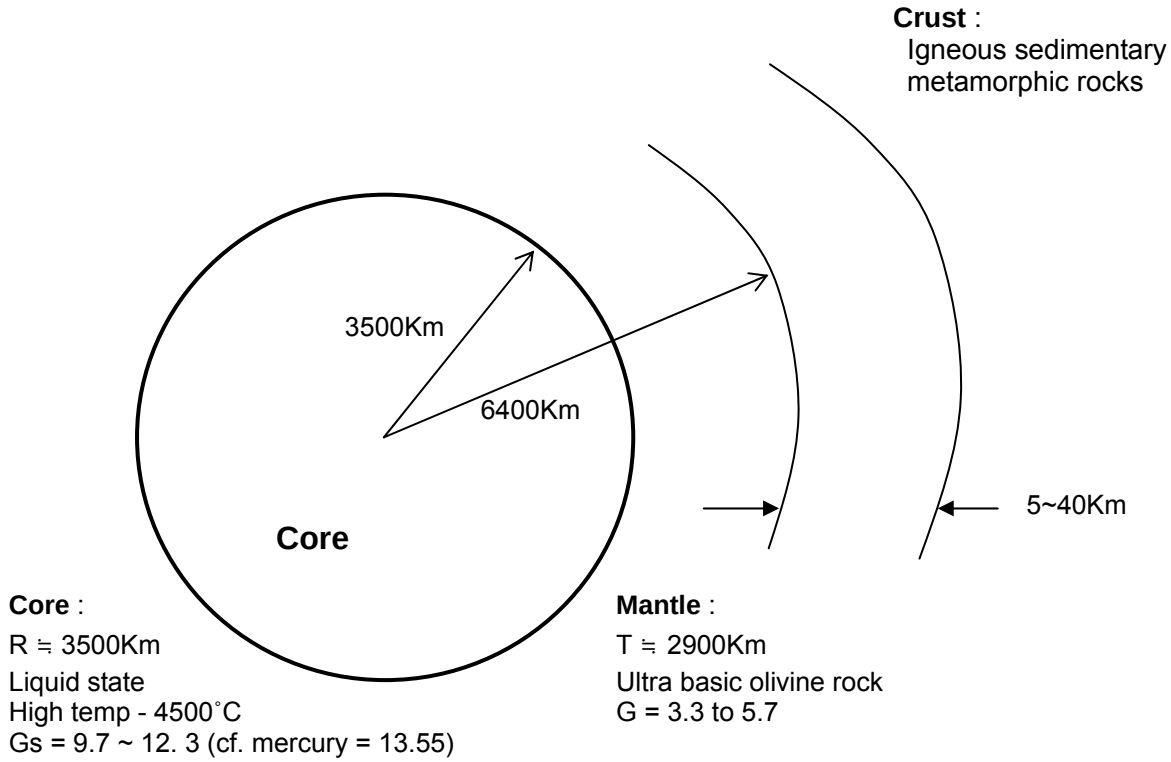
■ *Soil Dynamics : overview*

Dynamic loads (Source of Vibrations)

- Earthquakes
- Supported machines
- Bomb blasting
- Wind or wave action of water

Earth & Earthquakes

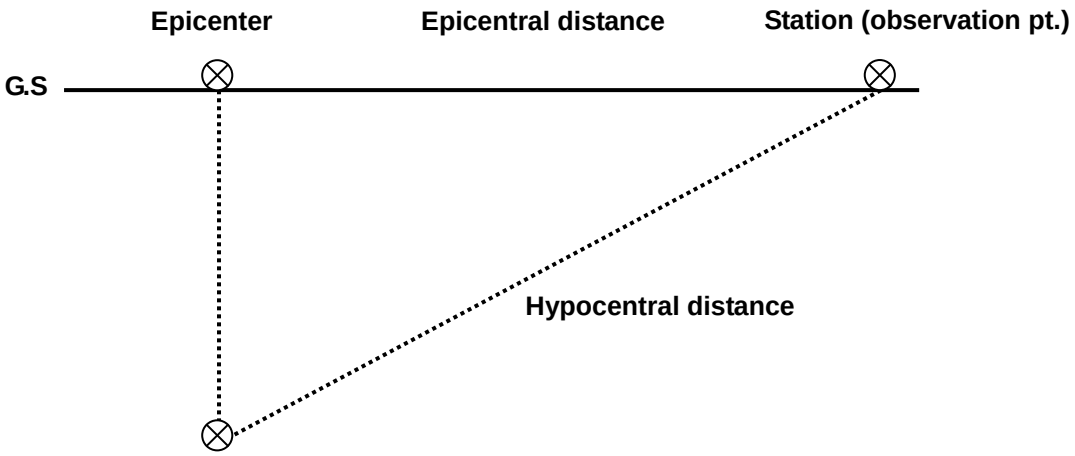
Max Depth of the source of earthquakes
= 700 Km (2000˚C, 30˚C/Km)



Core :
R ≒ 3500Km
Liquid state
High temp - 4500˚C
Gs = 9.7 ~ 12. 3 (cf. mercury = 13.55)

Mantle :
T ≒ 2900Km
Ultra basic olivine rock
G = 3.3 to 5.7

Earthquakes



Hypocenter, (where major energy released)
(Focus)

Size of Earthquakes(Intensity / magnitude)

- Intensity

1. Rossi – Forel (RF) scale (1880s)
   I - X

2. modified Mercalli (MM) scale (1931)
   I - XII

3. Japanese Meteorological Agency (JMA) scale
   I - VII

4. Medvedev – Spoonheuer – Karnik (MSK) scale
   I - XII

Table 2-1 Modified Mercalli Intensity Scale of 1931

I	Not felt except by a very few under especially favorable circumstances
II	Felt by only a few persons at rest, especially on upper floors of buildings; delicately suspended objects may swing
III	Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake; standing motor cars may rock slightly; vibration like passing of truck; duration estimated
IV	During the day felt indoors by many, outdoors by few; at night some awakened; dishes, windows, doors disturbed; walls make cracking sound; sensation like heavy truck striking building; standing motor cars rocked noticeably
V	Felt by nearly everyone, many awakened; some dishes, windows, etc., broken; a few instances of cracked plaster; unstable objects overturned; disturbances of trees, piles, and other tall objects sometimes noticed; pendulum clocks may stop
VI	Felt by all, many frightened and run outdoors; some heavy furniture moved; a few instances of fallen plaster or damaged chimneys; damage slight
VII	Everybody runs outdoors; damage negligible in buildings of good design and construction, slight to moderate in well-built ordinary structures, considerable in poorly built or badly designed structures; some chimneys broken; noticed by persons driving motor cars
VIII	Damage slight in specially designed structures, considerable in ordinary substantial buildings, with partial collapse, great in poorly built structures; panel walls thrown out of frame structures; fall of chimneys, factory stacks, columns, monuments, walls; heavy furniture overturned; sand and mud ejected in small amounts; changes in well water; persons driving motor cars disturbed
IX	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb; great in substantial buildings, with partial collapse; buildings shifted off foundations; ground cracked conspicuously; underground pipes broken
X	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked; rails bent; landslides considerable from river banks and steep slopes; shifted sand and mud; water splashed over banks
XI	Few, if any (masonry) structures remain standing; bridges destroyed; broad fissures in ground; underground pipelines completely out of service; earth slumps and land slips in soft ground; rails bent greatly
XII	Damage total; practically all works of contruction are damaged greatly or destroyed; waves seen on ground surface; lines of sight and level are distorted; objects thrown into the air

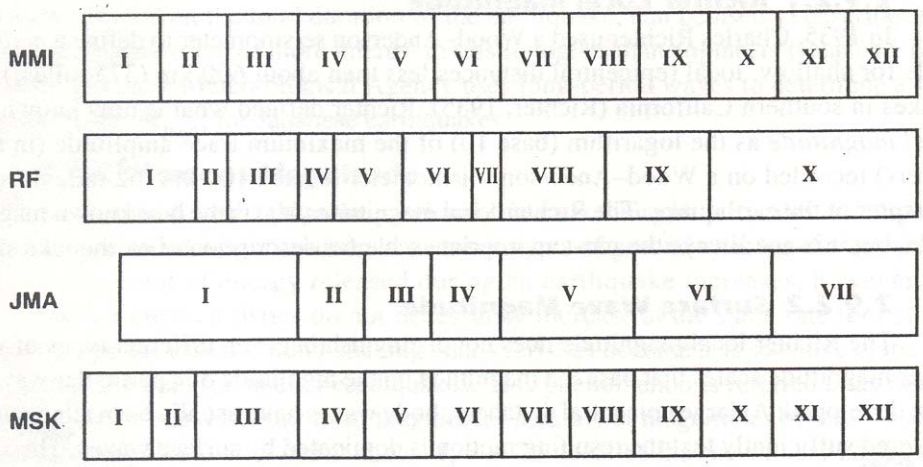


Figure 2.27 Comparison of intensity values from modified Mercalli (MMI), Rossi–Forel (RF), Japanese Meteorological Agency (JMA), and Medvedev–Spoonheuer–Karnik (MSK) scales. (After Richter (1958) and Murphy and O'Brien (1977).)

■ Magnitude

- Richter Local magnitude (M_L)
  - The logarithm(base 10) of the max trace amplitude (in micrometers) recorded on a Wood-Anderson Seismometer located 100 Km from the epicenter of the earthquake.

- Surface Wave magnitude(M_s)

$$M_s = \log A + 1.66 \log \triangle + 2.0$$

A : the maximum ground displacement in micrometers

$\triangle$: the epicentral distance of the seismometer in degrees (360° max)

- Used for shallow (< 70 Km) , distant (> 1000 Km)
  & moderate to large earthquakes

- Body wave magnitude (m_b)

$$m_b : \log A - \log T + 0.01\triangle + 5.9$$

A : the p-wave amplitude in micrometers

T : the period of the p-wave (≒ 1 sec)

- Used for deep focused earthquakes.

- Moment magnitude(M_w)

$$M_w = \frac{\log M_o}{1.5} - 10.7$$

M_o : the seismic moment in dyne-cm

$M_o = \mu A \bar{D}$ μ : the rupture strength of the material along the fault

A : the rupture area

$\bar{D}$: the average amount of slip

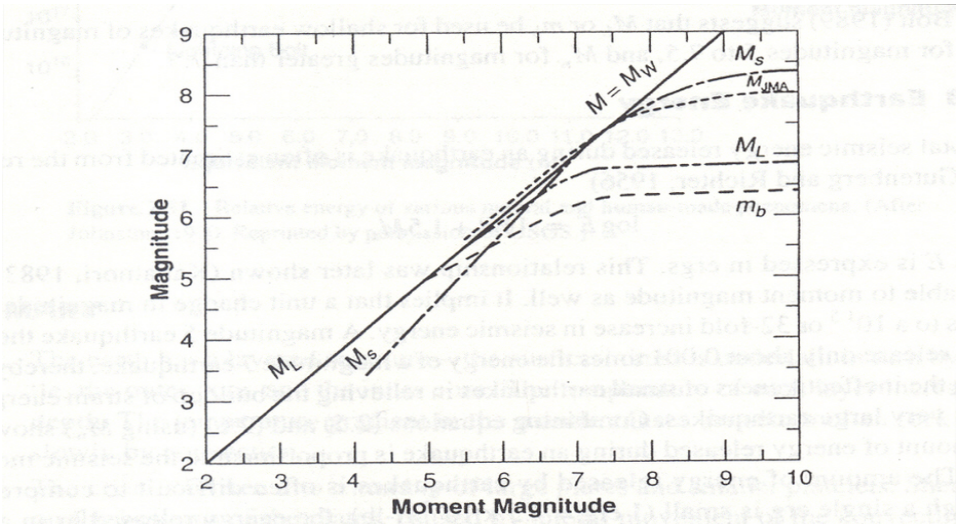


Figure 2.29 Saturation of various magnitude scales: M_w (moment magnitude), M_L (Richter local magnitude), M_s (surface wave magnitude), m_b (short-period body wave magnitude), m_B (long-period body wave magnitude), and M_{JMA} (Japanese Meteorological Agency magnitude). (After Idriss, 1985.)

■ Bolt(1989)

- M_L & m_b for 3~7
- M_s for 5~7.5
- M_w for > 7.5

■ Earthquake Energy

$$\log E = 11.8 + 1.5\, M_s$$

- The total seismic energy released is often estimated from this relationship
- Applicable to M_w as well

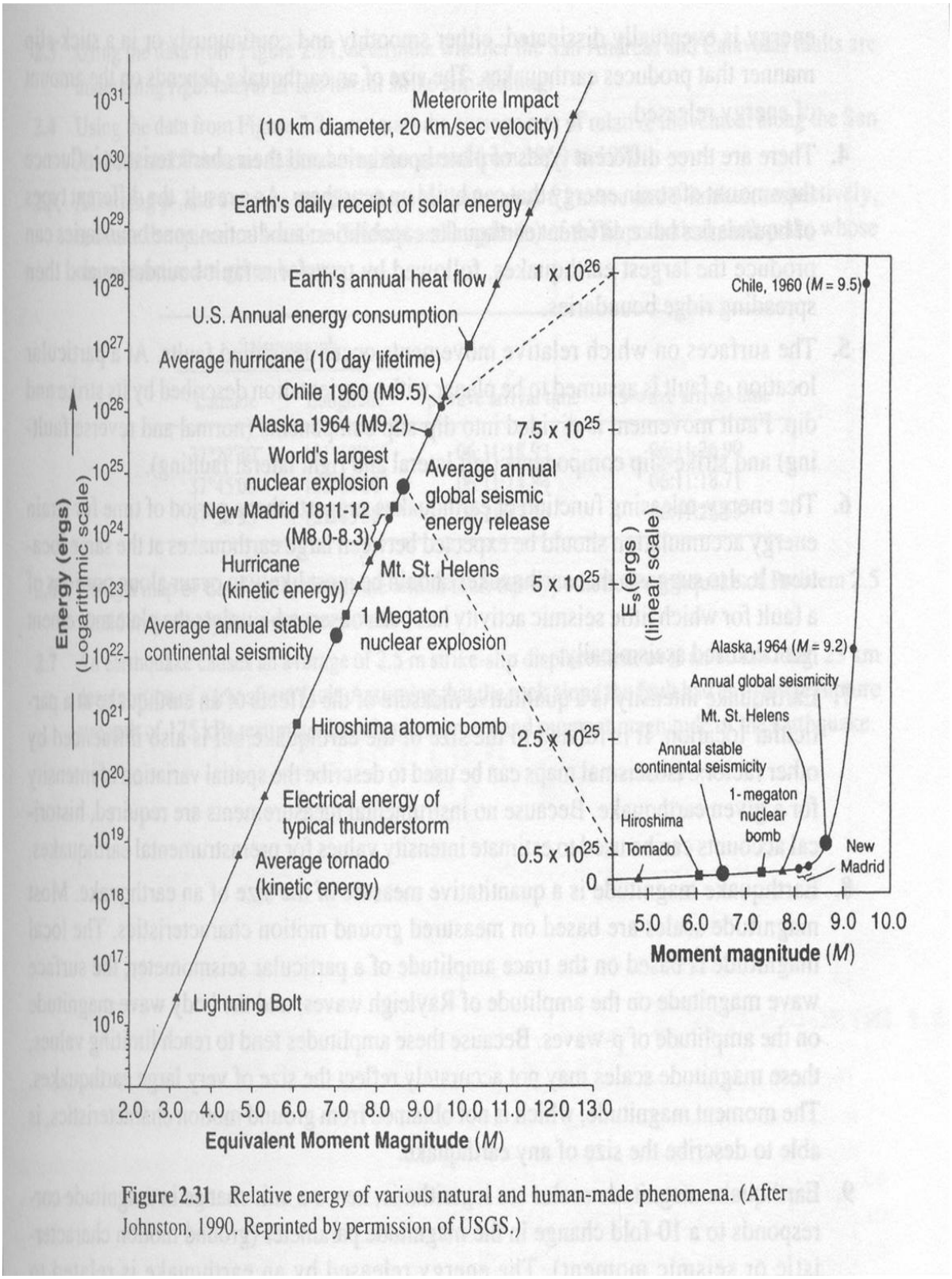


Figure 2.31 Relative energy of various natural and human-made phenomena. (After Johnston, 1990. Reprinted by permission of USGS.)

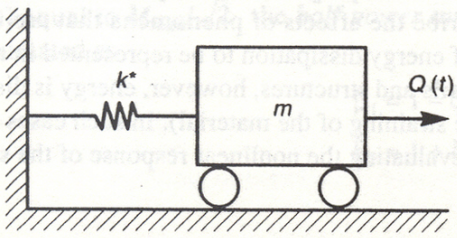


Figure B.18 SDOF system with spring of complex stiffness.

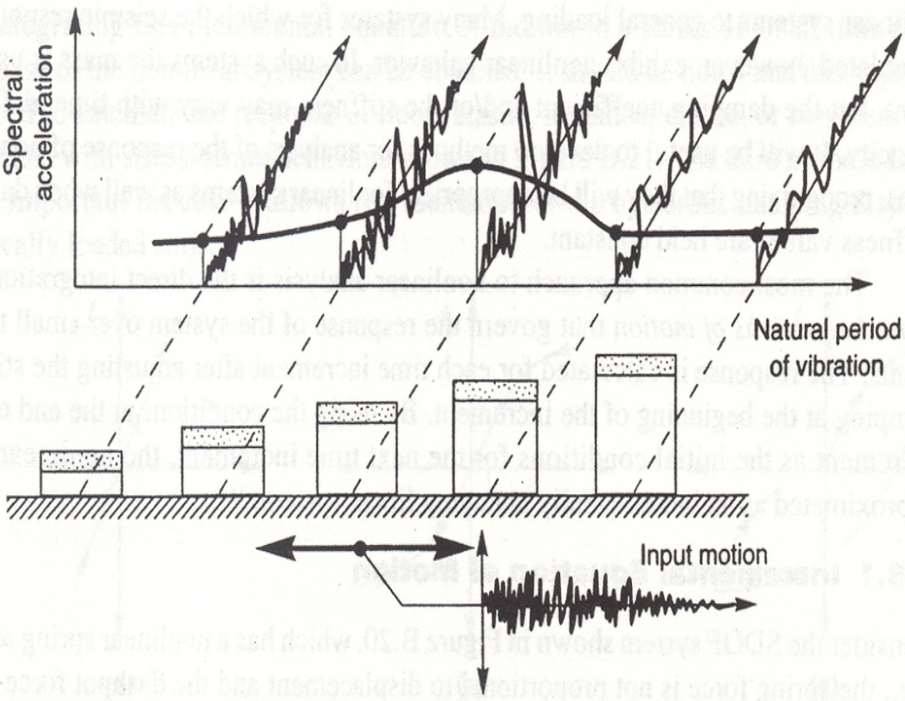


Figure B.19 Response specrum. Spectral accelerations are the maximum acceleration amplitudes of SDOF systems in response to the same input motion. The response system is obtained by plotting the spectral accelerations against the periods of vibrations of the SDOF systems.

- Limiting Amplitude of Vibrations for a particular frequency in machine foundations

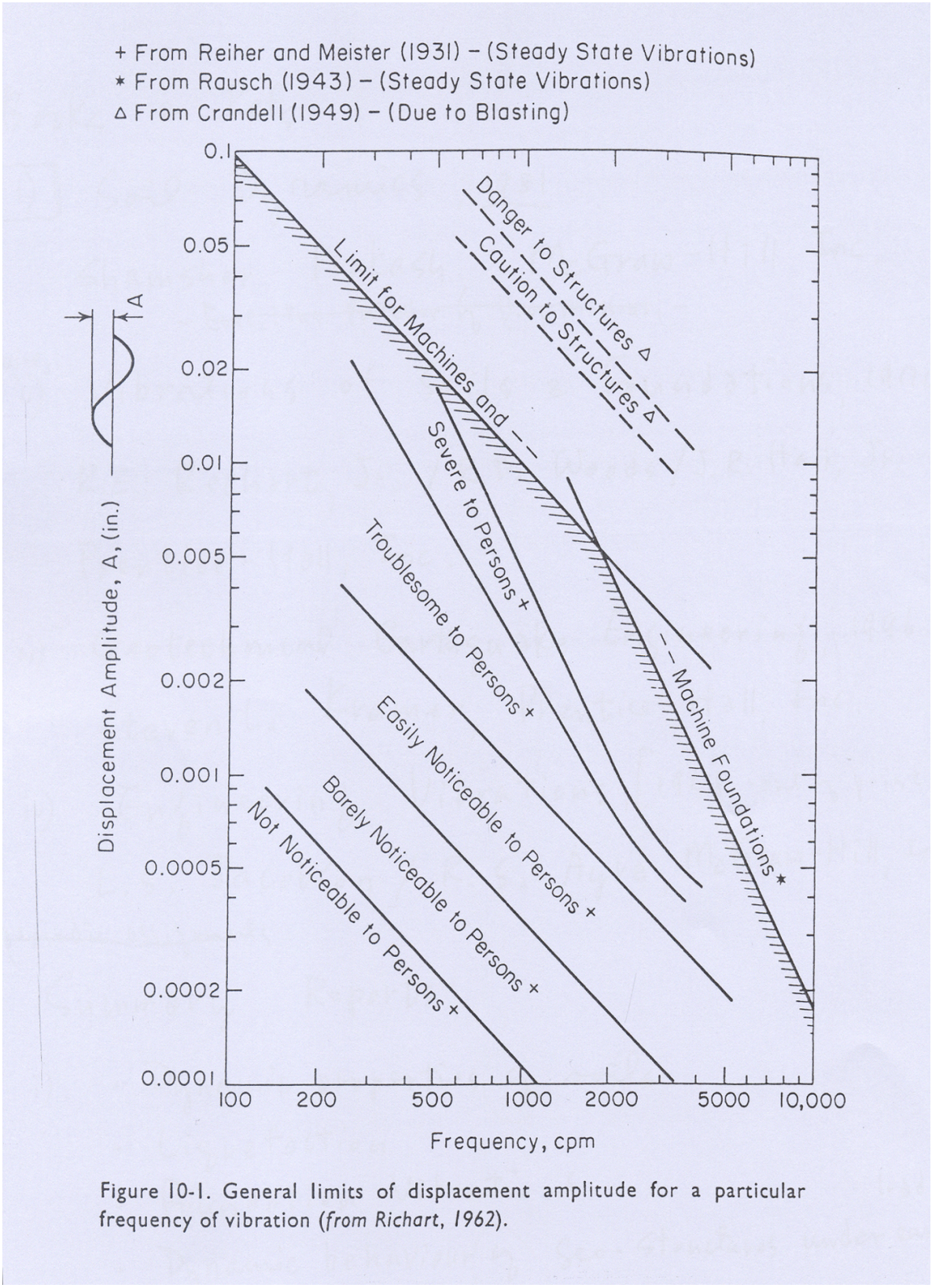


Figure 10-1. General limits of displacement amplitude for a particular frequency of vibration (*from Richart, 1962*).