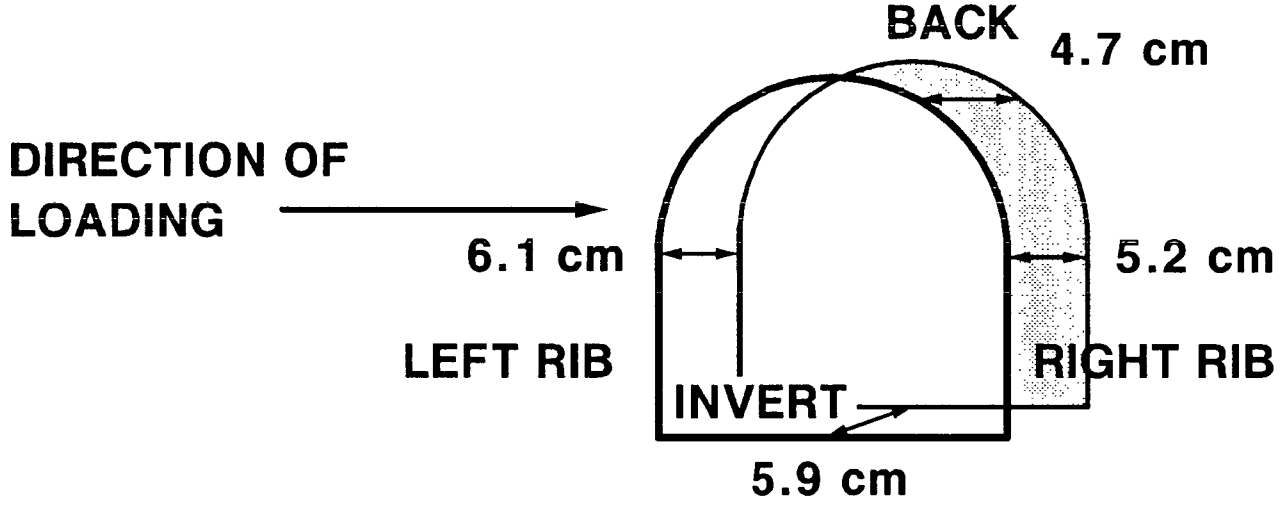
Pre-test View of Rib Farthest from Event

Post-test View of Rib Farthest from Event

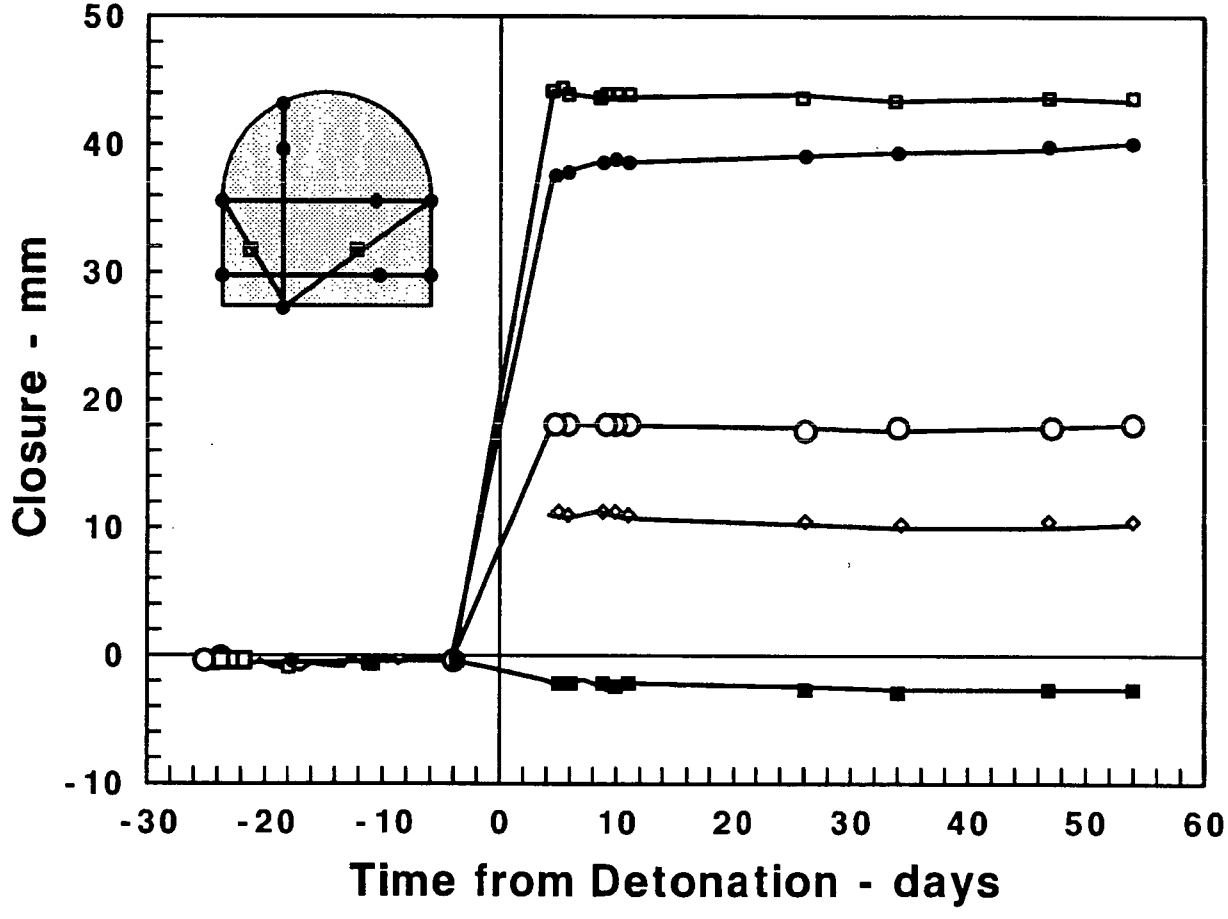
Pre-test View of Rib Closest to Event

Post-test View of Rib Closest to Event

Results from the Tunnel Dynamics Experiment Permanent Displacements



Results from the Tunnel Dynamics Experiment Tunnel Convergence Measurements



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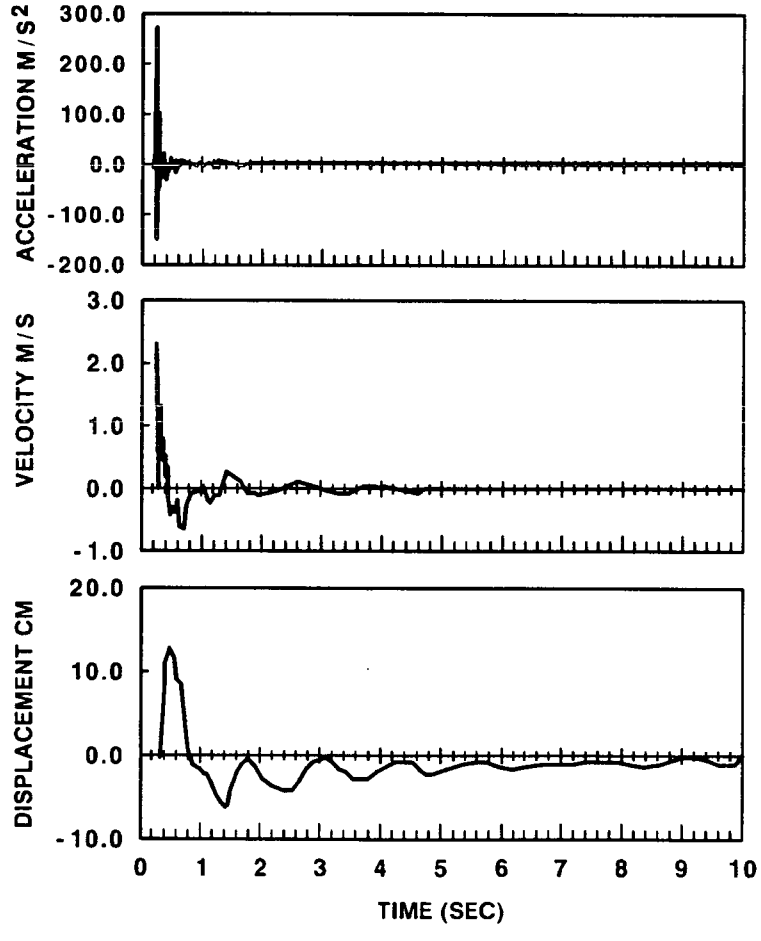
Results from the Tunnel Dynamics Experiment Radial Free-Field Ground Motions



Conclusions from the Tunnel Dynamics Experiment

- A self-consistent data set produced
- Only minor damage was observed
- Observed damage consistent with case histories in the literature

Question:

Are the results applicable to Yucca Mountain?
(Major differences in source, geology & ground motion levels)

Analysis

Source differences

- Compression dominated vs. shear dominated
- Duration of shaking
- Frequency content

Comments

- For wavelengths and tunnel dimensions of interest, tunnel behavior will be similar for both compression dominated and shear dominated wavefronts
- Duration of shaking within a factor of 2
- Frequency not important as long as wavelength/ tunnel diameter is large (i.e. > 8)

Analysis

Geologic differences

Repository: Moderately to densely welded ash-flow tuff - highly fractured

TDE: Non-welded, partially saturated ash-fall tuff

Comments

- RMR of repository rock → 61 & TDE → 57 implies that these dissimilar rocks are comparable in their rock-mass behavior
- Assuming RMR captures important aspects of dynamic behavior, strains induced by same loading in repository rock would be ~20% less than TDE - damage essentially the same

Analysis

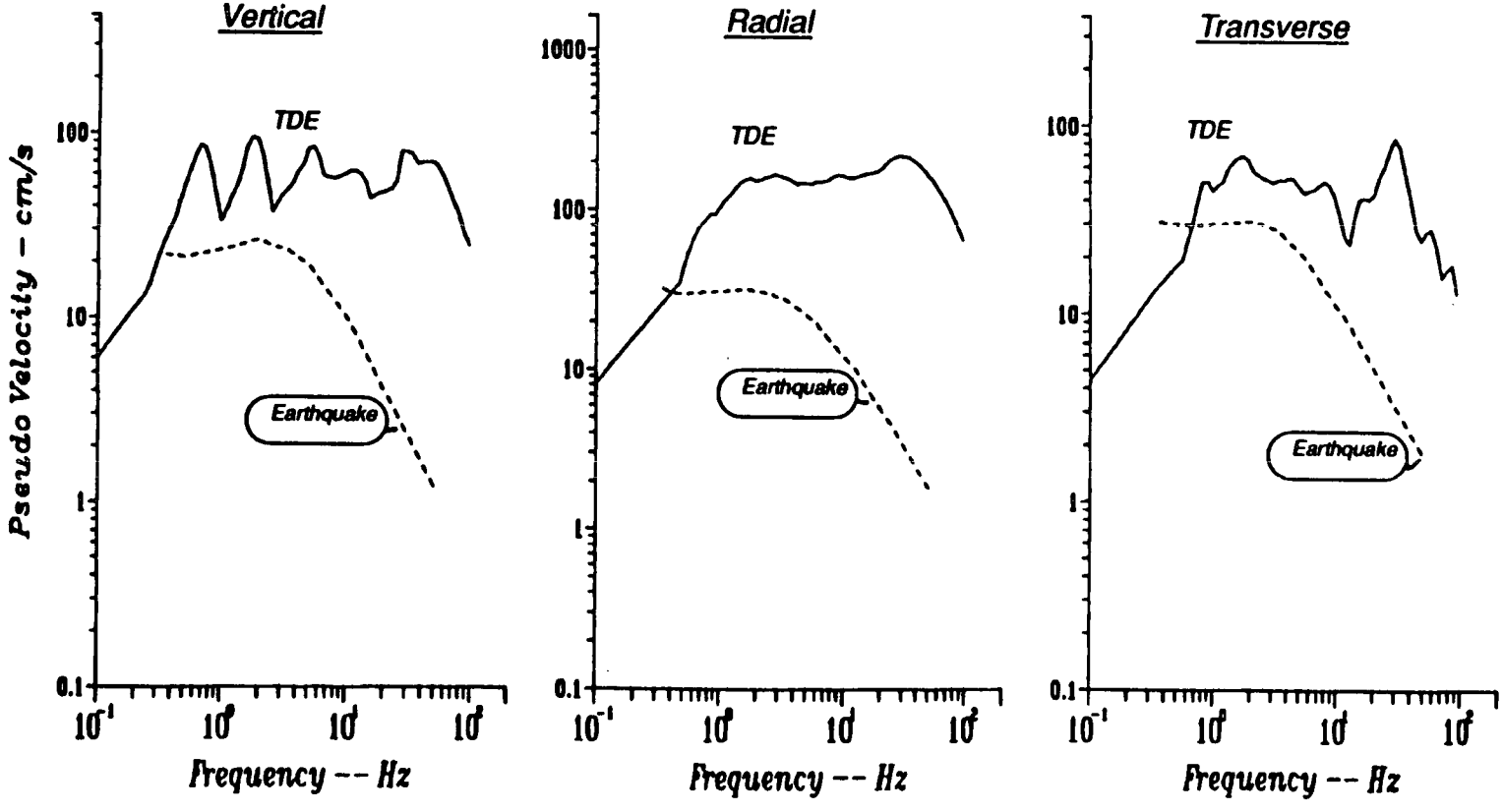
Design basis ground motions

- No design basis for repository tunnels yet - from RIB Version 4:
  - Design basis for exploratory shaft - ground motions of 0.3 g (vs. 28 g) and 0.3 m/s (vs. 23 m/s)
  - Design basis for other facilities - ground motions 0.4 g (vs. 28 g)

Comments

- Strains calculated from these motions order of magnitude less than TDE

Comparison of a Postulated Design Basis Earthquake and TDE Results



Conclusions

- TDE source stimulated a tunnel response similar to what might be expected in the near-field region of small-to-moderate (M_b = 5.0) earthquake
- Comparison of rock properties indicates a similar level of damage would have occurred in a tunnel constructed in the repository host rock subjected to same loading
- Ground motions used for design of repository tunnels likely to be much less than those observed in the TDE and can be accommodated in the design