

Sveučilište u Zagrebu

Građevinski fakultet

Diplomski sveučilišni studij

Smjer: **GEOTEHNIKA**

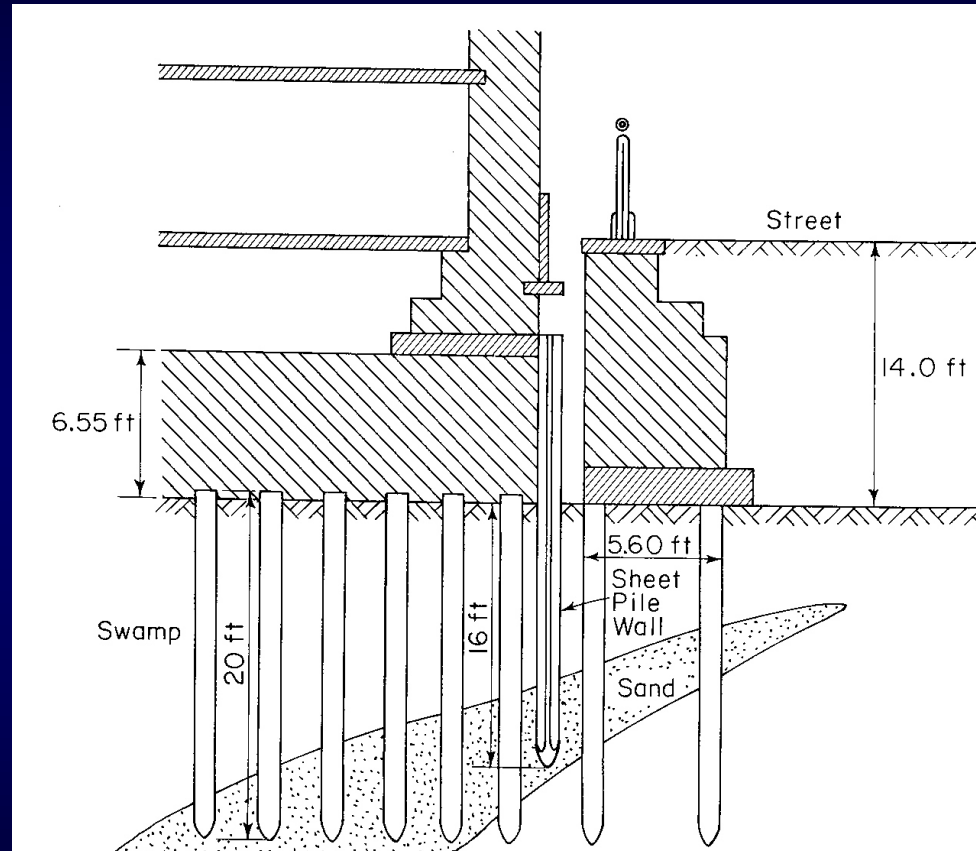
Geotehnika i zaštita okoliša 9

Prof. dr. sc. Tomislav Ivšić
Građevinski fakultet Zagreb

ZAŠTITA OD VIBRACIJA

IZVORI VIBRACIJA

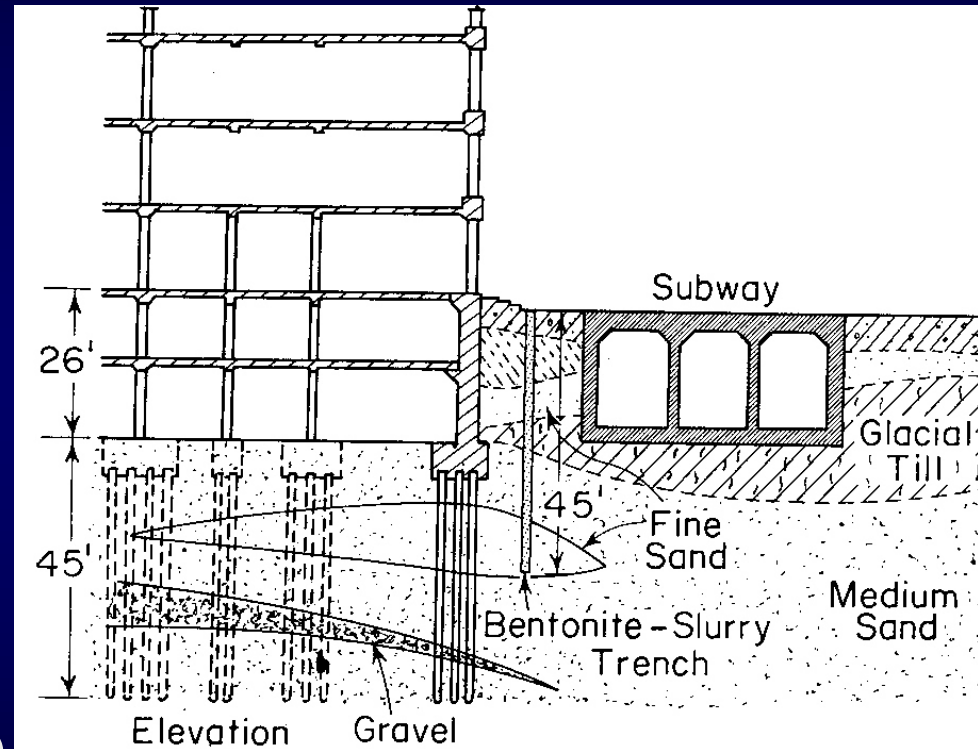
- Promet (ceste, željeznice – težina, brzina)
- Građevinski zahvati (vibronabijanje...)
- Industrija i energetika (razni strojevi)



ZAŠTITA OD VIBRACIJA

PROBLEMI UZROKOVANI VIBRACIJAMA

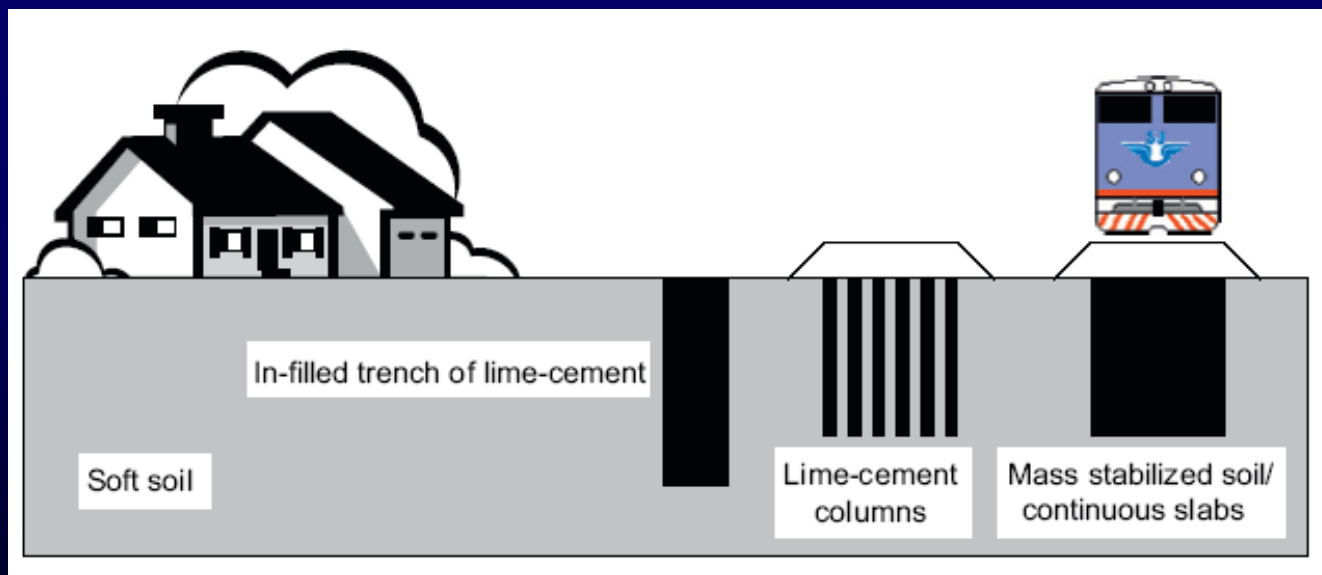
- Utjecaj na zgrade i druge građevine
- Utjecaj na instalacije
- Izazivanje neugode kod ljudi
- Oštećenja osjetljivih građevina (povijesni spomenici)
- Utjecaji na osjetljivu opremu (medicina, laboratoriji, komunikacije..)



ZAŠTITA OD VIBRACIJA

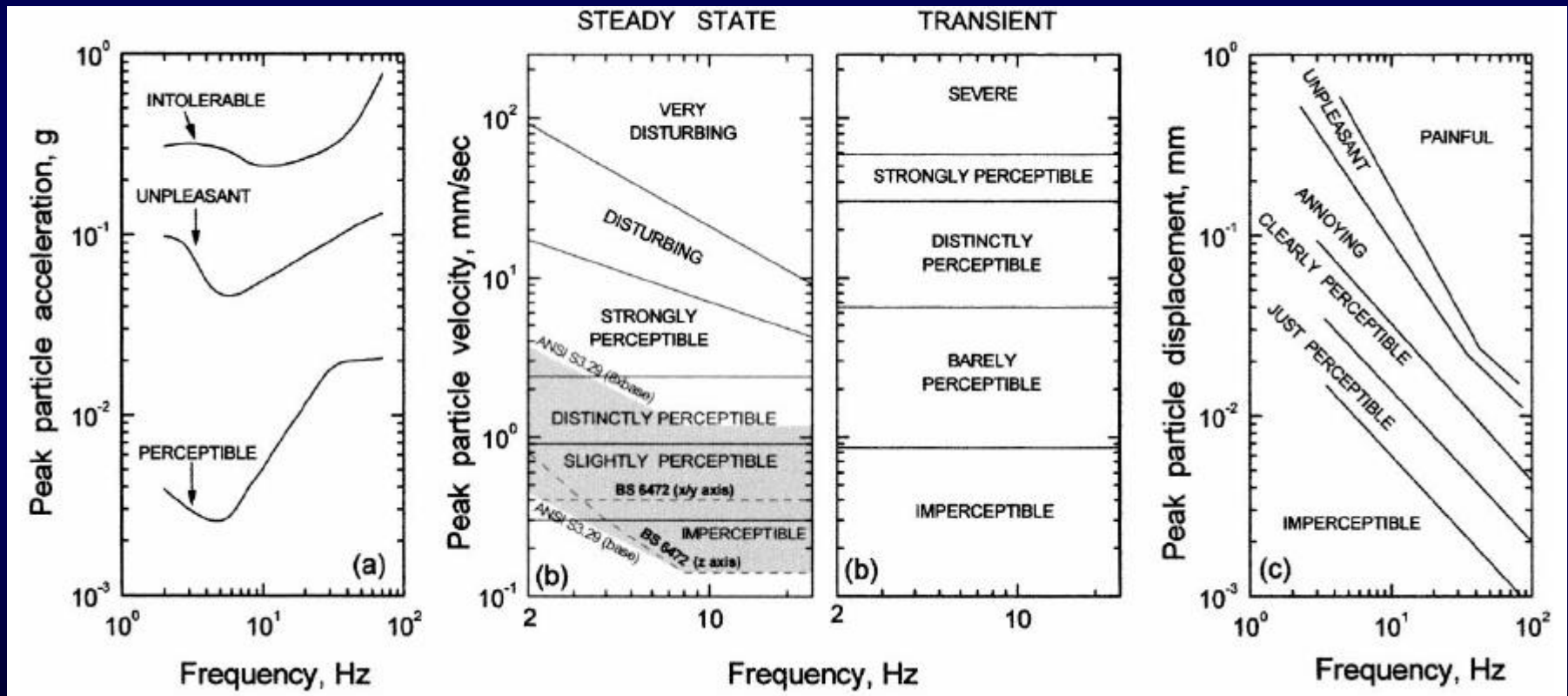
Osnovni koncepti zaštitnih mjera za redukciju vibracija

1. Na samom izvoru ili ispod njega (aktivna)
2. Zaklanjanje prostiranja valova na putu od izvora do izloženog objekta (zaslони, barijere)
3. Zaštitne mjere na samom objektu (pasivna)



ZAŠTITA OD VIBRACIJA

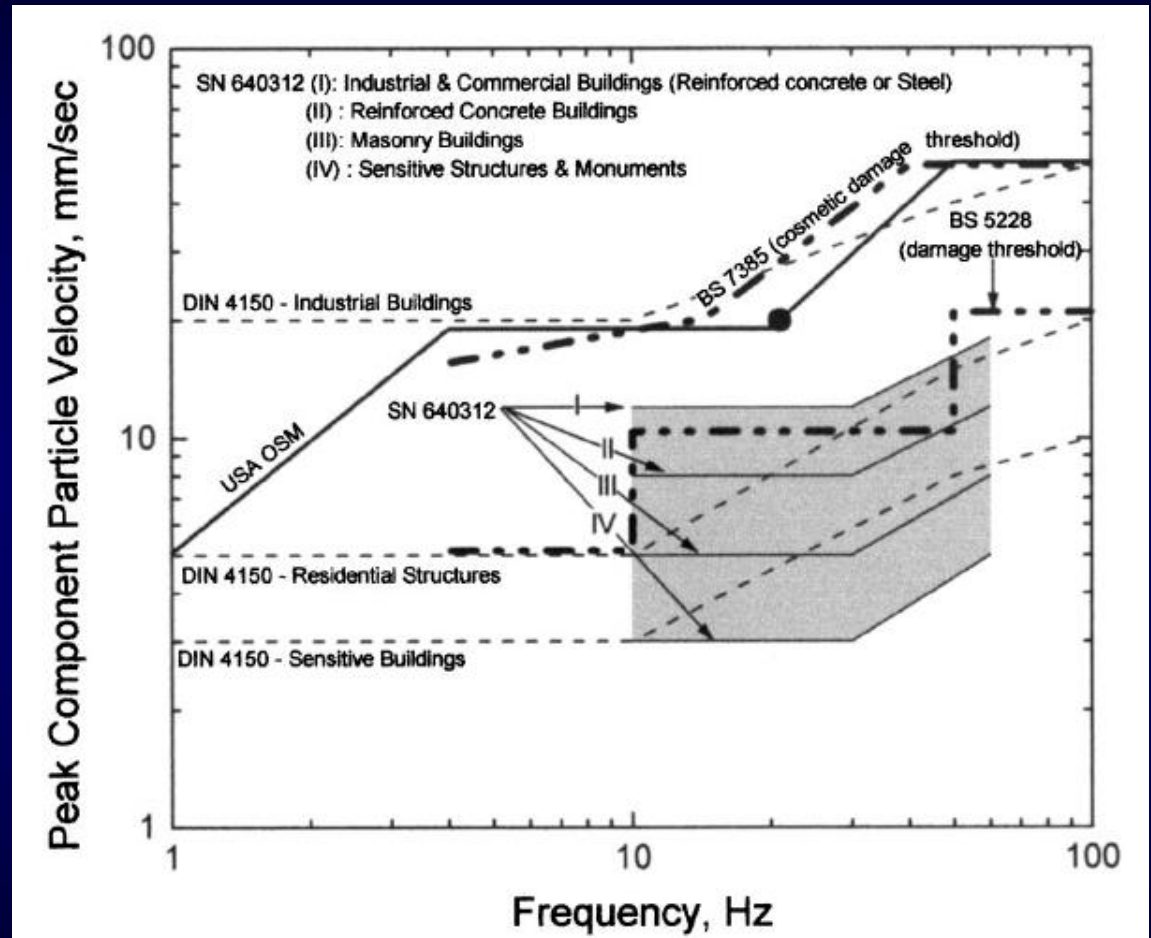
Kriteriji koje treba postići zaštitnim mjerama Opažanja ljudi i stupnjevi neugode



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**Kriteriji koje treba
postići zaštitnim
mjerama**

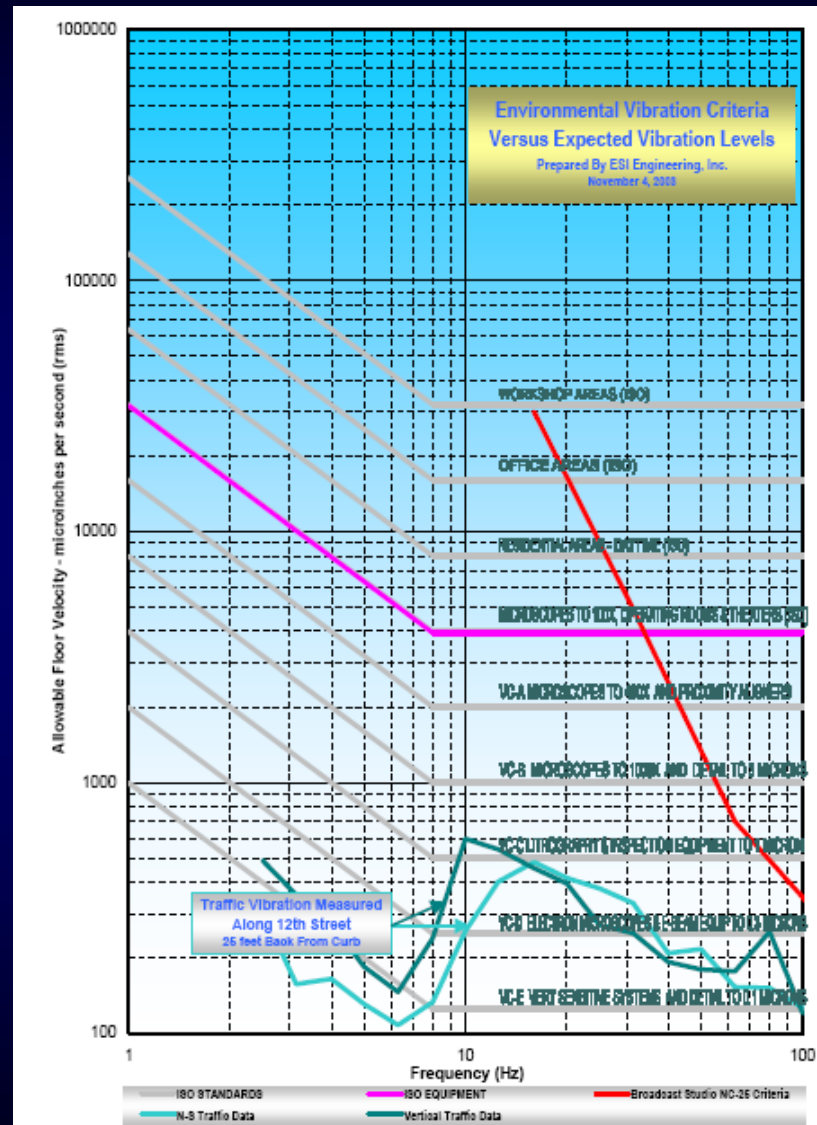
**Usporedba graničnih
vrijednosti za oštećenja
zgrada (razni propisi)**



ZAŠTITA OD VIBRACIJA

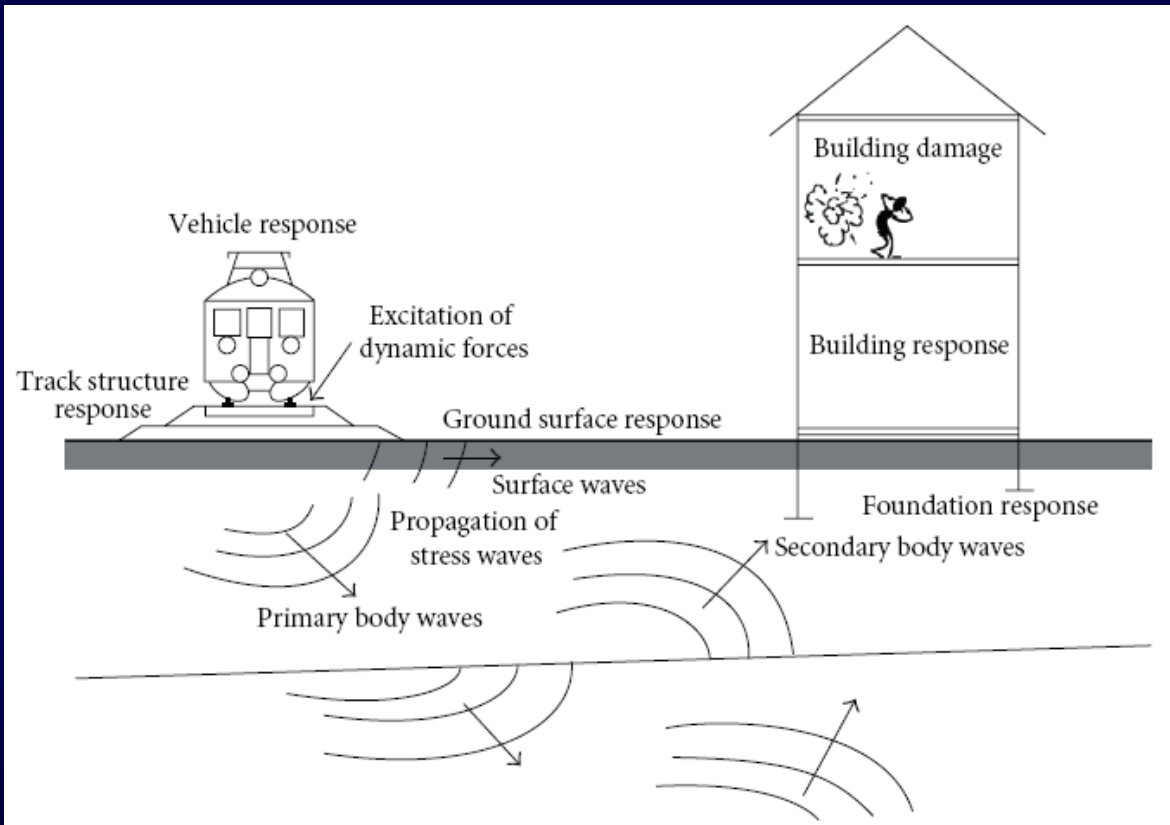
**Kriteriji koje treba
postići zaštitnim
mjerama**

**Usporedba graničnih
vrijednosti za prostorije
i opremu**



ZAŠTITA OD VIBRACIJA

Osnovni koncept prijenosa vibracija kroz tlo



VALOVI TLU

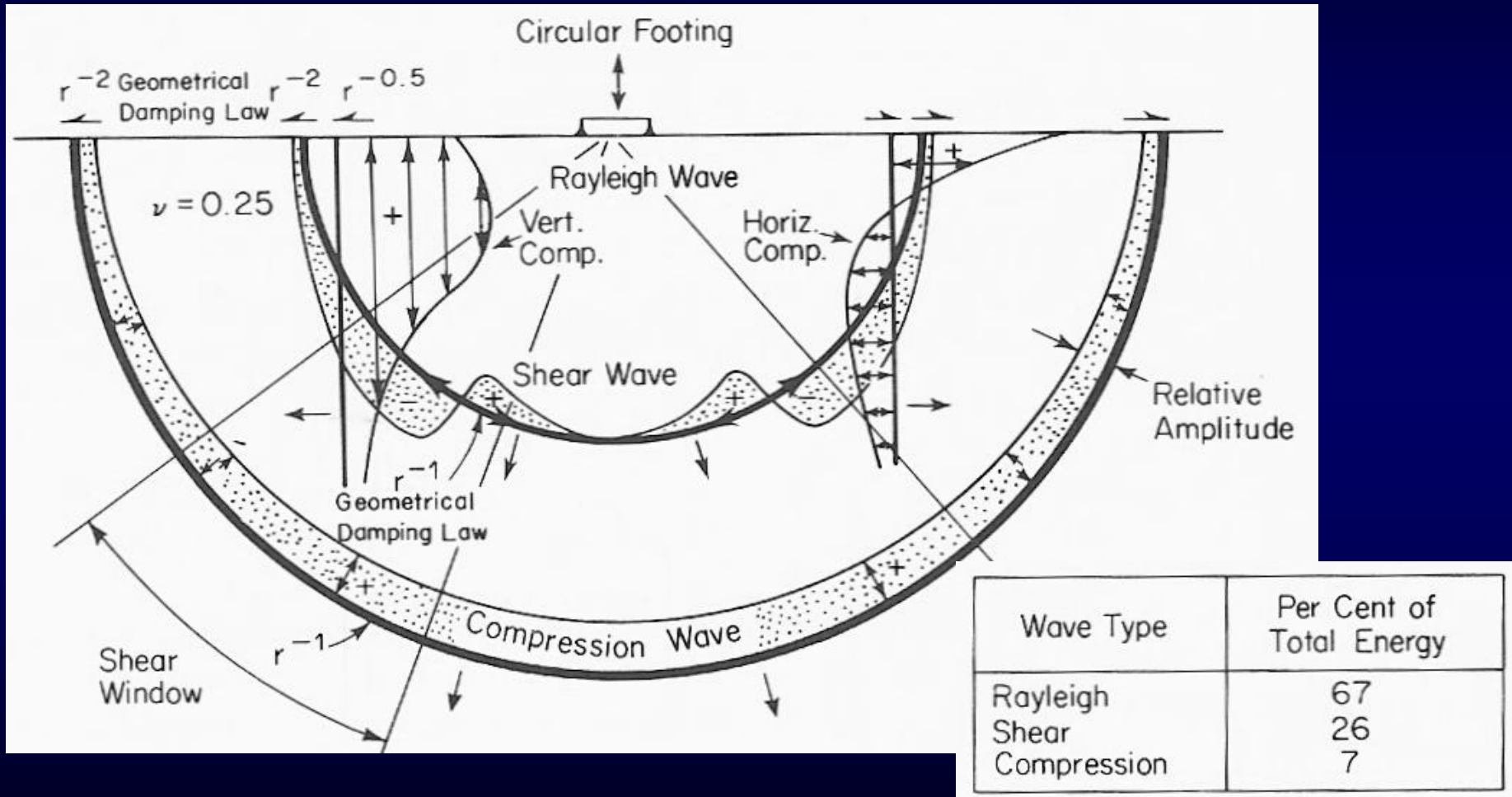
Body waves (P,S)
-uzdužni
.poprečni (SH,SV)

Površinski valovi

-Rayleigh
- Love

ZAŠTITA OD VIBRACIJA

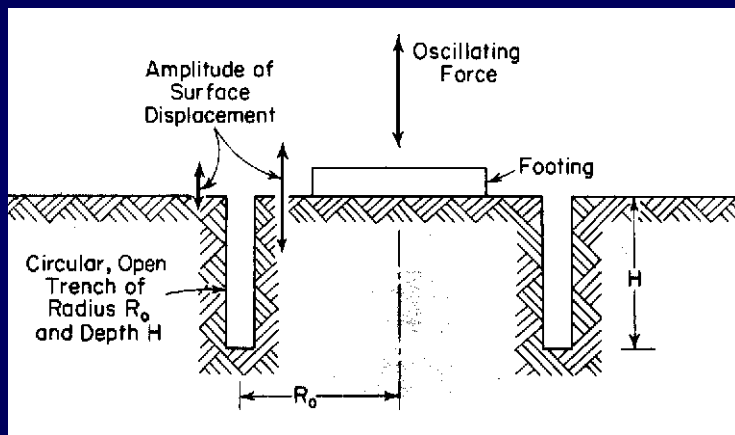
Osnovni koncept prijenosa vibracija kroz tlo



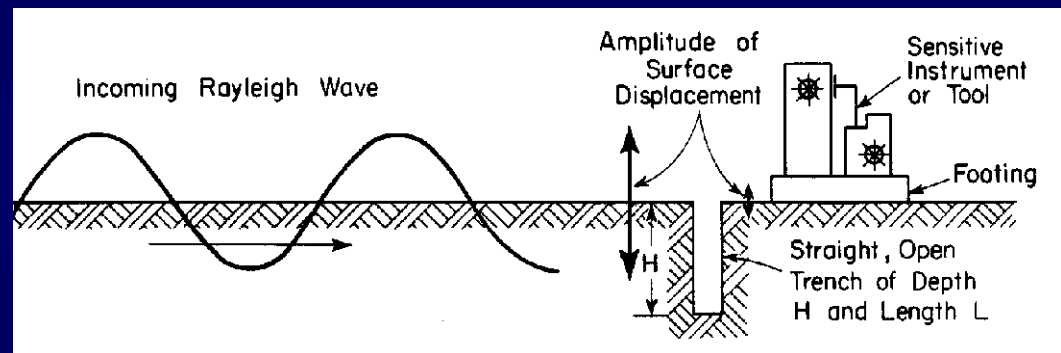
ZAŠTITA OD VIBRACIJA

Zaštitne barijere – rovovi, jarci

Aktivne

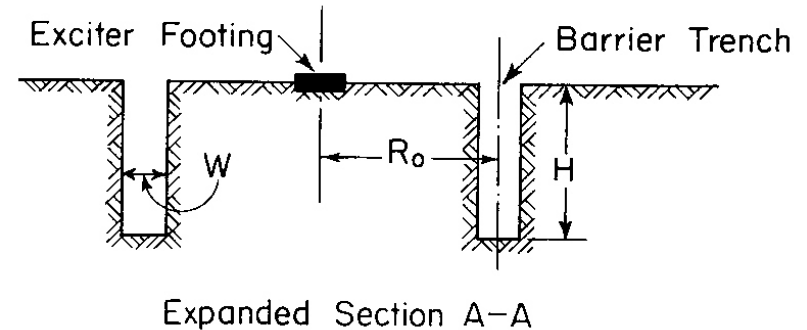
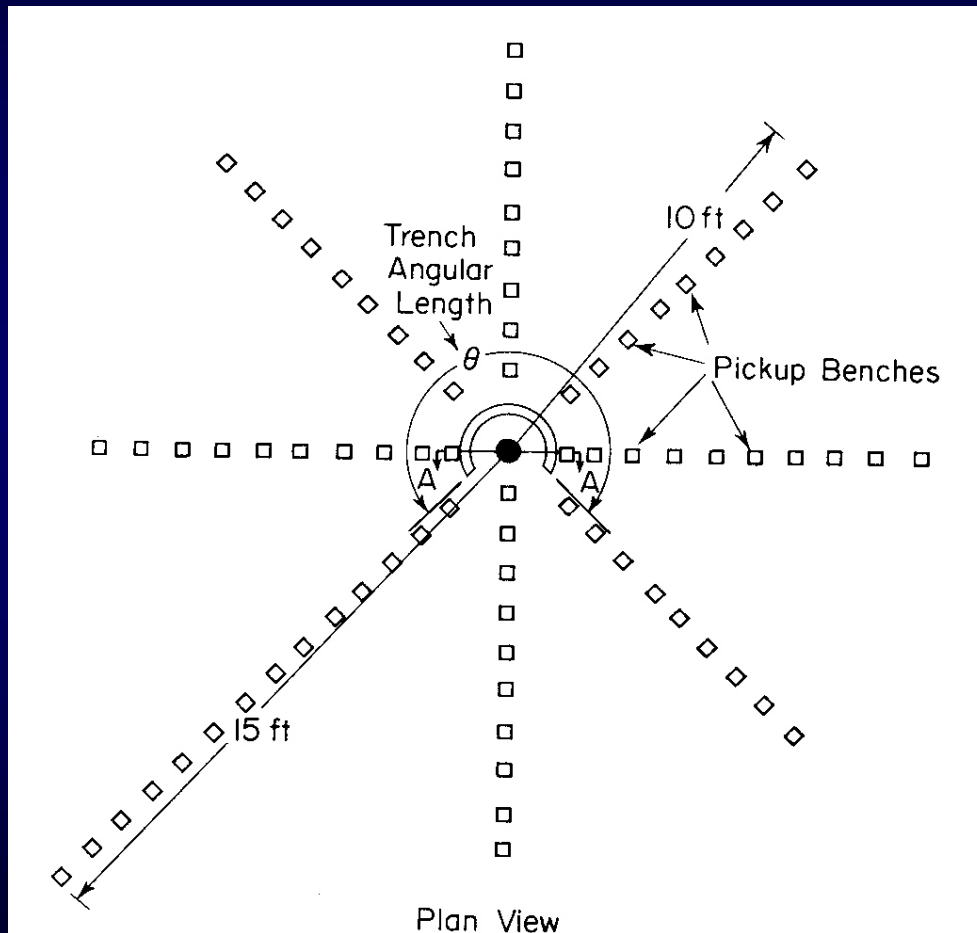


Pasivne



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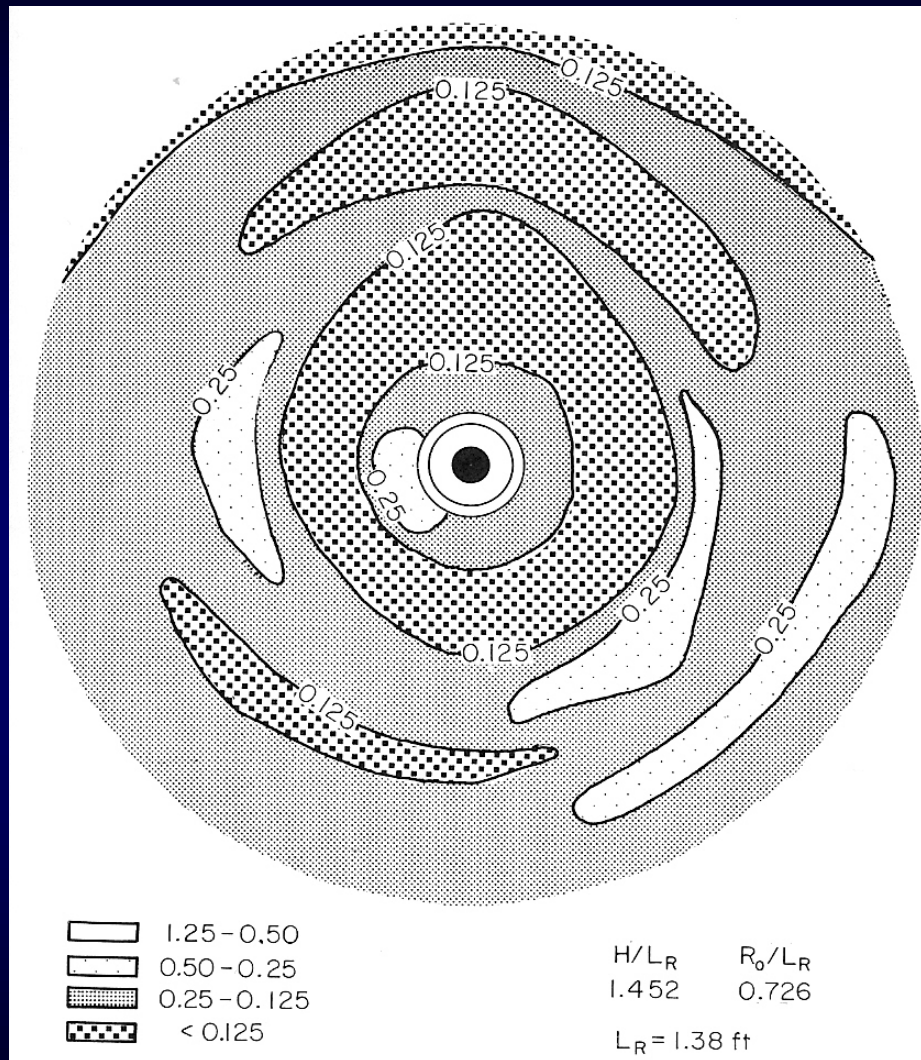
Mjerenja – širenje valova i učinak barijera



ZAŠTITA OD VIBRACIJA

Mjerenja – širenje
valova i učinak barijera

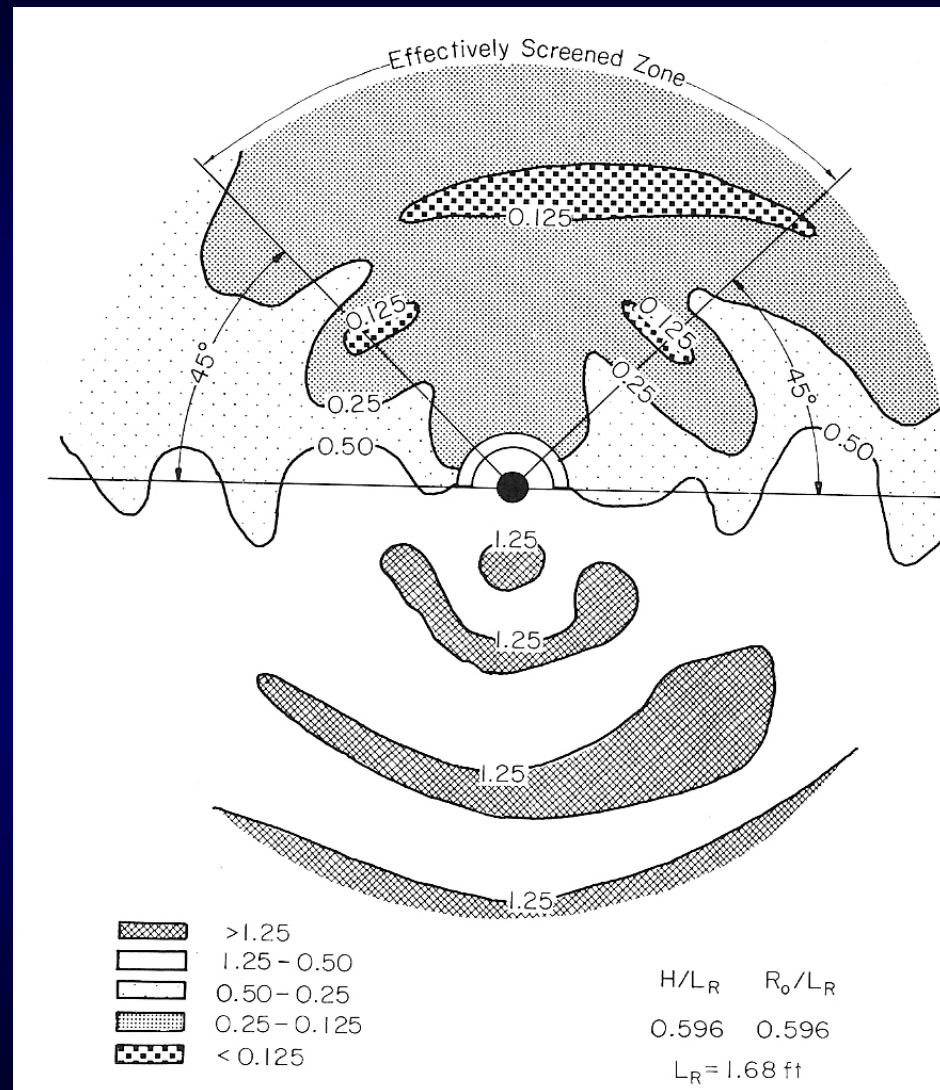
Puna zaštita oko izvora



ZAŠTITA OD VIBRACIJA

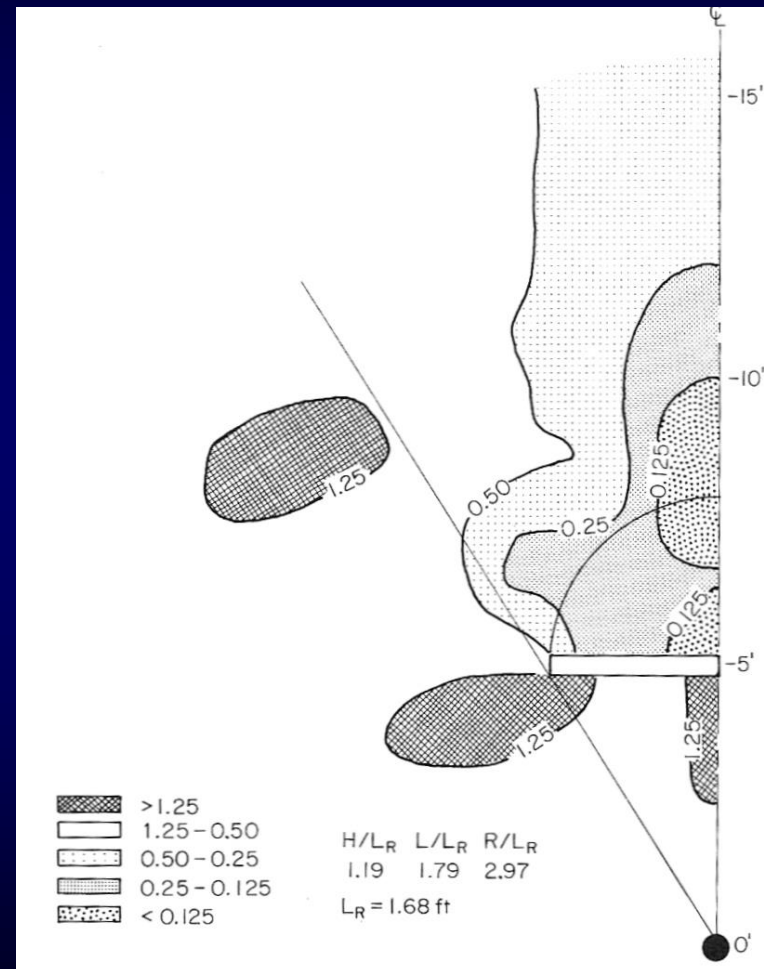
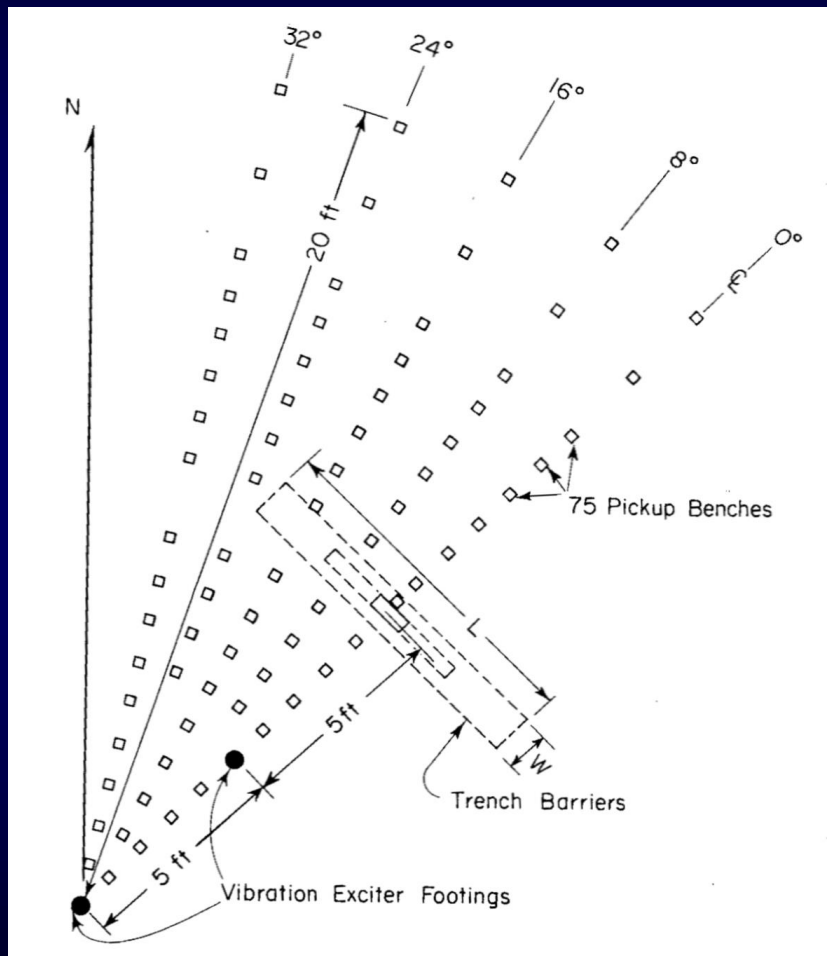
Mjerenja – širenje valova i
učinak barijera

Djelomična zaštita



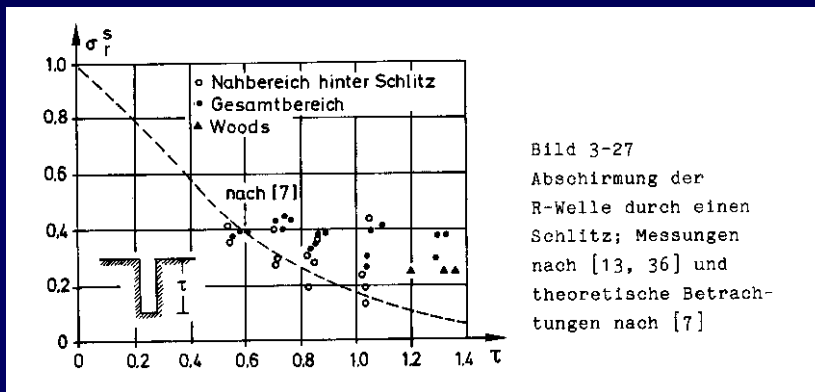
ZAŠTITA OD VIBRACIJA

Mjerenja – širenje valova i učinak barijera



ZAŠTITA OD VIBRACIJA

Mjerenja – širenje valova i učinak barijera



τ - relativna dubina jarka;

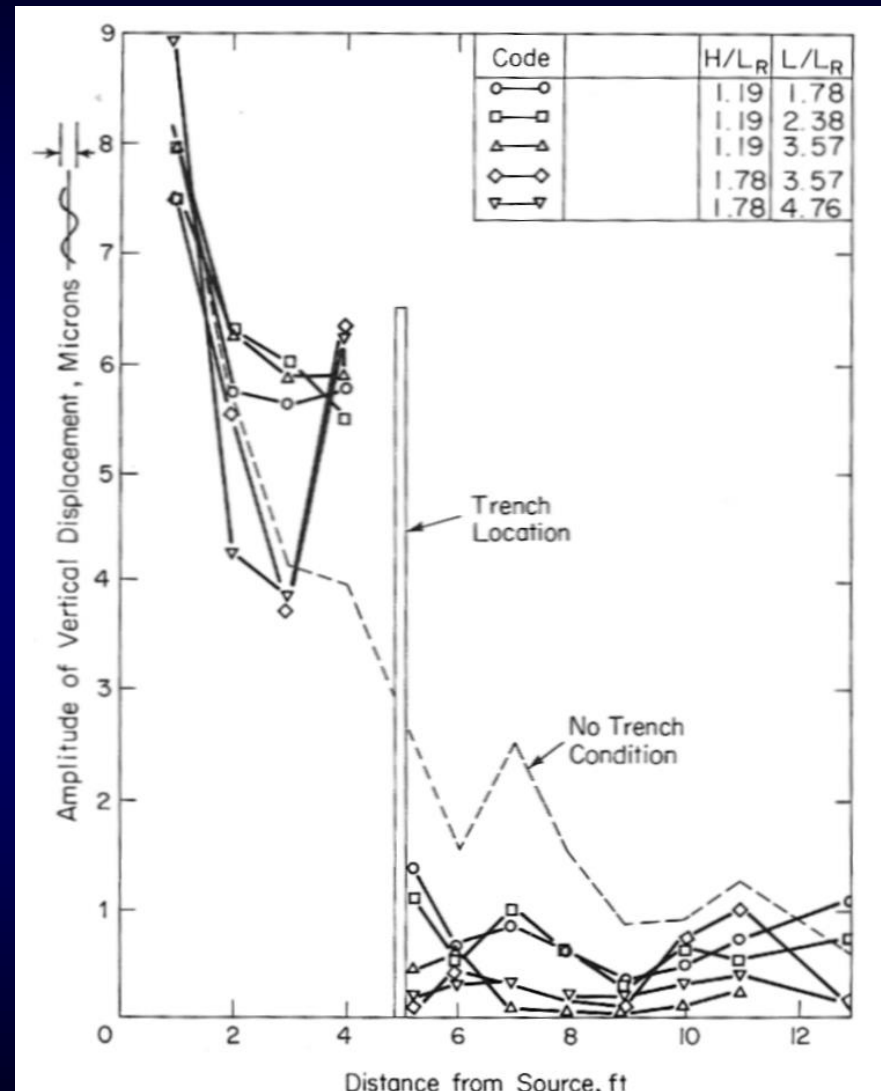
$$\tau = d / \lambda, \lambda = v_R / f$$

d - stvarna dubina jarka; λ – valna duljina ;

v_R – brzina širenja valova (npr.

Rayleighevih)

f – predominantna frekvencija



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Učinci barijera – proračuni i mjerenja

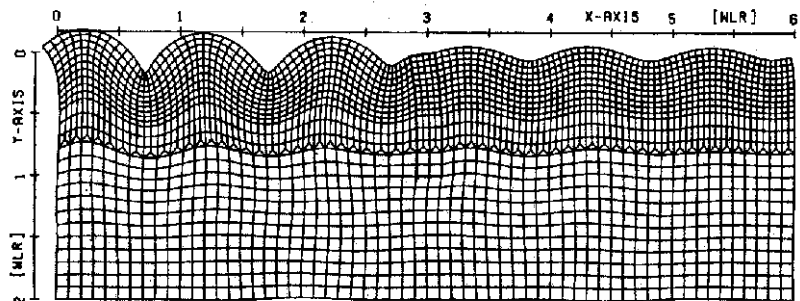


Bild 3-28 Abschirmung einer R-Welle durch Schlitzwand;
Fernfeld einer Wellenquelle (FE-Rechnung, eben)

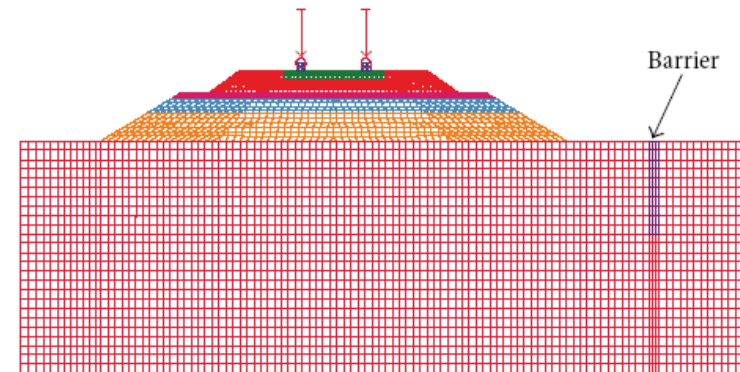
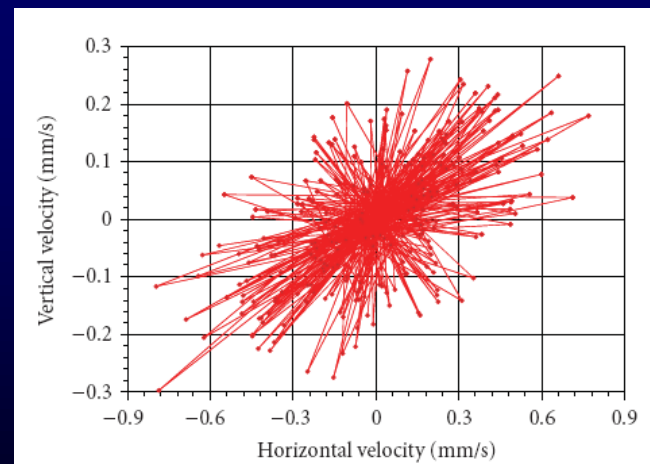
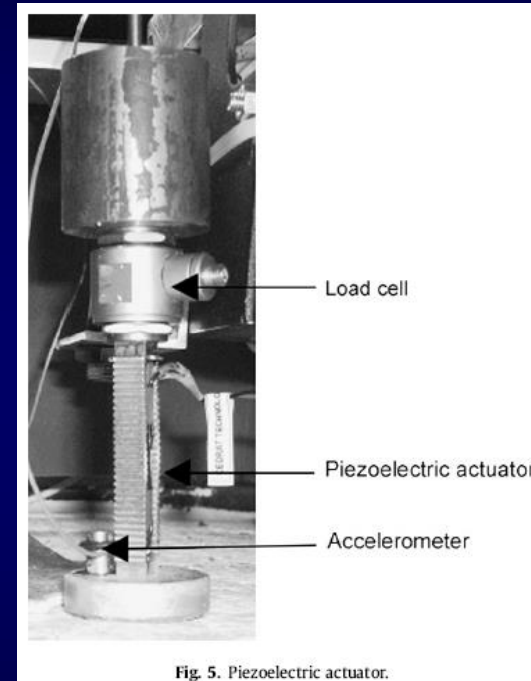
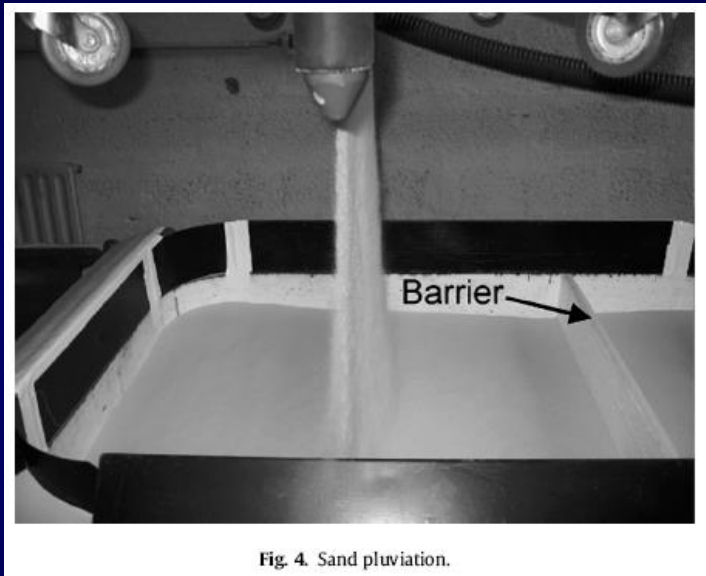


FIGURE 5: Finite element mesh of the two-dimensional model.



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Učinci barijera – proračuni i mjerenja



ZAŠTITA OD VIBRACIJA

Učinci barijera – proračuni i mjerenja

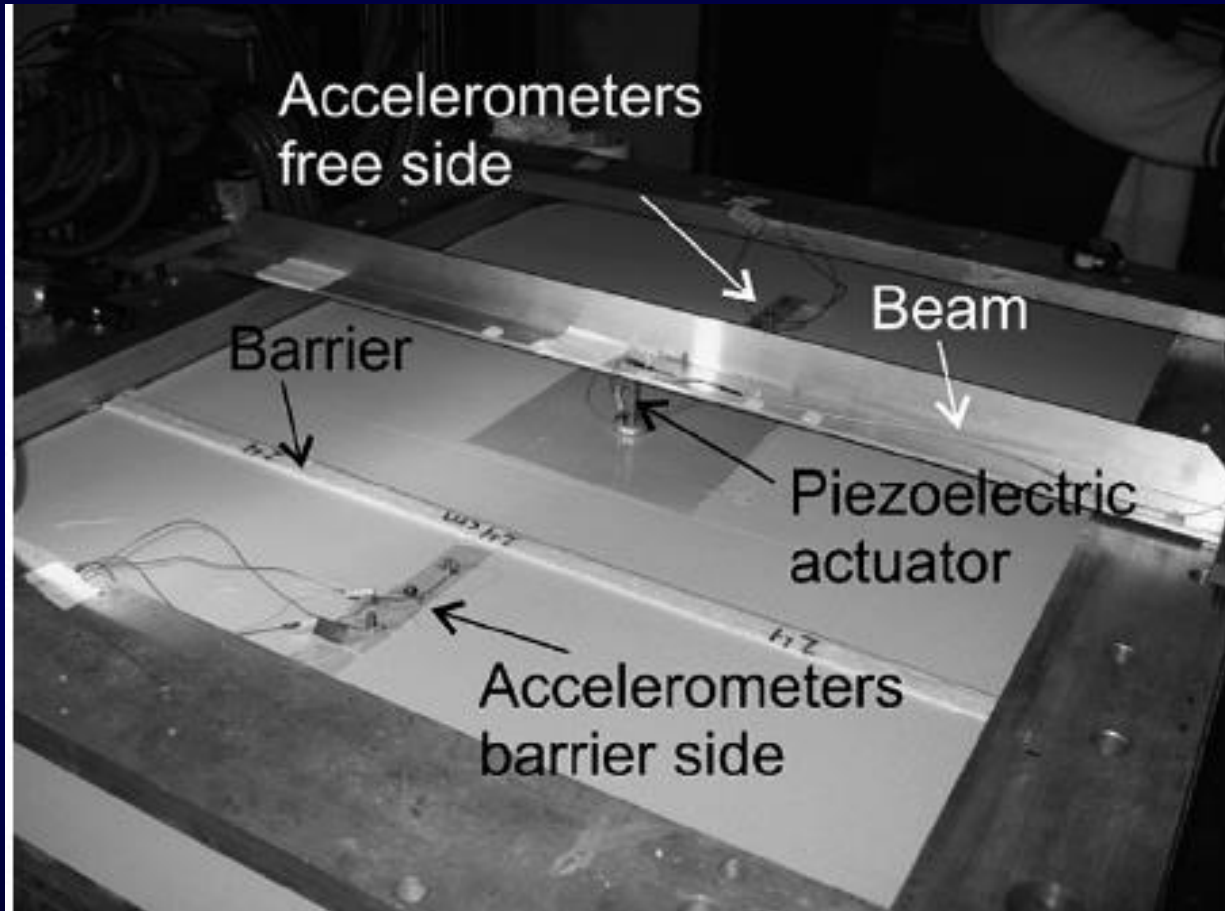
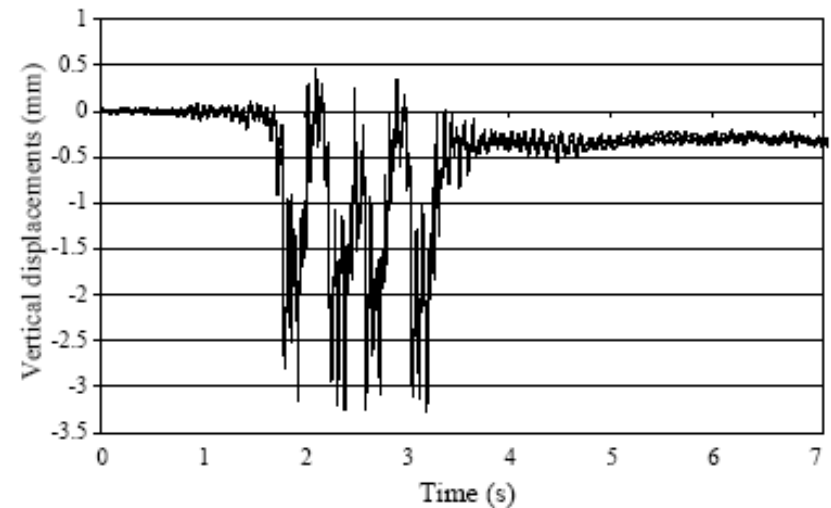
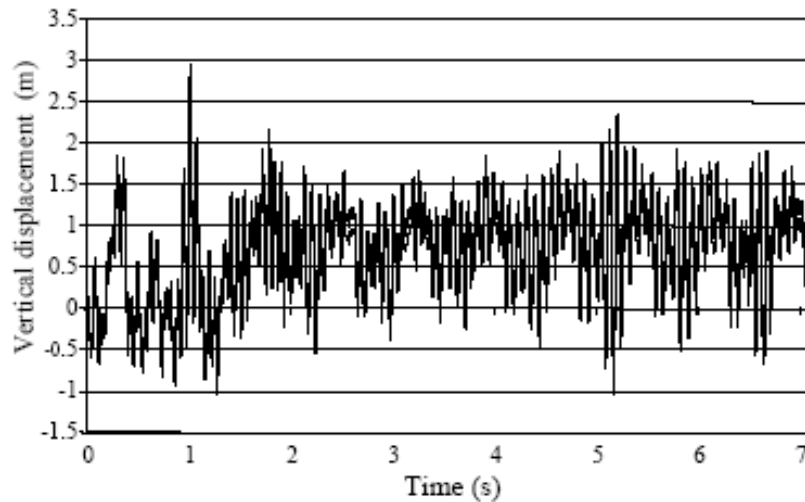


Fig. 6. Experimental test configuration

ZAŠTITA OD VIBRACIJA

Realni primjeri – input: a) vlak s 22 vagona b) 2 lokomotive



ZAŠTITA OD VIBRACIJA

Realni primjeri

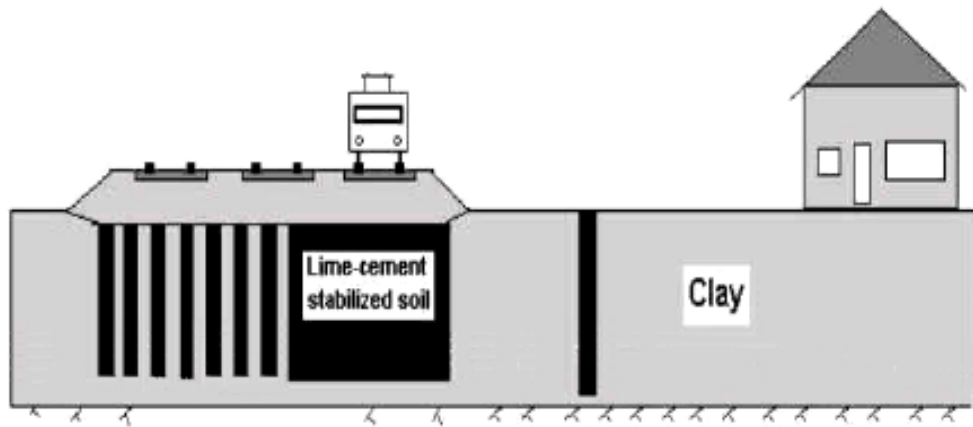
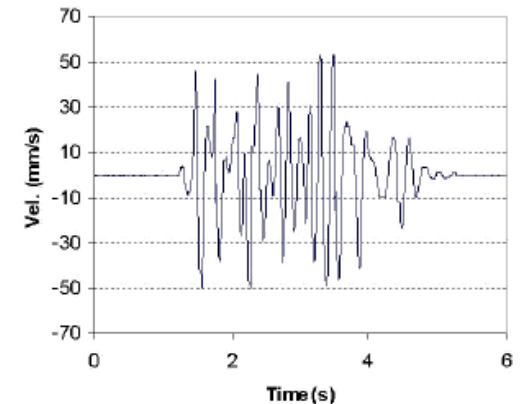
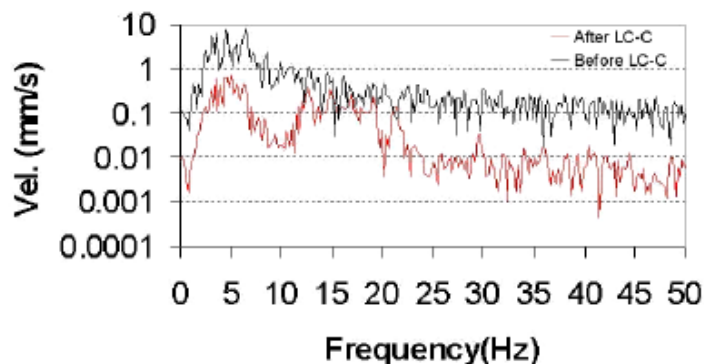
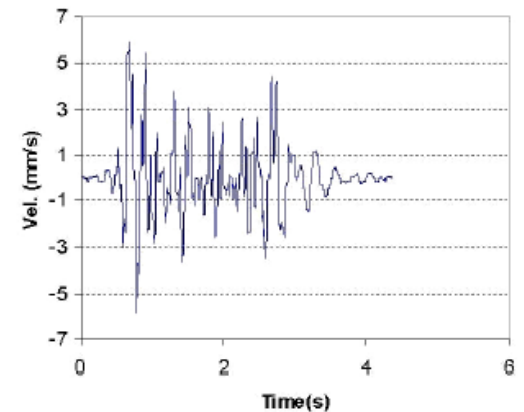


Fig. 1. Vibration reduction at Ledsgård, using lime-cement stabilized soil [2].



a) Before ground improvement



b) After ground improvement

ZAŠTITA OD VIBRACIJA

IZVEDBA BARIJERA

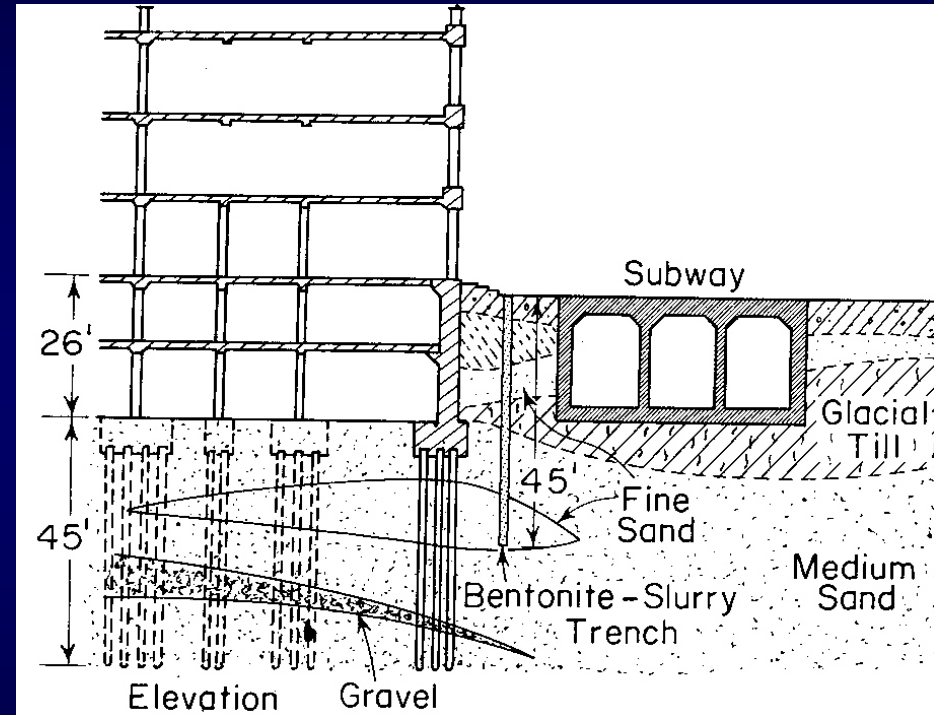
- Najbolje: prazan rov
- problem: stabilnost iskopa

Meke barijere (povoljnije):

- Stiropor (EPS) - geofom
- Plinski jastuci

Tvrde barijere:

- Talpe, AB dijafragme



ZAŠTITA OD VIBRACIJA

Plinski jastuci – Švedska (zadnjih cca 20 godina)



a) Inflated rubber balloon with excess pressure



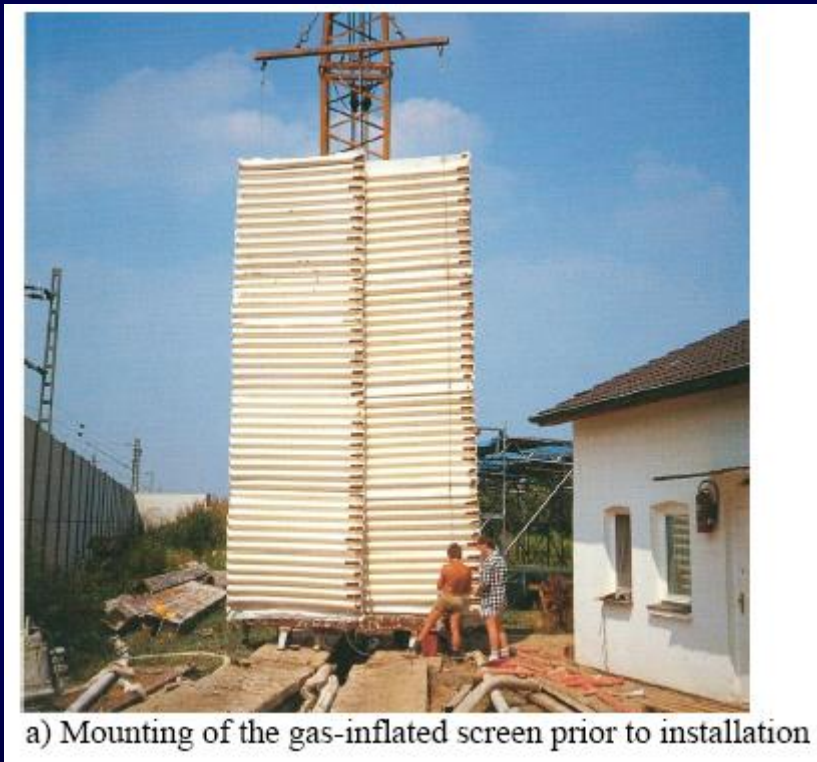
b) Due to water pressure, the volume of the balloon decreases and pressure equilibrium is reached. The membrane is completely unloaded.



c) Aluminium foil surrounding inflated balloon for diffusion reduction

ZAŠTITA OD VIBRACIJA

Plinski jastuci – Švedska (zadnjih cca 20 godina)



ZAŠTITA OD VIBRACIJA

Plinski jastuci – Švedska (zadnjih cca 20 godina)

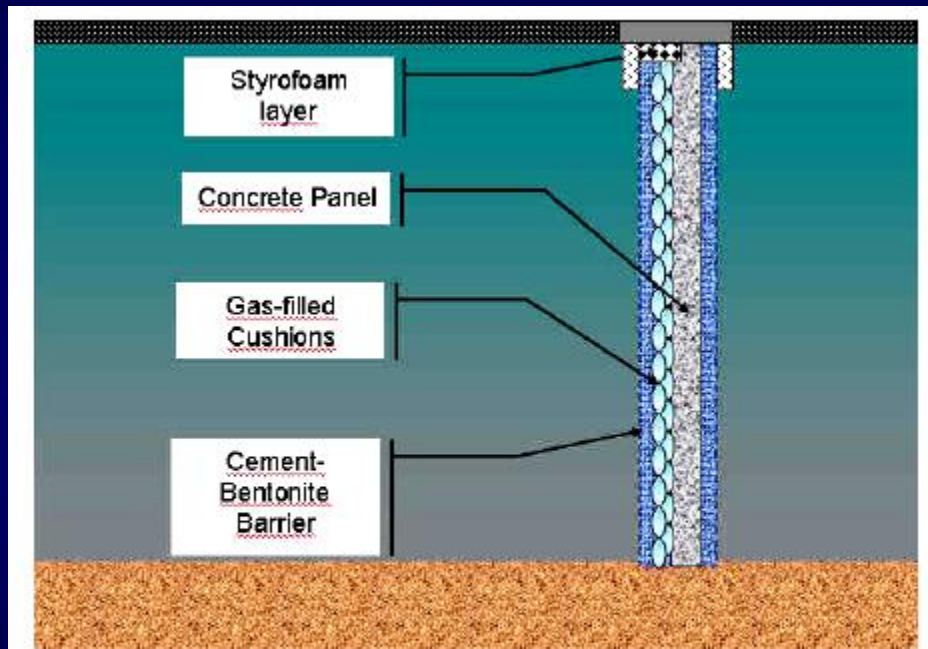


Fig. 10. Third generation of gas cushion system, with flexible cushions attached to stiff, prefabricated concrete panel.

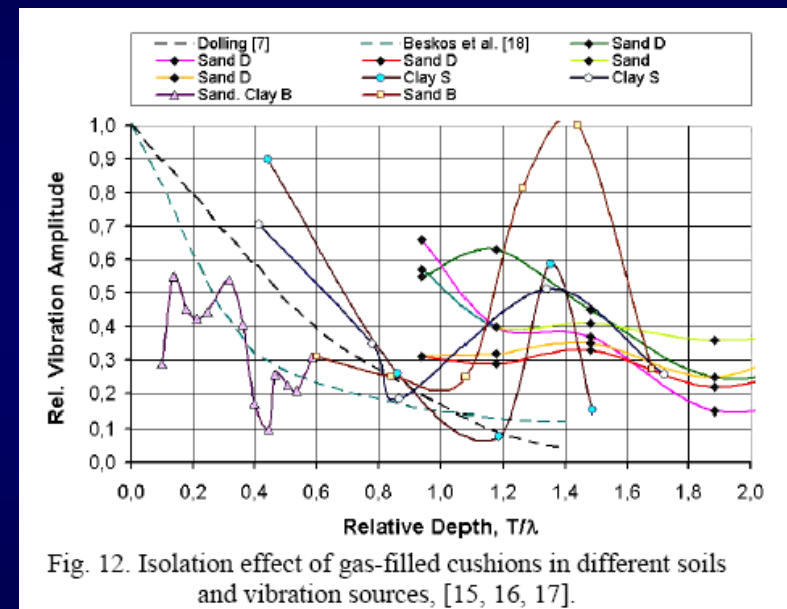


Fig. 12. Isolation effect of gas-filled cushions in different soils and vibration sources, [15, 16, 17].