ASCE 7-10 Seismic Provisions

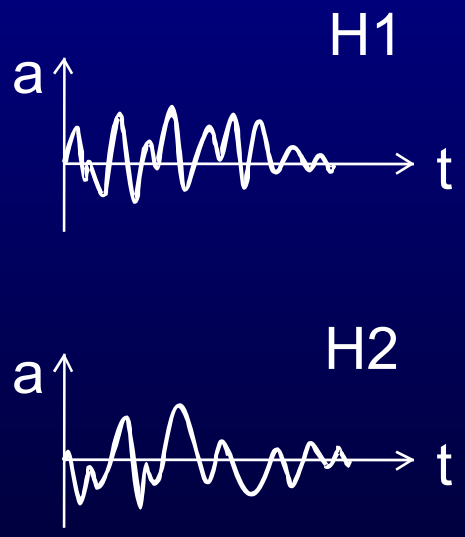
- Time-History Scaling for 3-D Dynamic Analysis
- Liquefaction Provisions

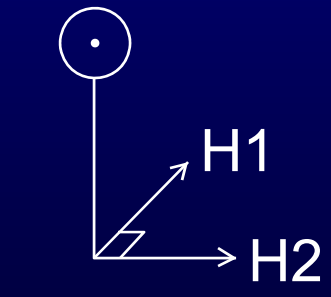
Site-Response Analysis for Liquefaction

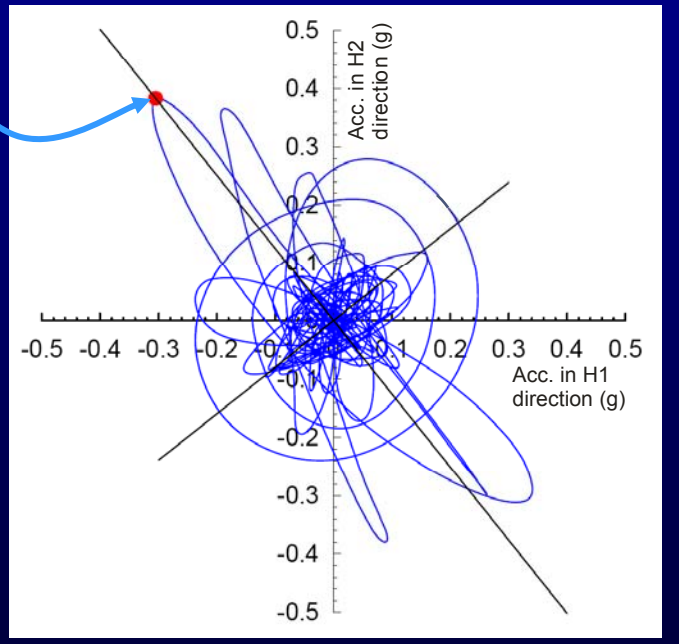
- Model Calibration
- Array Data & Results

C. B. Crouse
URS Corporation

2008 USGS S_s and S_1 Maps in ASCE 7-10 will be





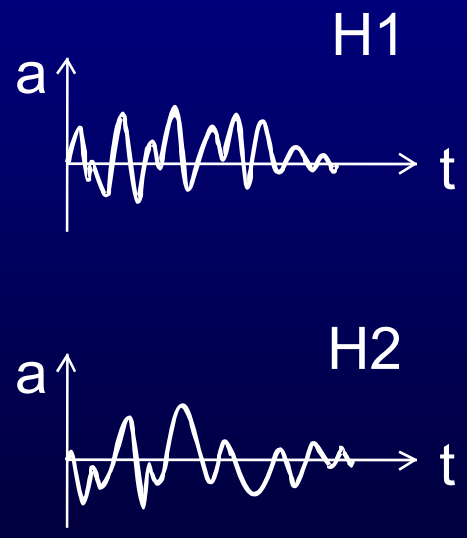


2002 USGS S_S and S_1 Ground Motion Maps in ASCE 7-05 are

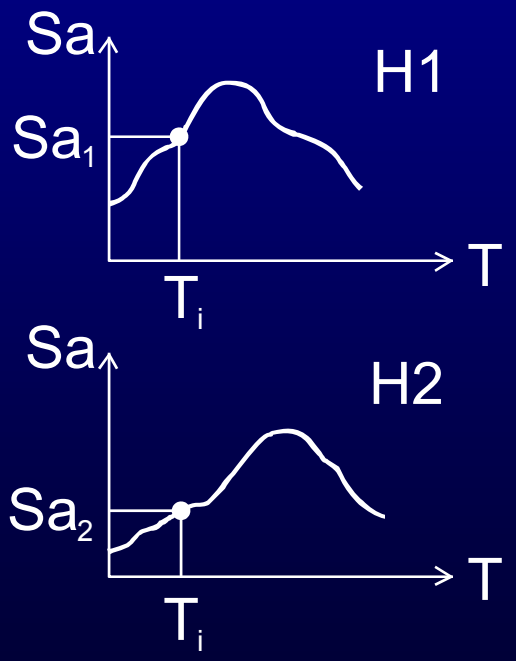
$\sqrt{Sa_1 * Sa_2}$ (geometric mean)

Geometric Mean = $\sqrt{Sa_1 * Sa_2}$

Accelerogram
Horizontal Components

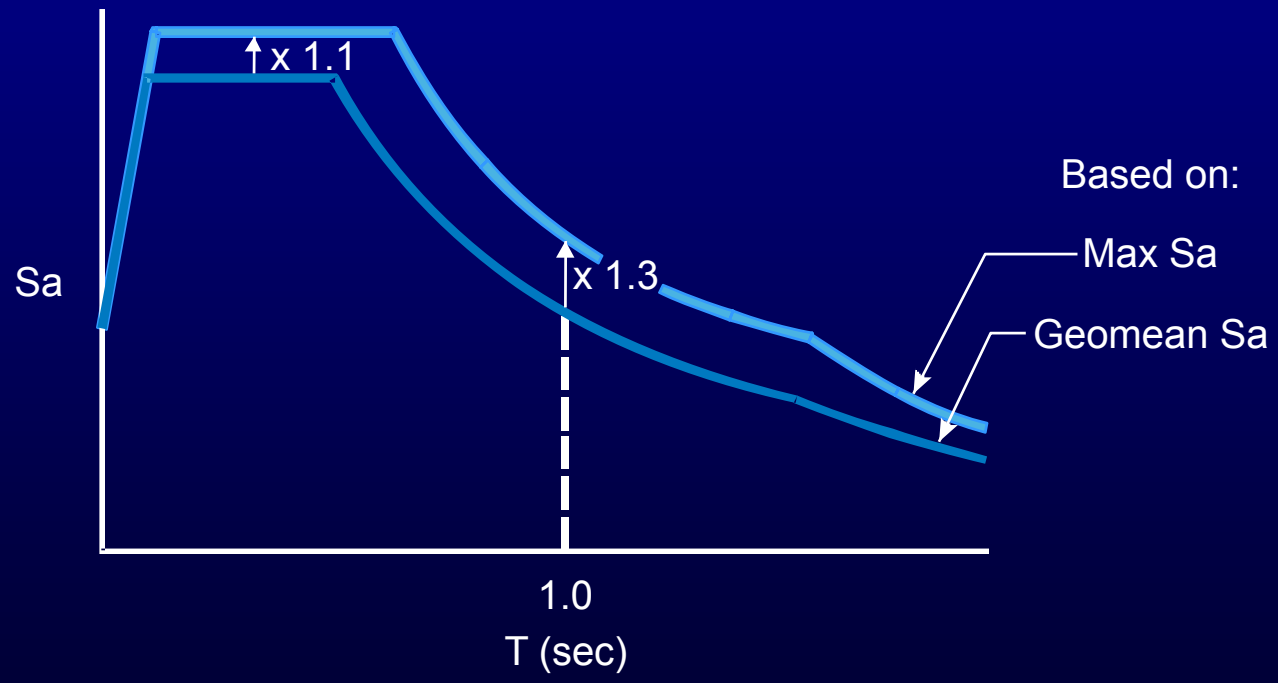


Response Spectra



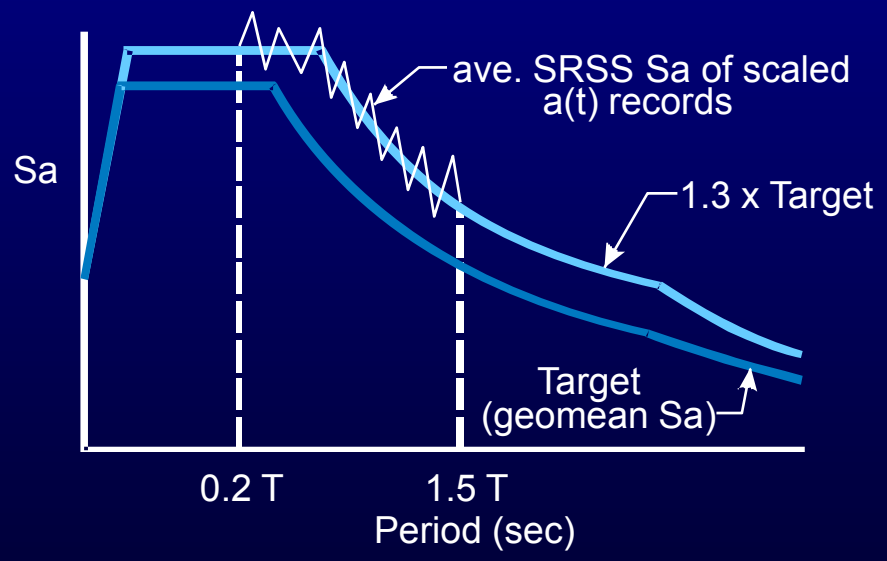
Geomean Sa vs Max Sa

Bedrock Response Spectra

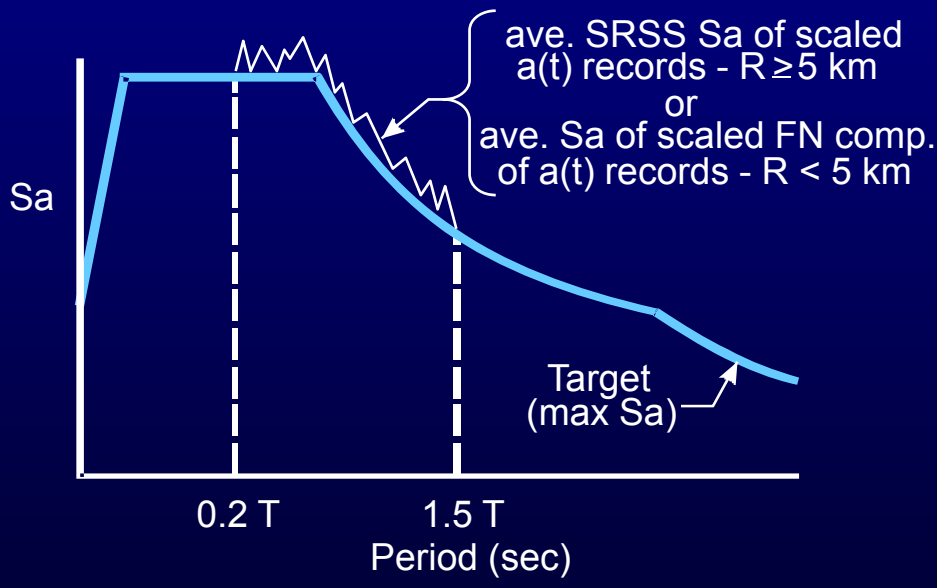


Time-History Scaling for H1 and H2 components – 3D Analysis

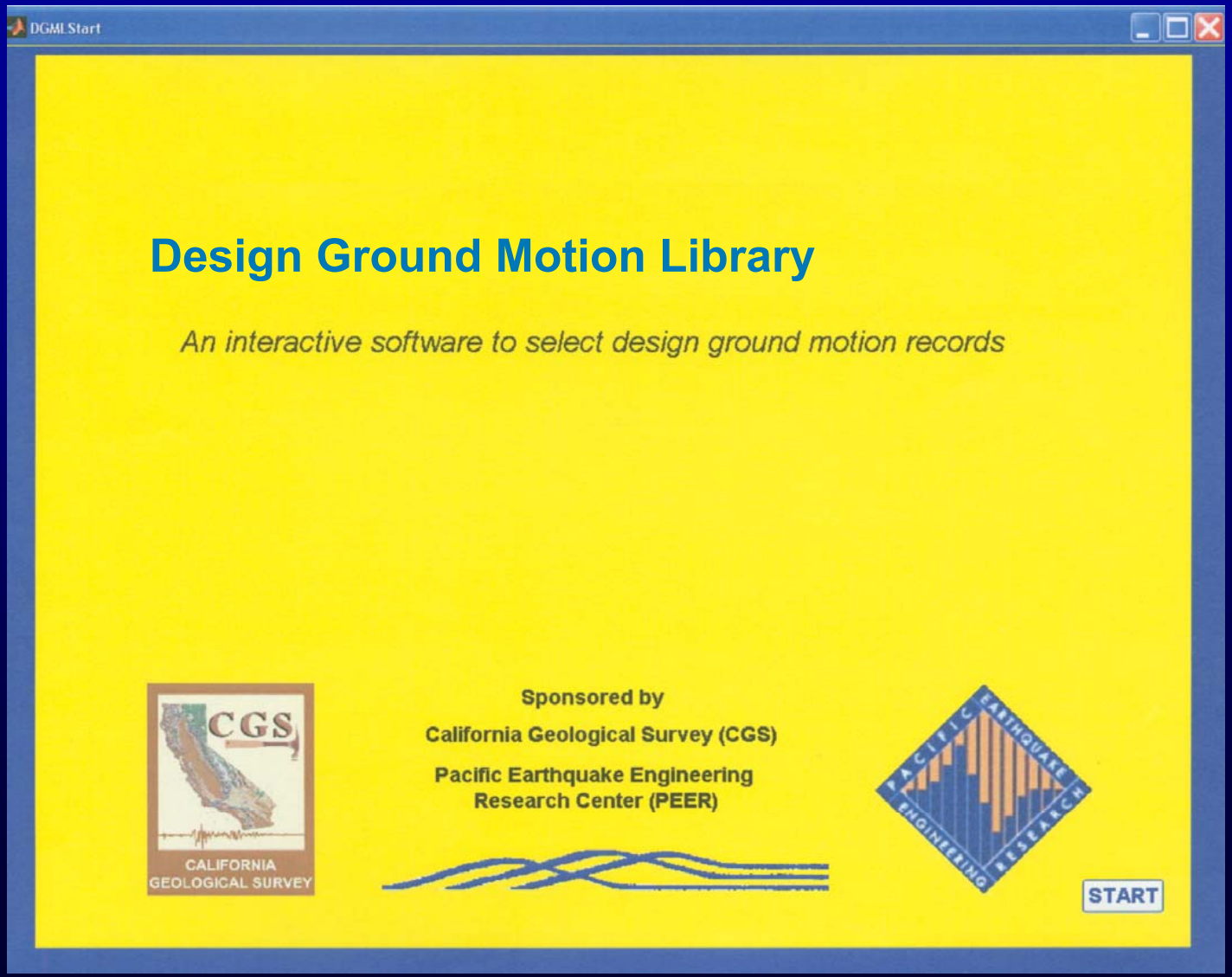
ASCE 7-05



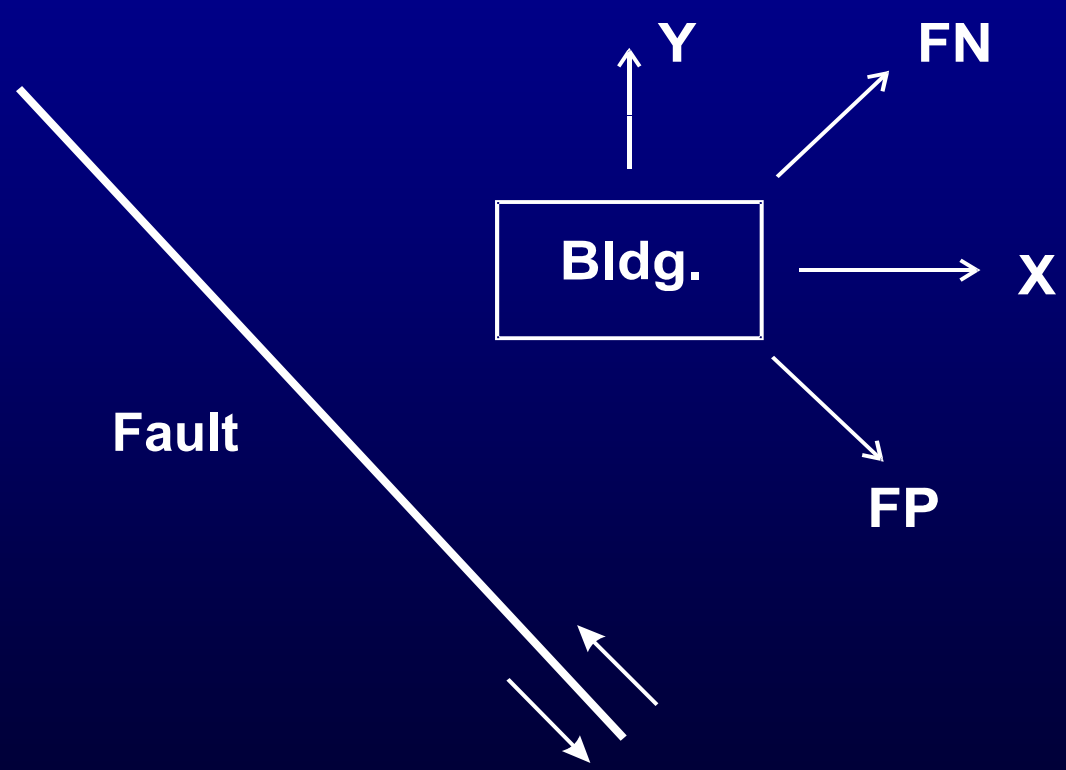
ASCE 7-10



Ground-Motion Records



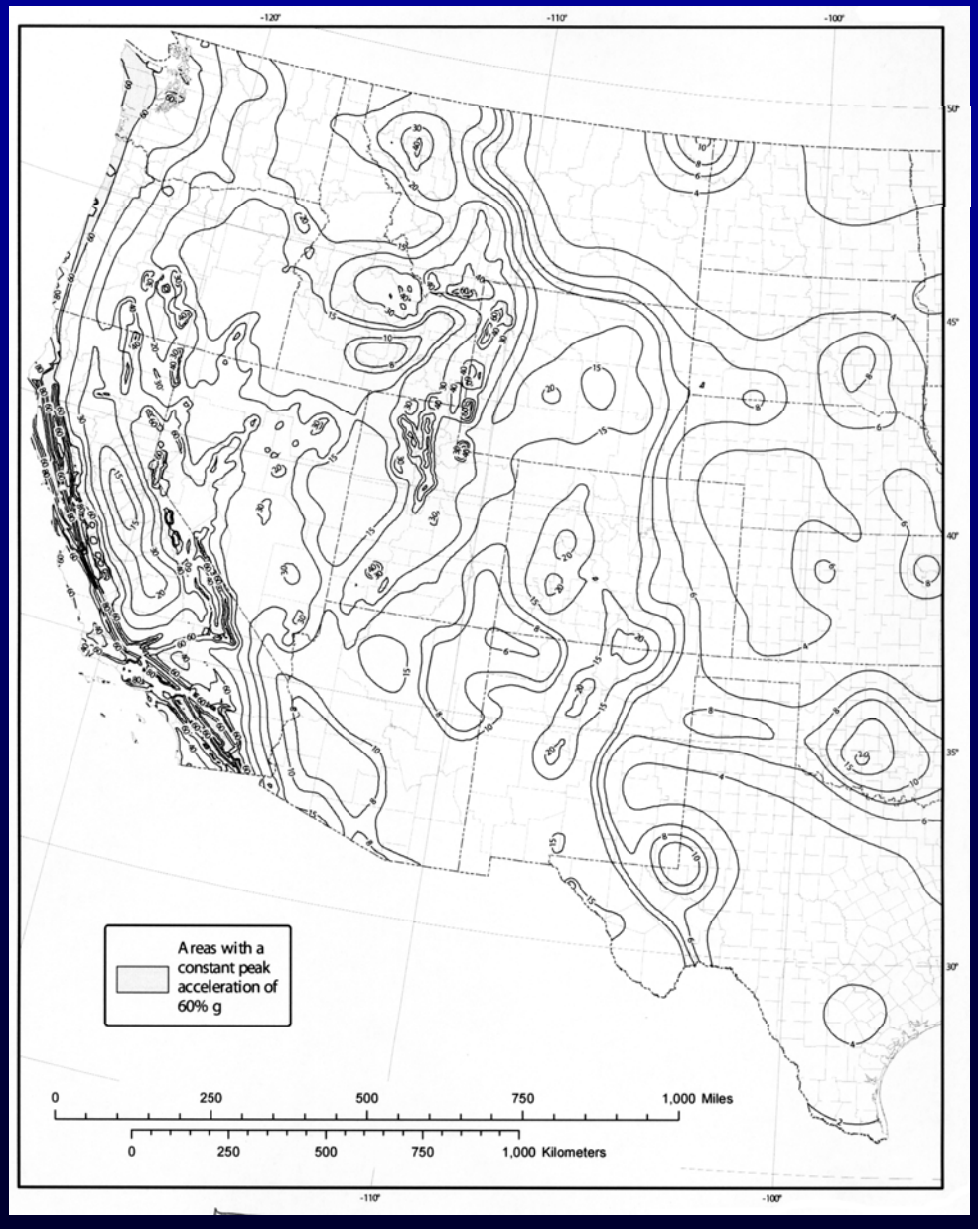
Transform FN & FP a(t) into X & Y a(t)



Liquefaction Assessment

ASCE Standard	Ground-Motion Parameter
7-05	S_S / 2.5
7-10	PGA (geomean) for Site Class

MCE Geometric Mean PGA, %g, Site Class B

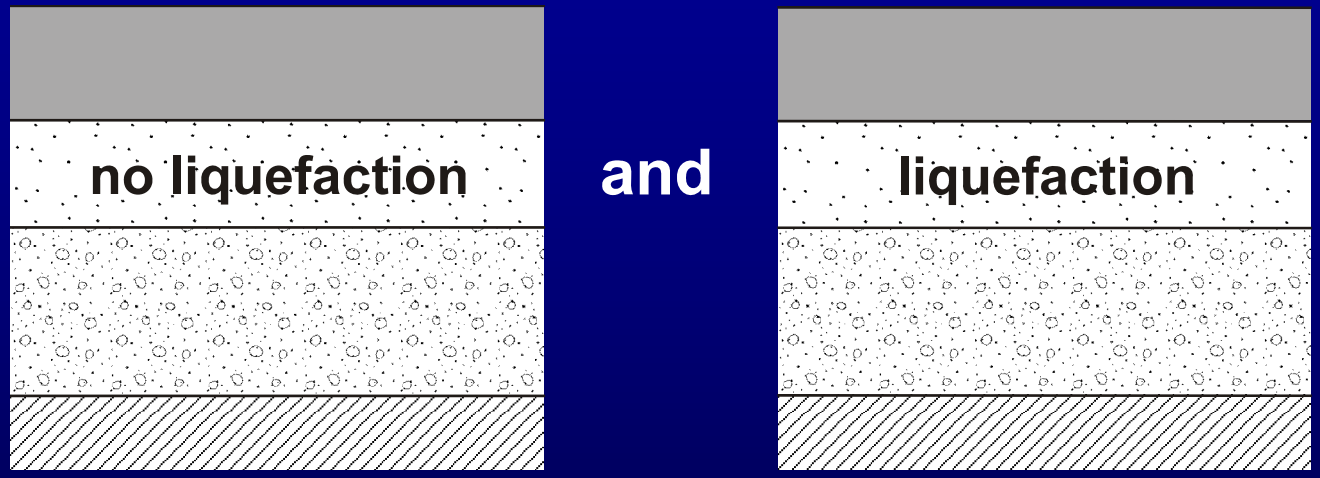


Site Coefficients F_{PGA}

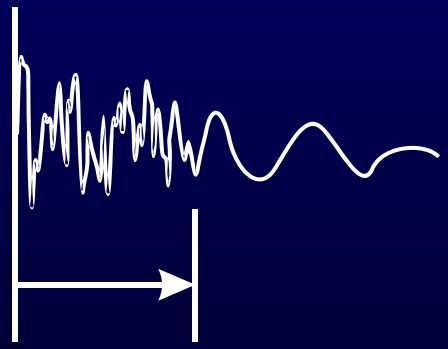
Site Class	Mapped Maximum Considered Geometric Mean Peak Ground Acceleration, PGA				
	PGA ≤ 0.1	PGA = 0.2	PGA = 0.3	PGA = 0.4	PGA ≥ 0.5
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9
F	See Section 11.4.7				

Note: Use straight-line interpolation for intermediate values of PGA.

Site Response Analysis – Liquefiable Soils



Reason for 2 SRA's :

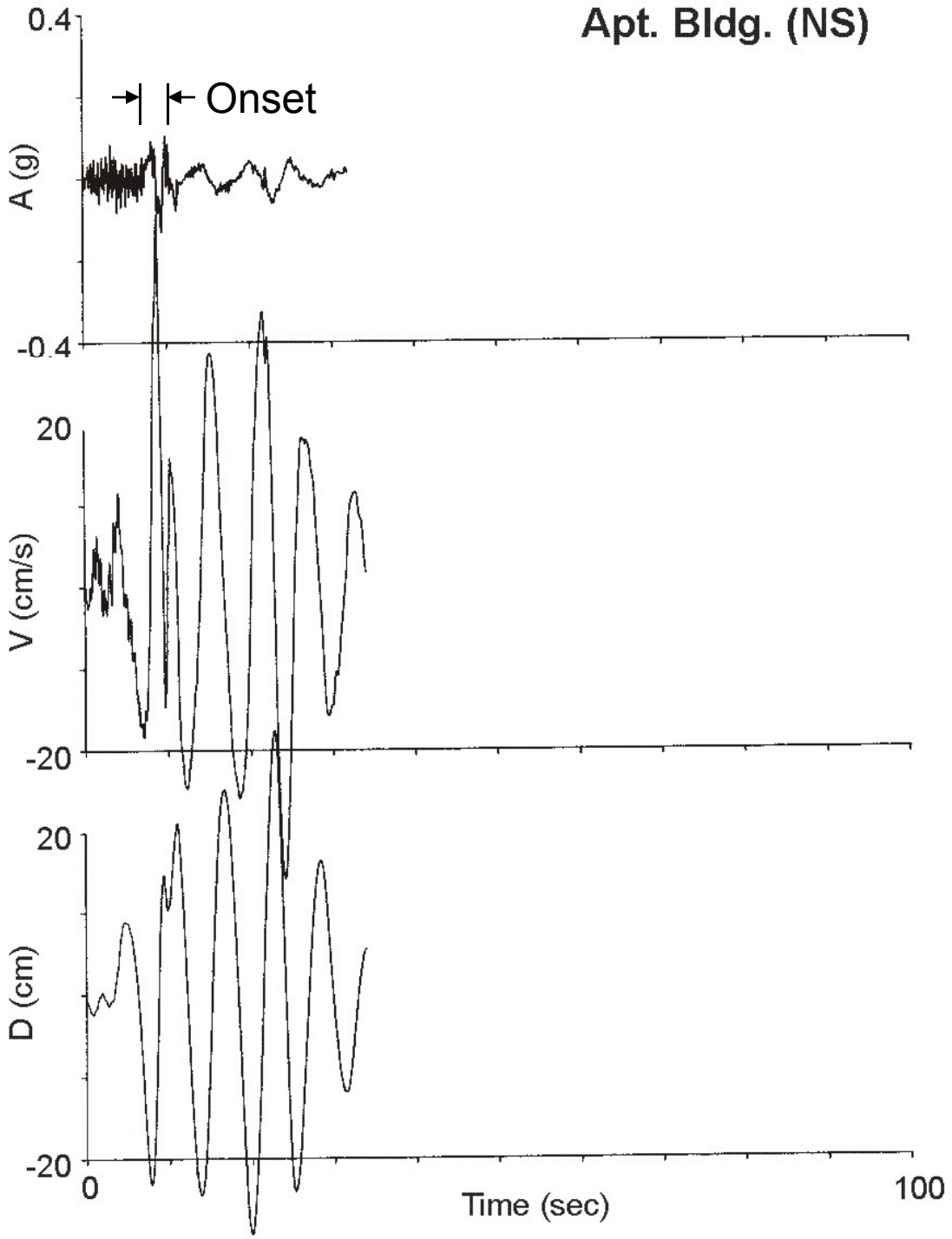


t_{onset} ?

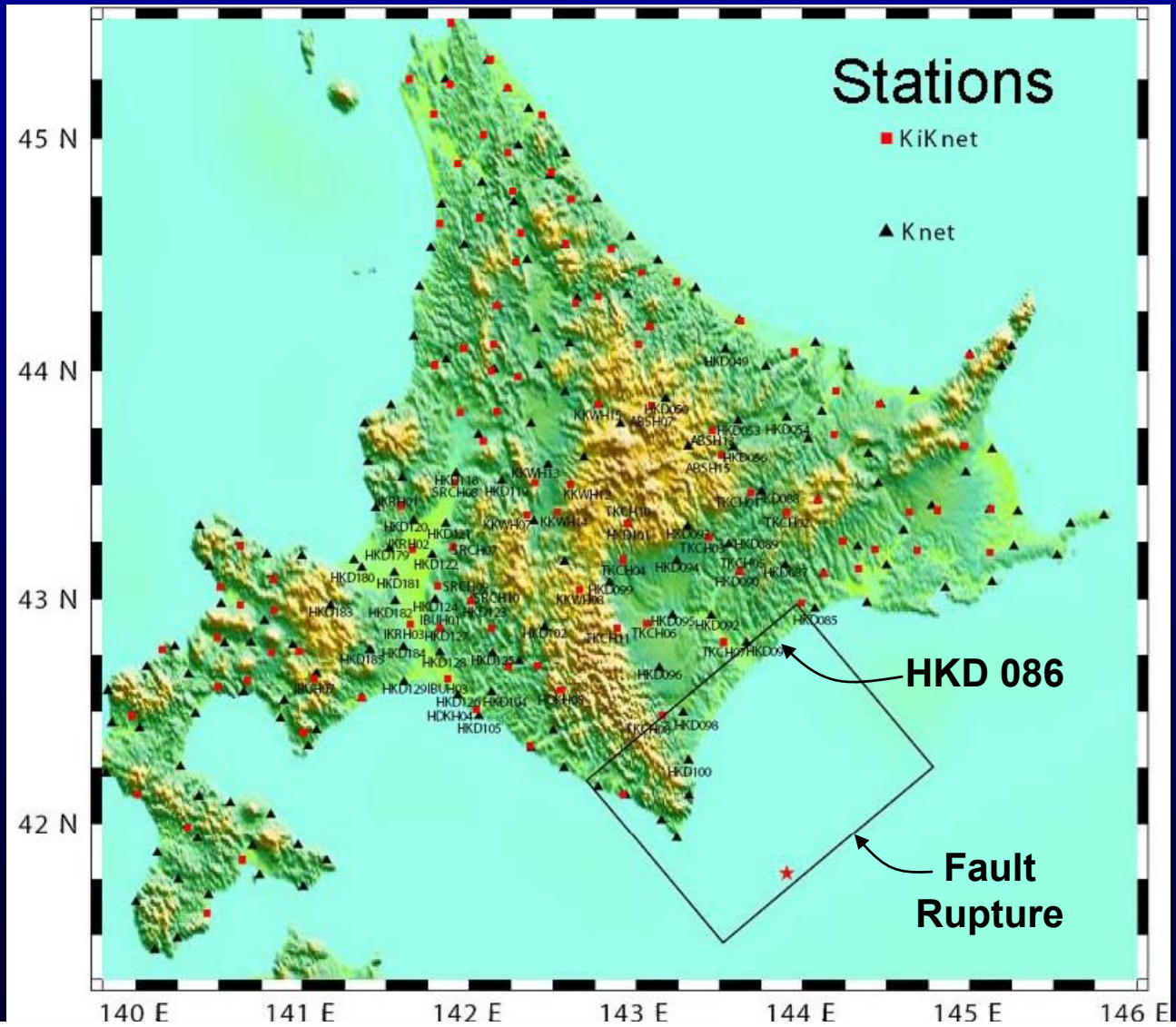
1964 M7.5 Niigata, Japan, Earthquake Damage from Liquefaction

1964 M 7.5 Niigata Earthquake

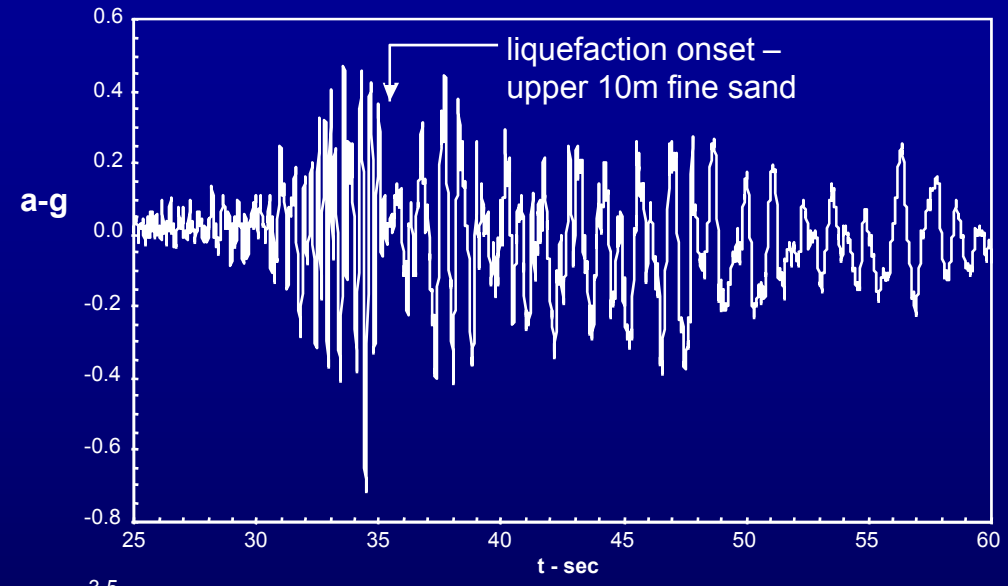
Liquefaction Onset ~ 8-10 sec after start of strong shaking

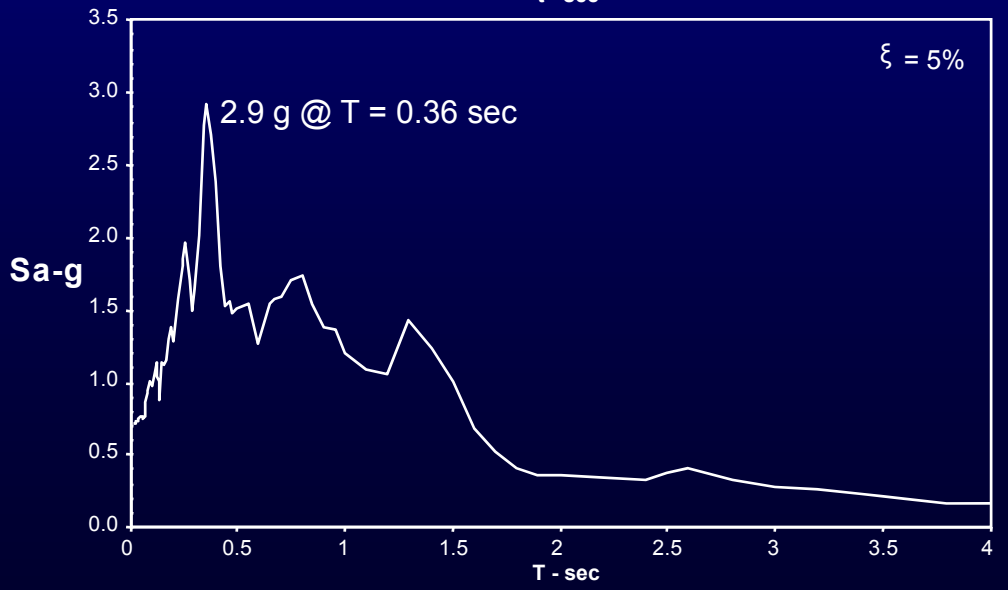


2003 M 8.3 Tokachi-oki, Japan, Earthquake

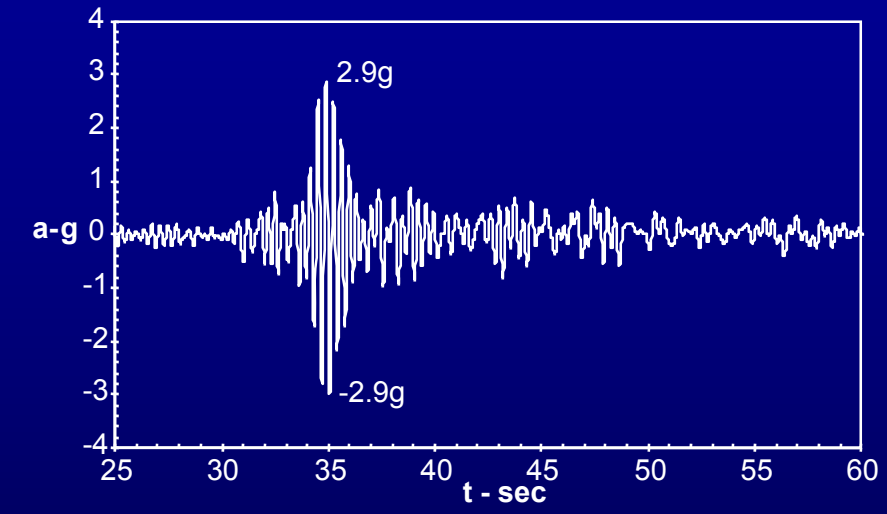


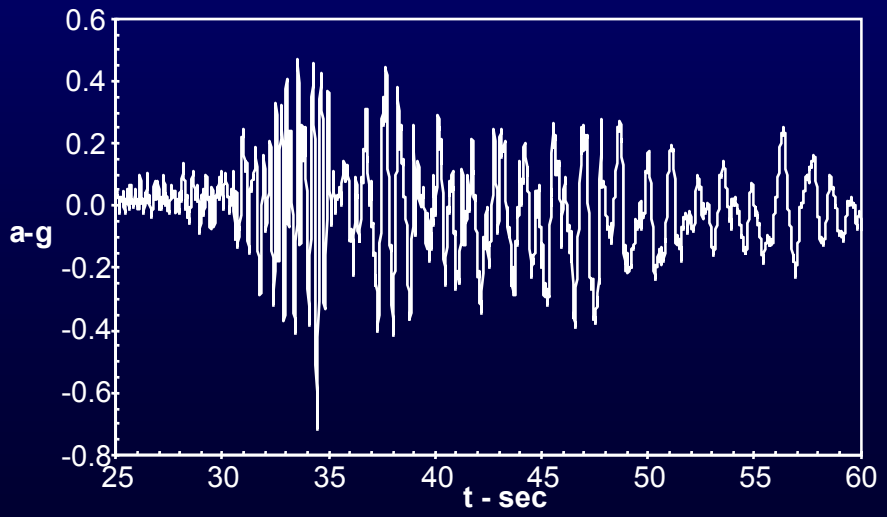
2003 M 8.3 Tokachi-oki Earthquake
HKD 086 NS Comp.

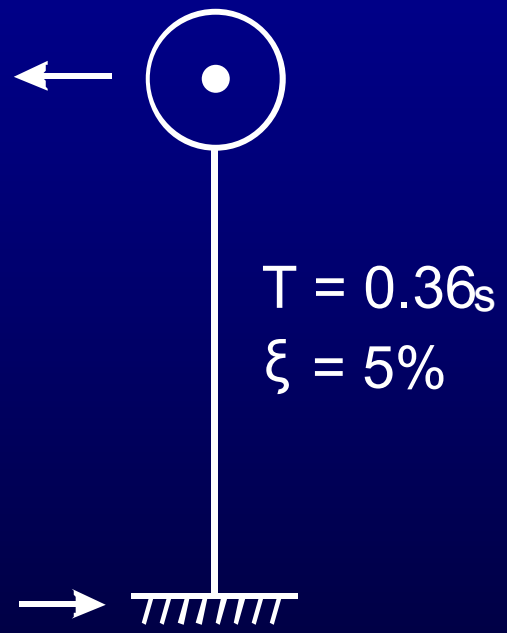




Acceleration Response to HKD 086 NS Comp.



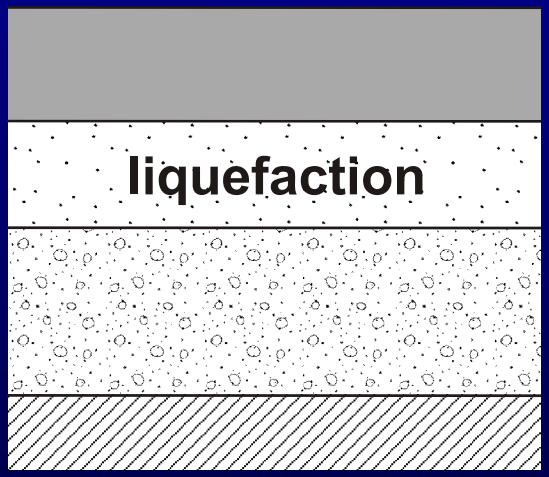




T = 0.36s

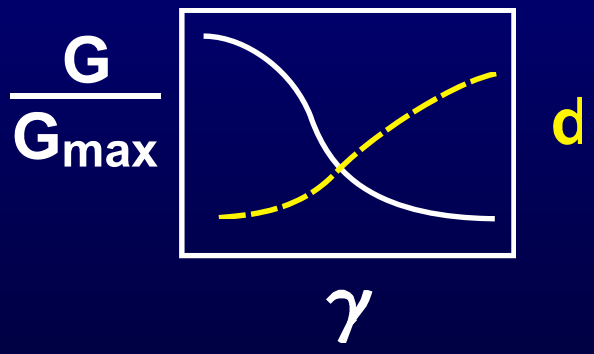
ξ = 5%

Soil Properties – Liquefied Layer



- Depends on SRA model

SHAKE



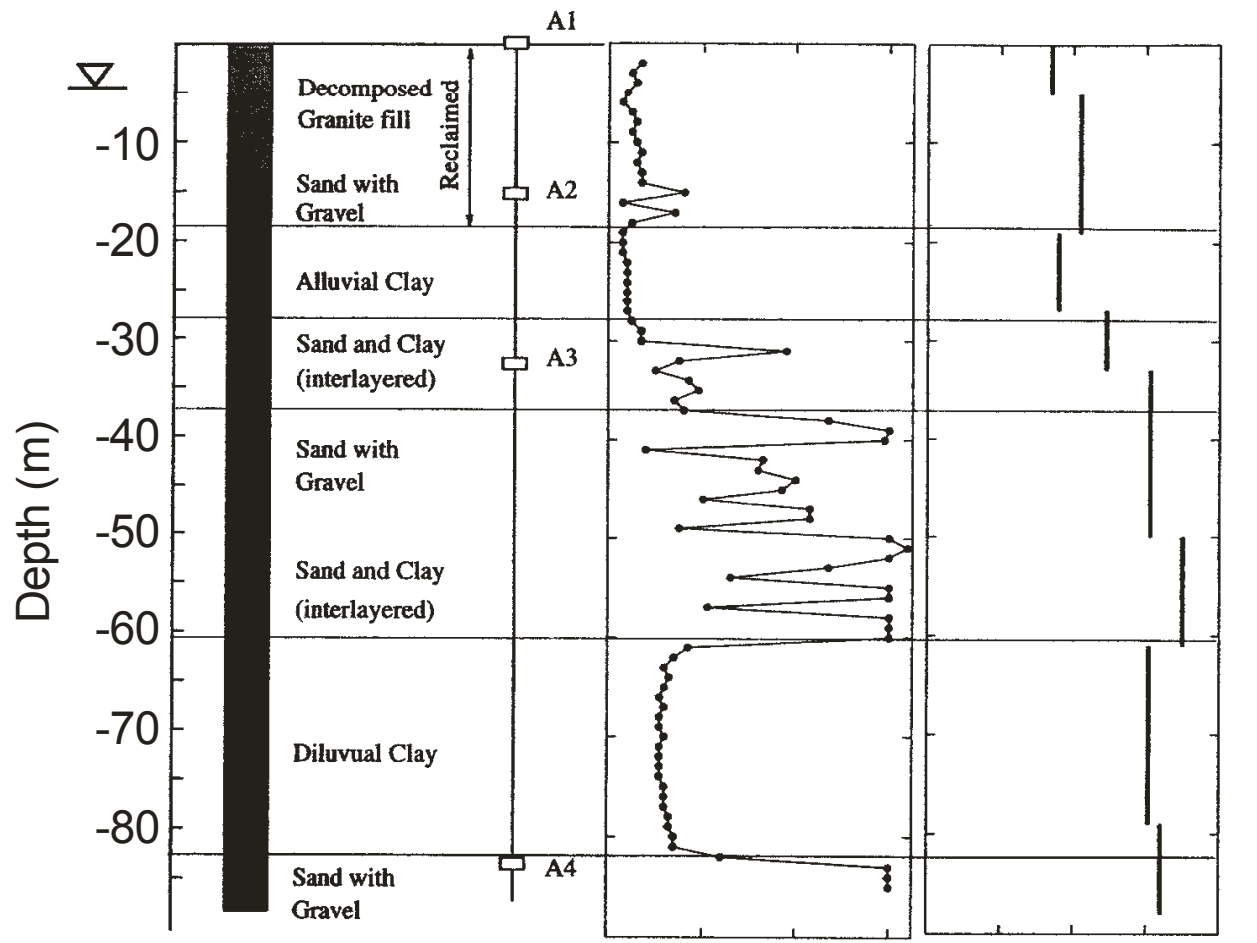
or G (or V_s), d – constants

(borehole arrays)

Ground-Motion Data
Site-Response Calibration

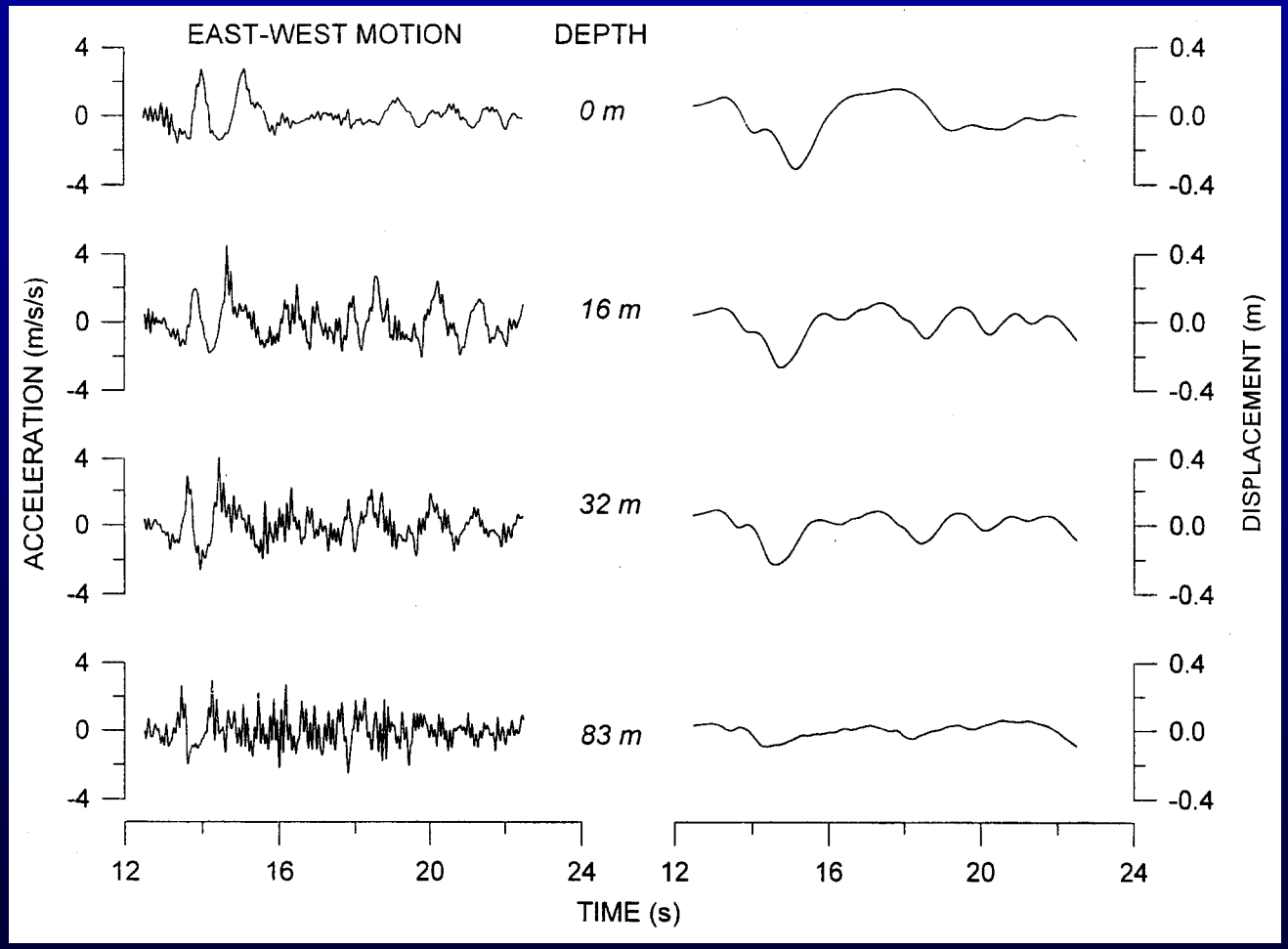
- Port Island, Japan. 1995 Kobe M 6.9
- Wildlife Array, CA. 1987 Superstition Hills M 6.6

Port Island, Japan
Vertical Accelerometer Array



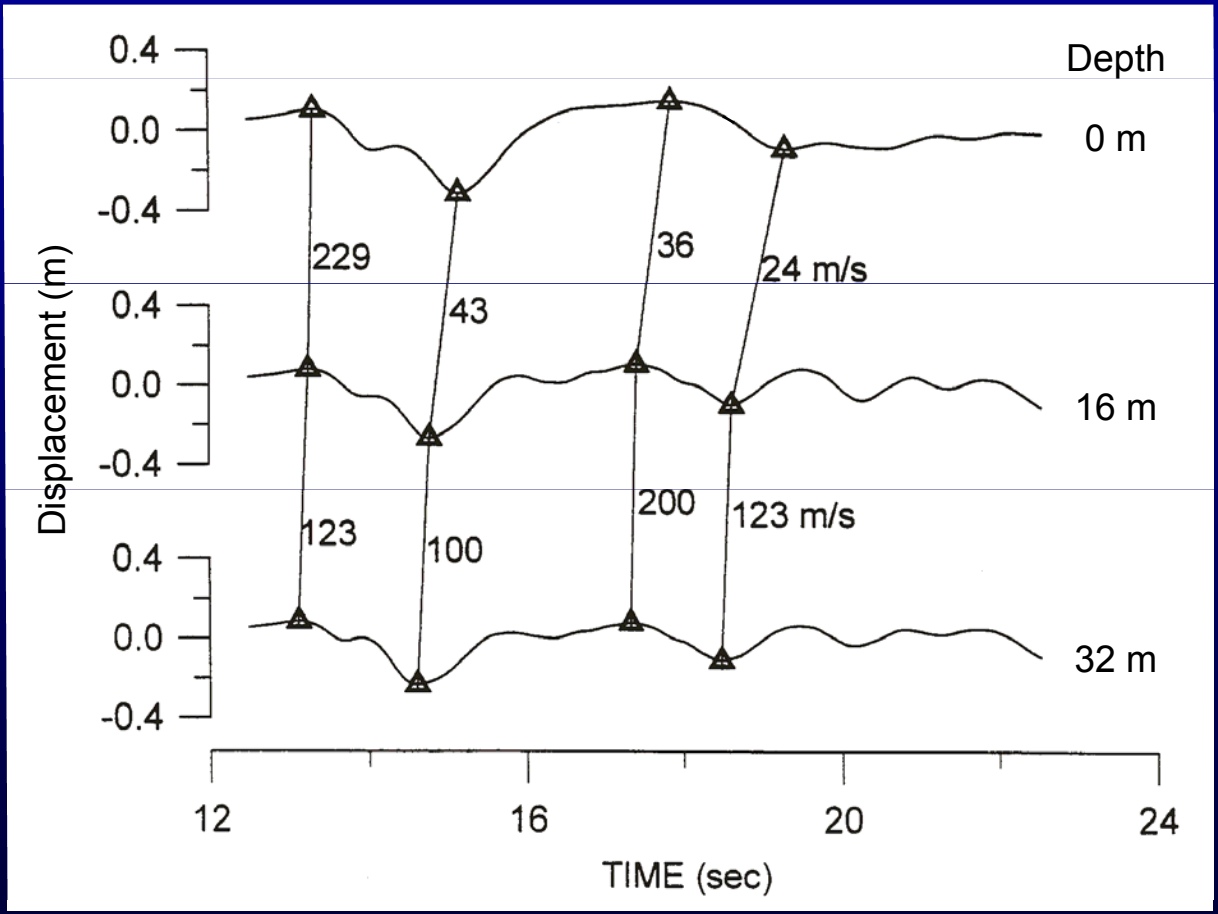
Ref: Elgamal et al. (1996)

Port Island Array EW Records
1995 M 6.9 Kobe Earthquake



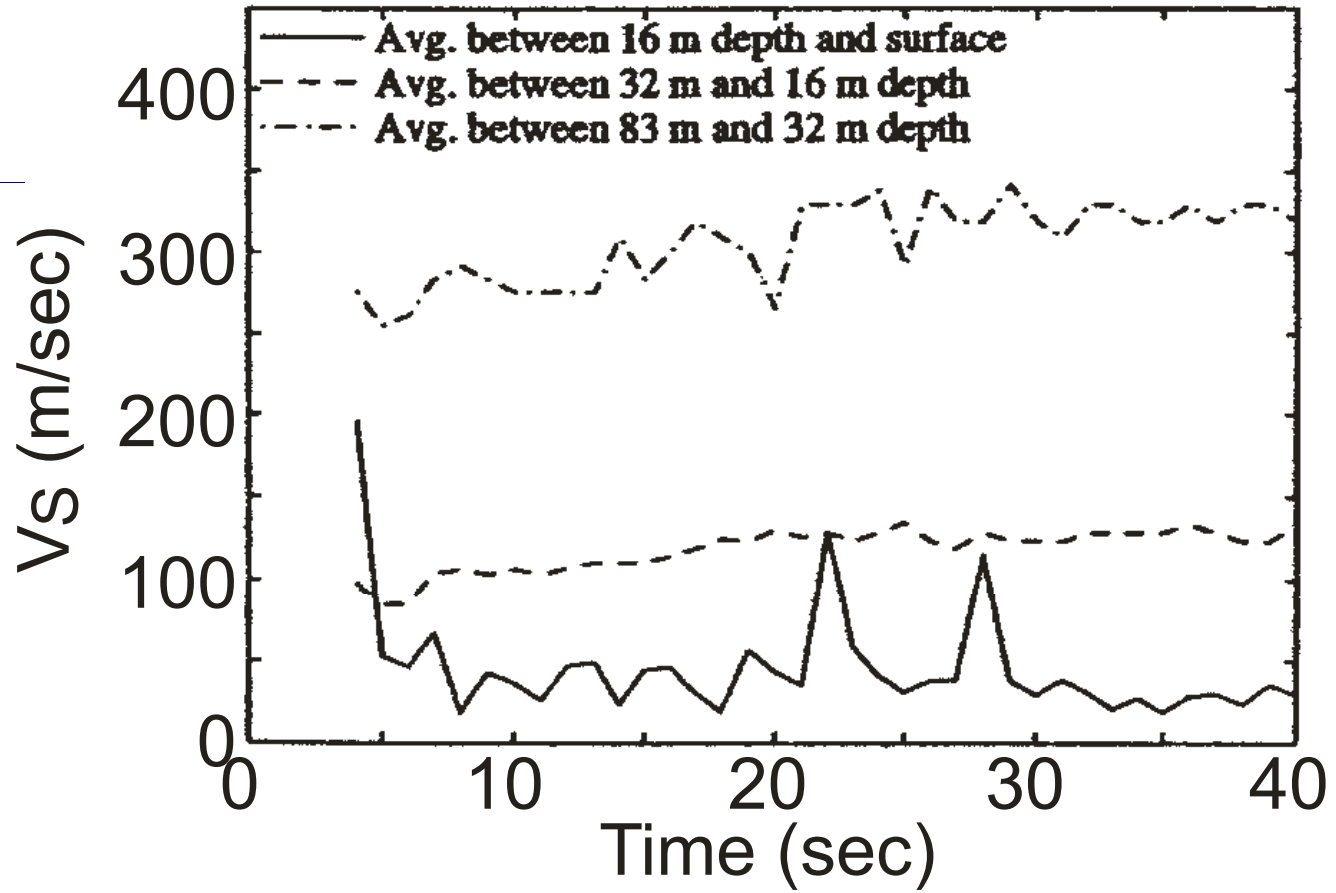
Ref.: Davis & Berrill (1998)

Port Island – 1995 Kobe Earthquake
V_S versus Time



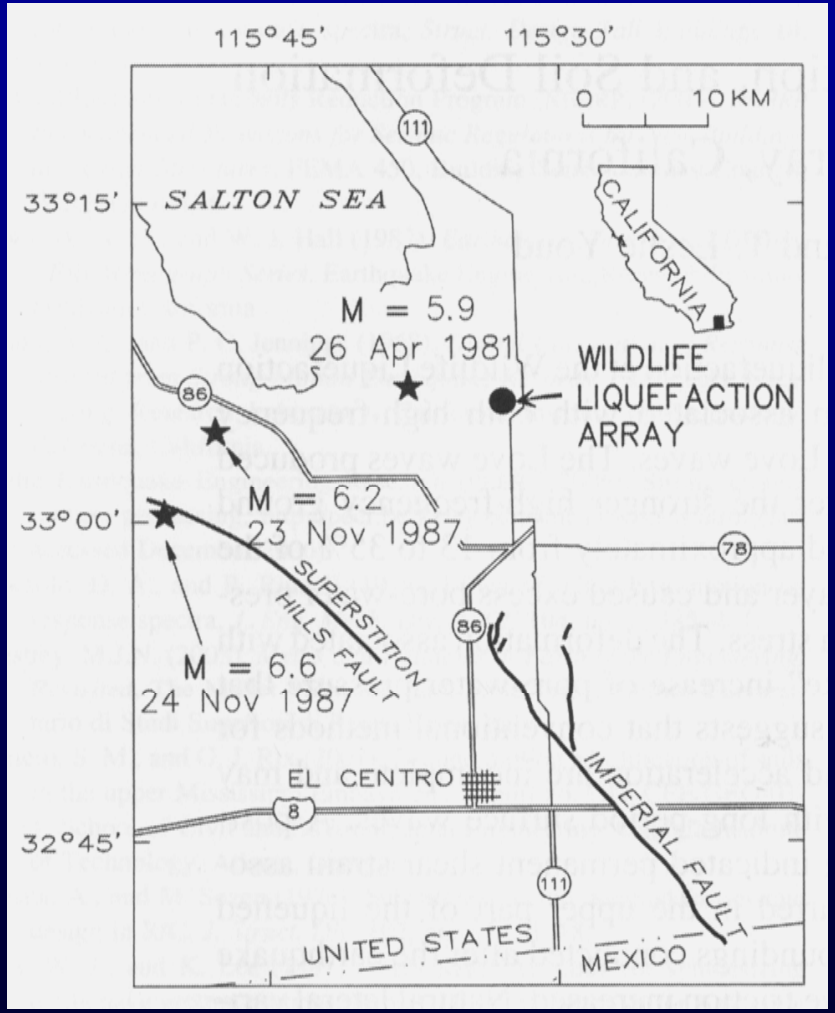
Ref.: Davis & Berrill (1998)

Port Island – 1995 Kobe Earthquake
V_S versus Time



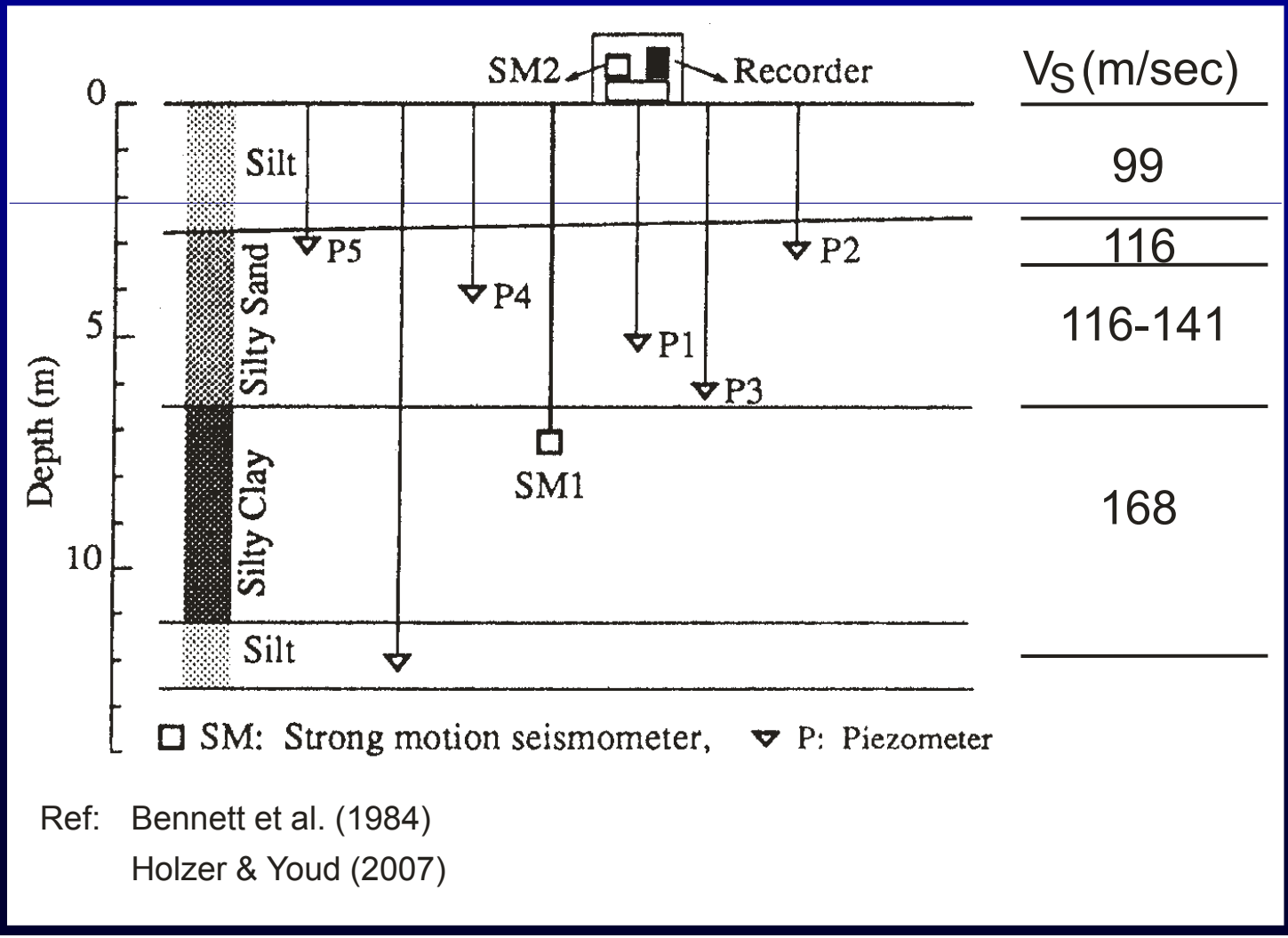
Ref: Elgamal et al. (1996)

Location Map of Wildlife Array



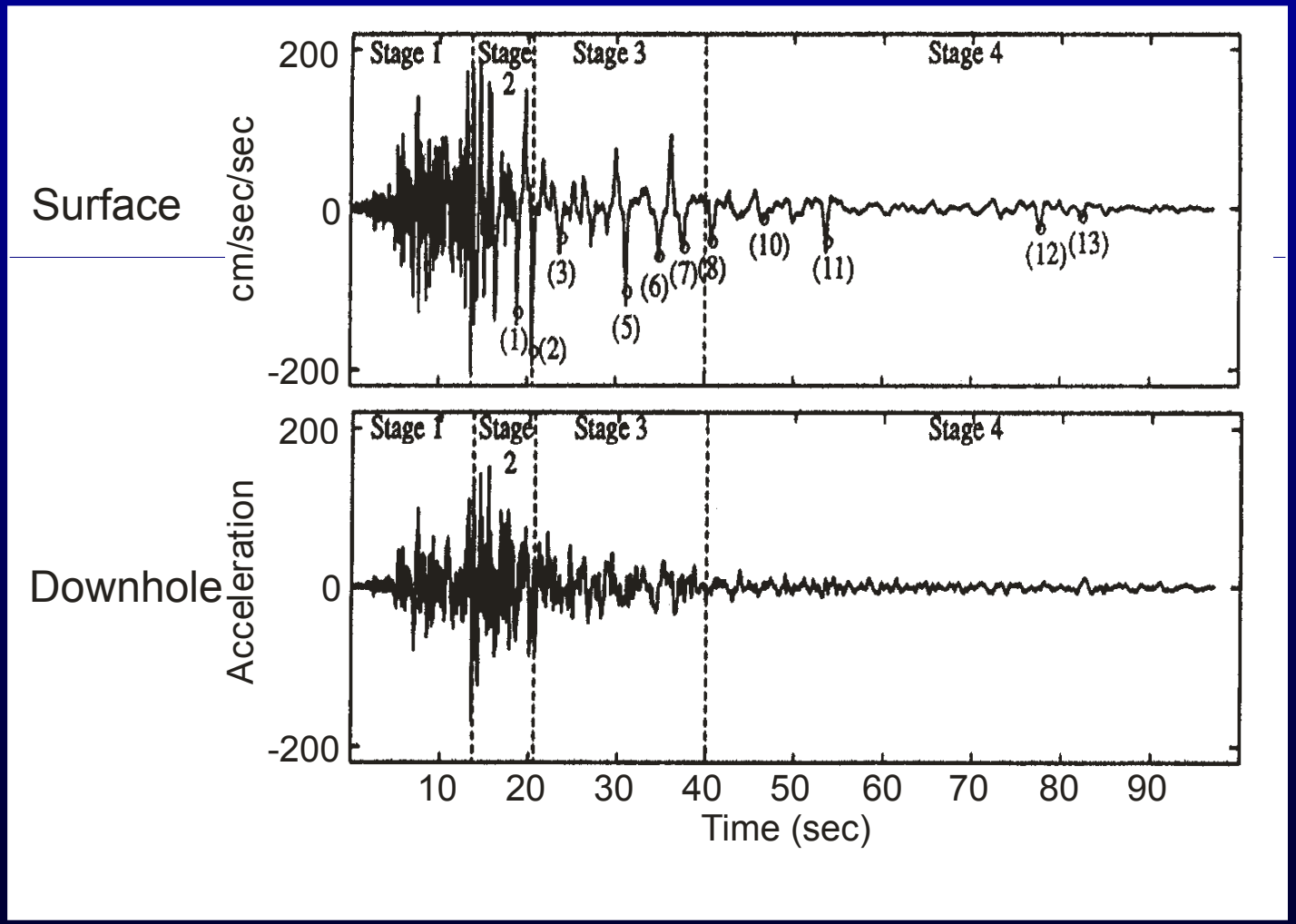
Ref.: Holzer & Youd (2007)

Wildlife Array Instrumentation



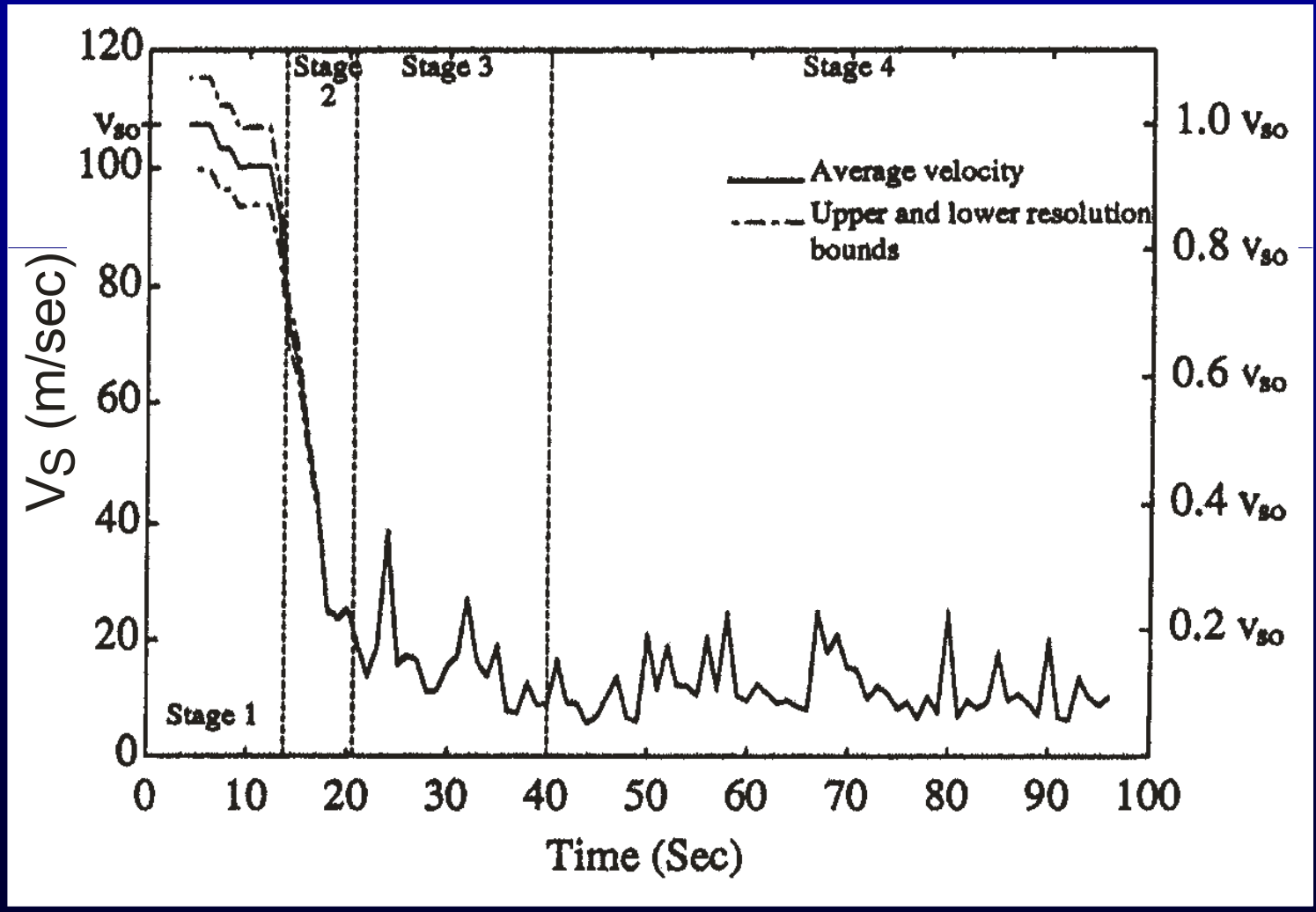
Ref: Bennett et al. (1984)
Holzer & Youd (2007)

Wildlife NS Accelerograms
1987 M 6.6 Superstition Hills EQ



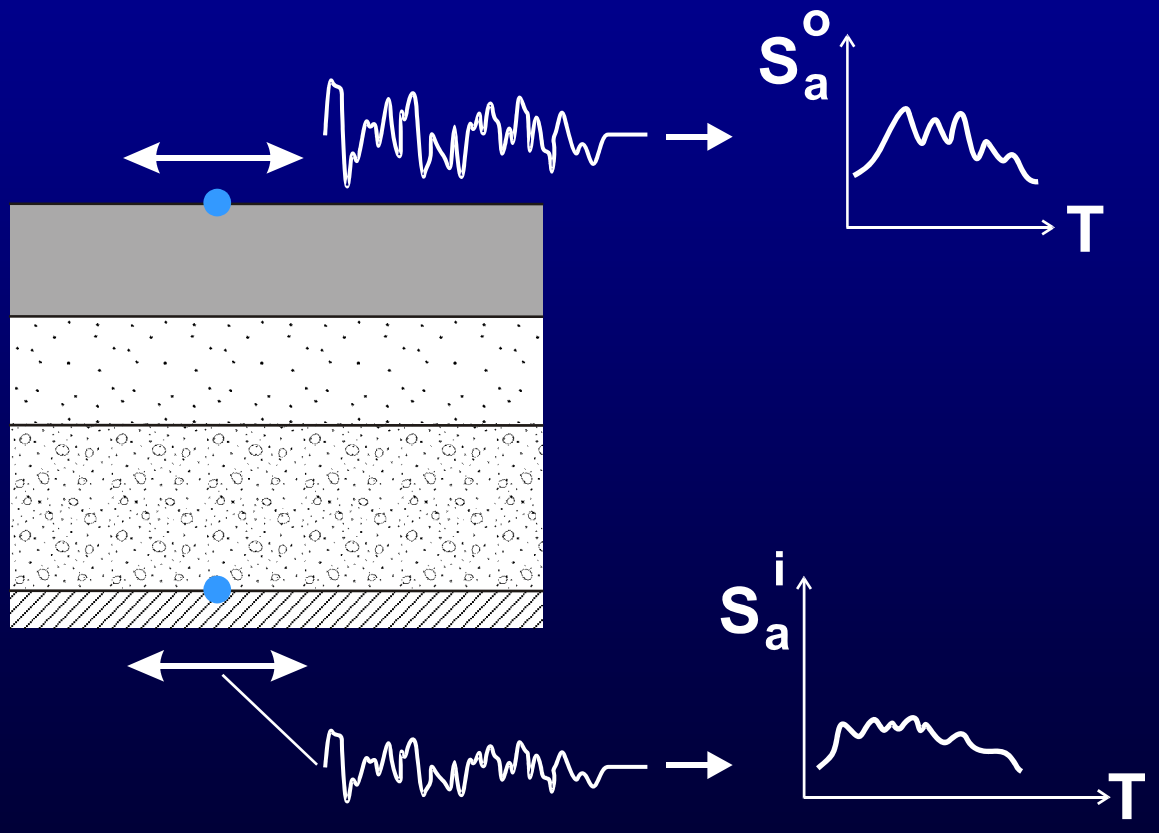
Ref.: Zeghal & Elgamal (1994)

Wildlife – 1987 Superstition Hills EQ
V_S versus Time



Ref.: Zeghal & Elgamal (1994)

Estimation of Material Damping Ratio (ξ)
Liquefied Soil

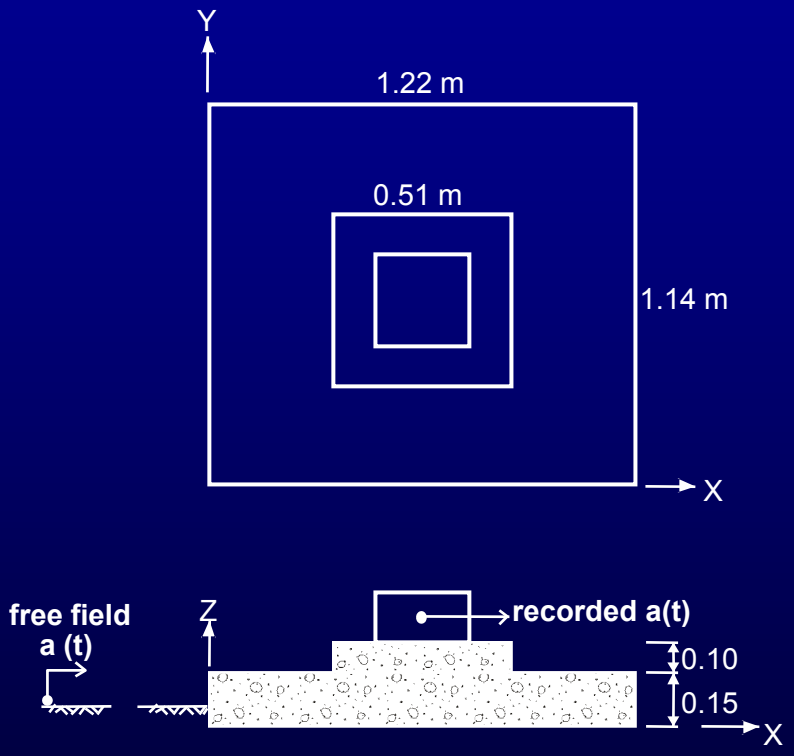


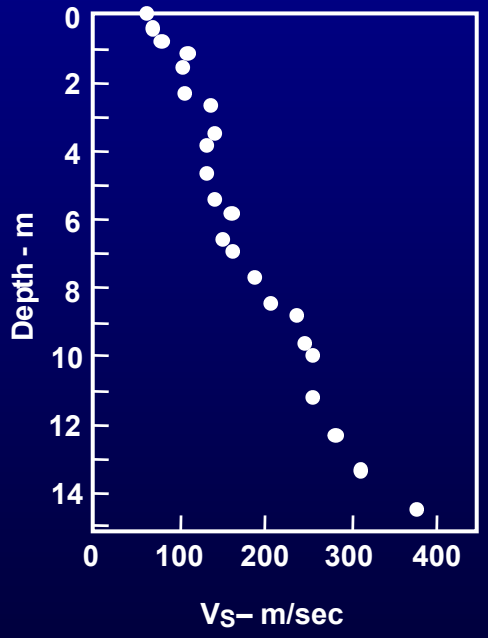
a(t) records from Port Is. & Wildlife

ξ ~ 20%

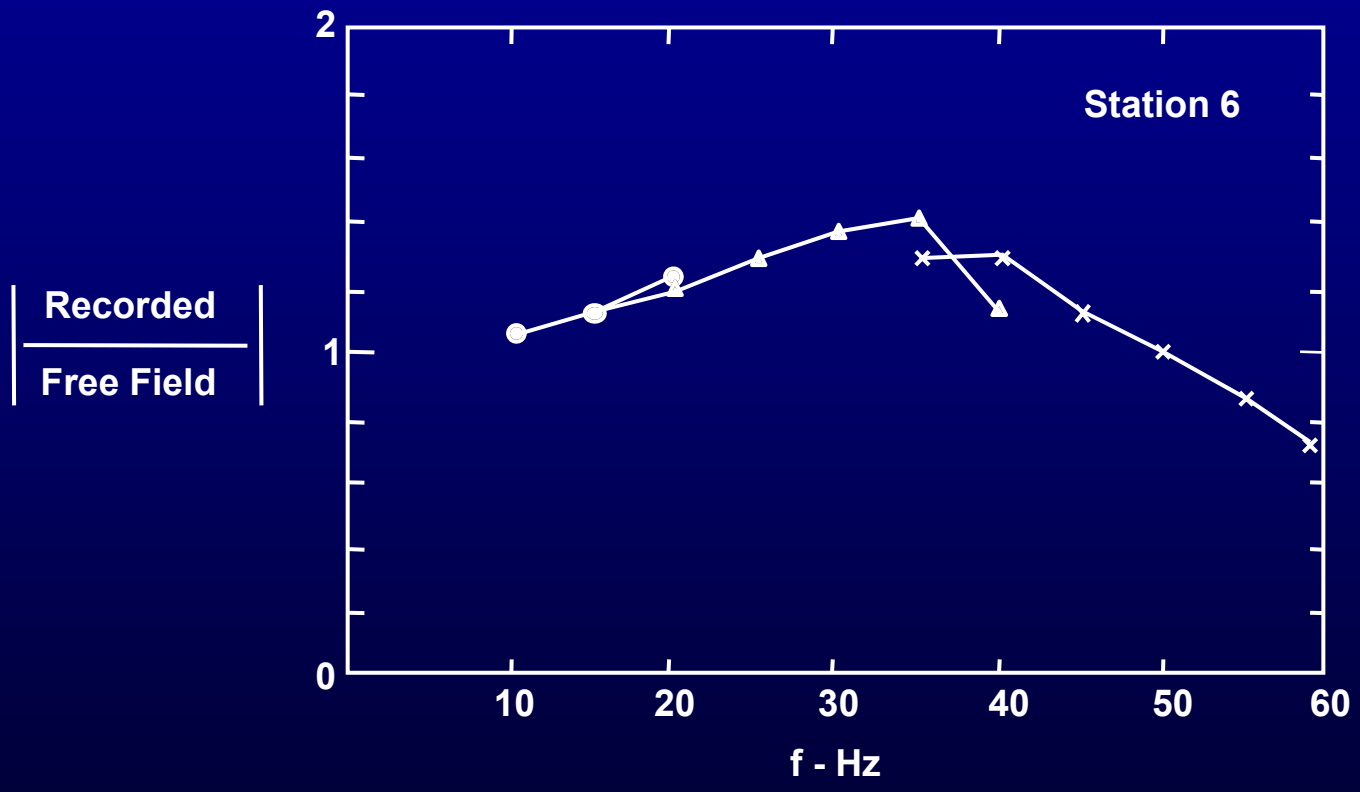
Wildlife Site
Surface Accelerograph Station

USGS El Centro Station 6





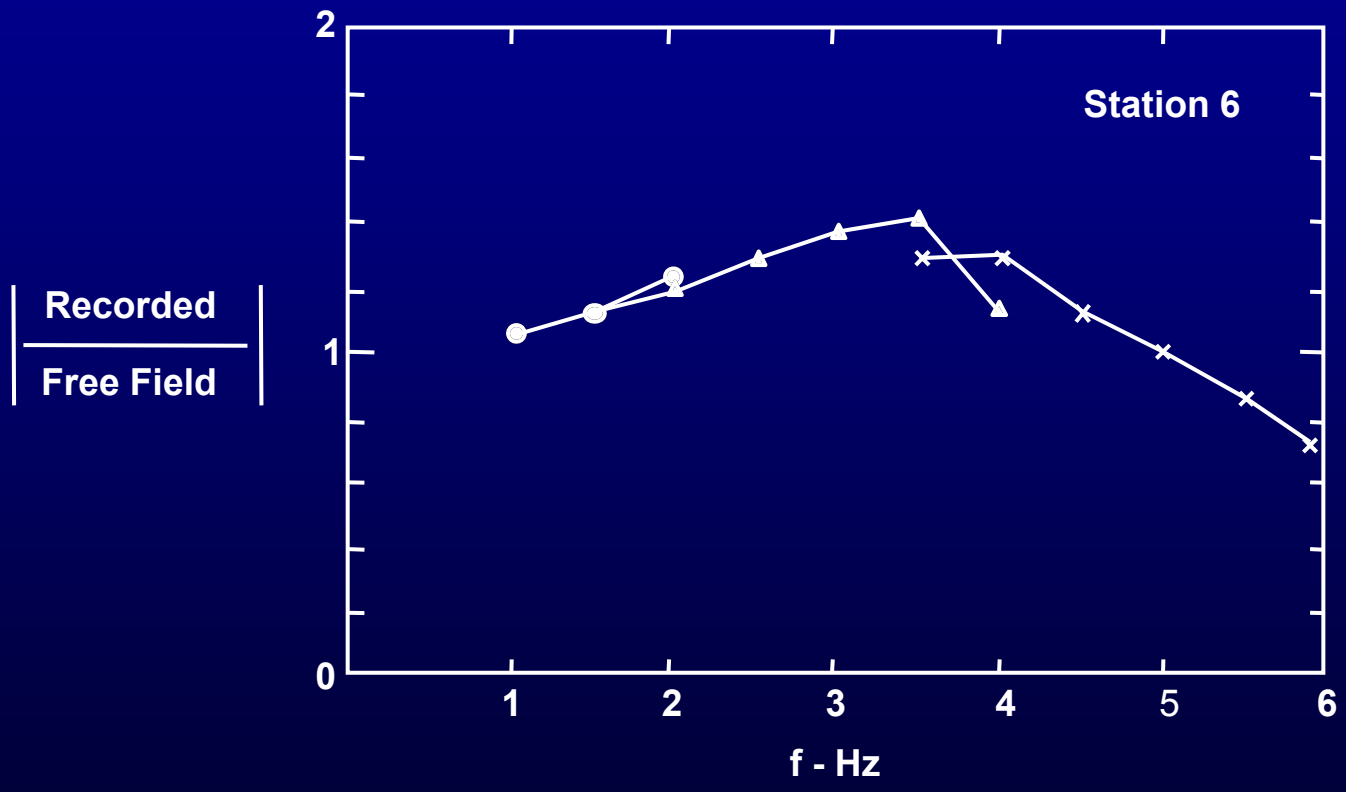
Experimental Transfer Function (low strain)



Ref. Crouse & Hushmand (1989)

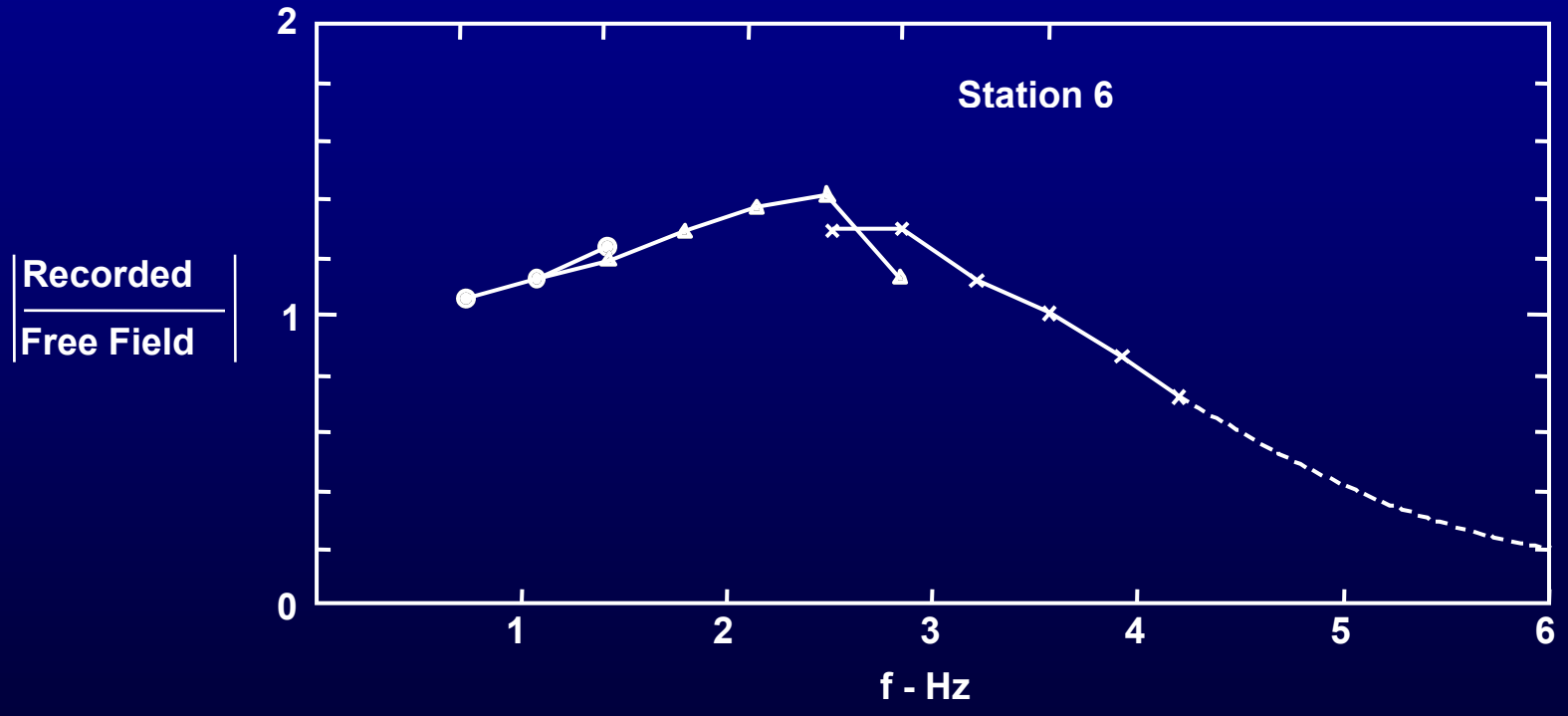
Approximate Transfer Function (liquefaction)

$V_S^{liq} = \frac{1}{10} V_S^{low\ strain}$, Pad Thickness = 6”

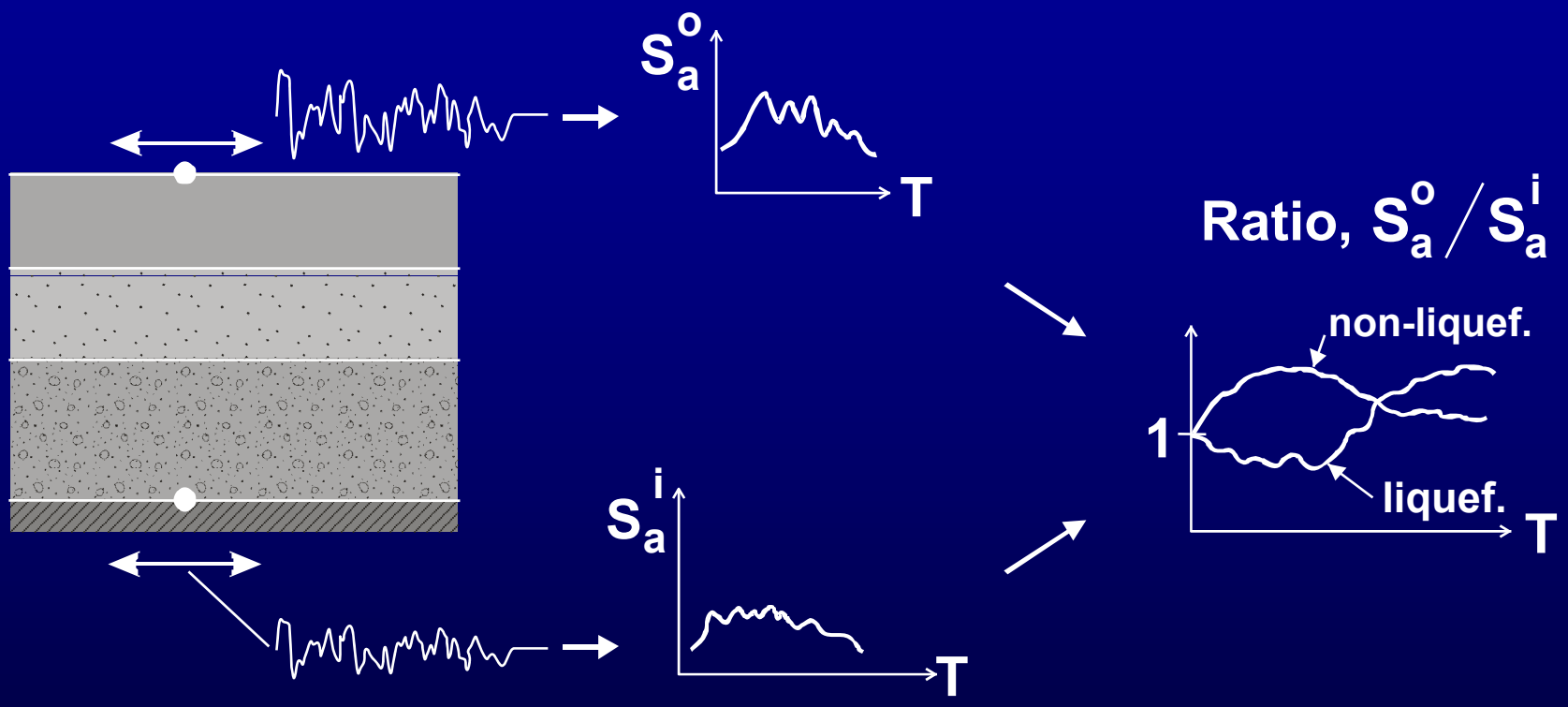


Approximate Transfer Function (liquefaction)

$V_S^{liq} = \frac{1}{10} V_S^{low\ strain}$, Pad Thickness = 12”



Site Response Analysis
(liquefaction & non-liquefaction cases)



Summary

- New Seismic Provisions in ASCE 7-10
  1. 3-D Dynamic Analysis – Accelerogram Scaling

     Scale SRSS to Target S_a (not 1.3 X Target S_a)

  2. Ground-Motion Parameter for Liquefaction

     Geomean PGA (not S_{DS} / 2.5 or S_S / 2.5)

Summary (con't.)

- Liquefied Soil Parameters for Equivalent Linear Site-Response Analysis

  Use Vertical Accelerometer Array Data

  V_S = 15 – 30 m/s

  ξ ~ 20% w/o soil-pad interaction

  } Port Island & Wildlife