

NPTEL ONLINE CERTIFICATION COURSES

EARTHQUAKE SEISMOLOGY

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Module 03 : Surface Waves and Dispersion

Lecture 01: Surface waves and its Properties, Types Of Surface Waves

CONCEPTS COVERED

- Surface Waves
- Properties Of Surface Waves
- Types Of Surface Waves
- Summary

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Surface Waves

- After having the discussion of P-and S-waves, we might expect that the seismogram resulting from an earthquake would consists of pulses of P-and S-waves arrivals.

- However, seismograms are dominated by large longer period waves that arrive after P-and S-waves. These waves are surface waves whose energy is concentrated near earth's surface.

- Their energy spreads two dimensionally and decays with distance 'r' from the source approximately as r^{-1}, whereas the body waves spreads three dimensionally and decays approximately as r^{-2} . Thus at large distance from the source, surface waves are prominent on seismogram.

Surface Waves

- Surface waves can cause damage to large buildings at relatively far distances (~50 km). Body waves near an epicenter typically are higher than 1 Hz which is near the resonant (and most damaging) frequency for small buildings like houses.

- Surface waves have lower frequencies which are near the resonant frequency of the larger buildings. Because surface waves decay in amplitude slower than body waves, they affect buildings further away than body waves do.

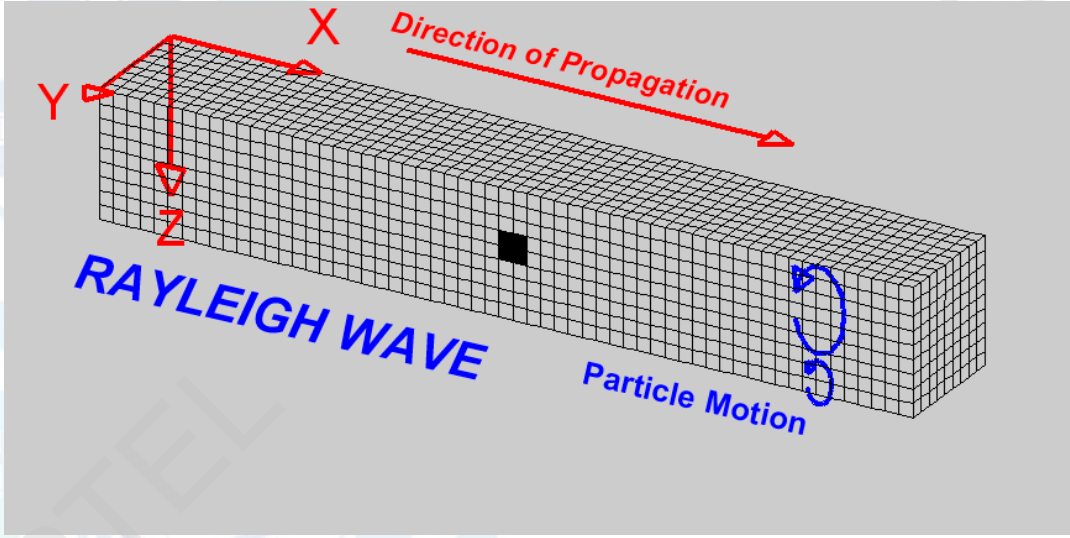
- Surface waves are sensitive to different depths within in the earth depending on their frequency. For seismologists, this makes them very handy for determining upper mantle structure, we look at surface wave properties as a function of frequency and then use this to interpret Earth structure at various depths.

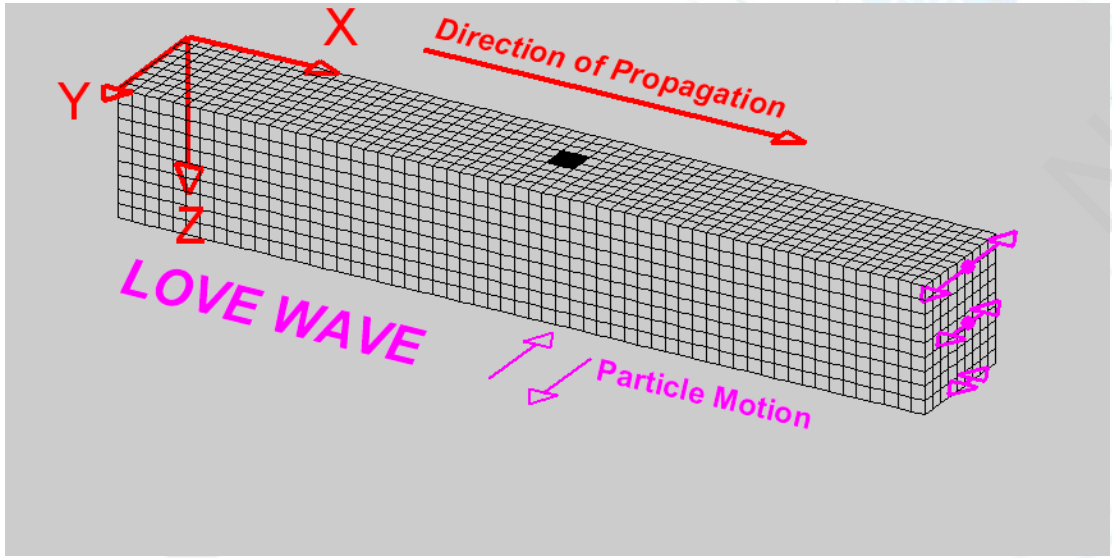
- At much smaller scales, surface waves are also used to interpret soil structure with depth or even smaller in scale-elastic properties of various media.

Surface Waves

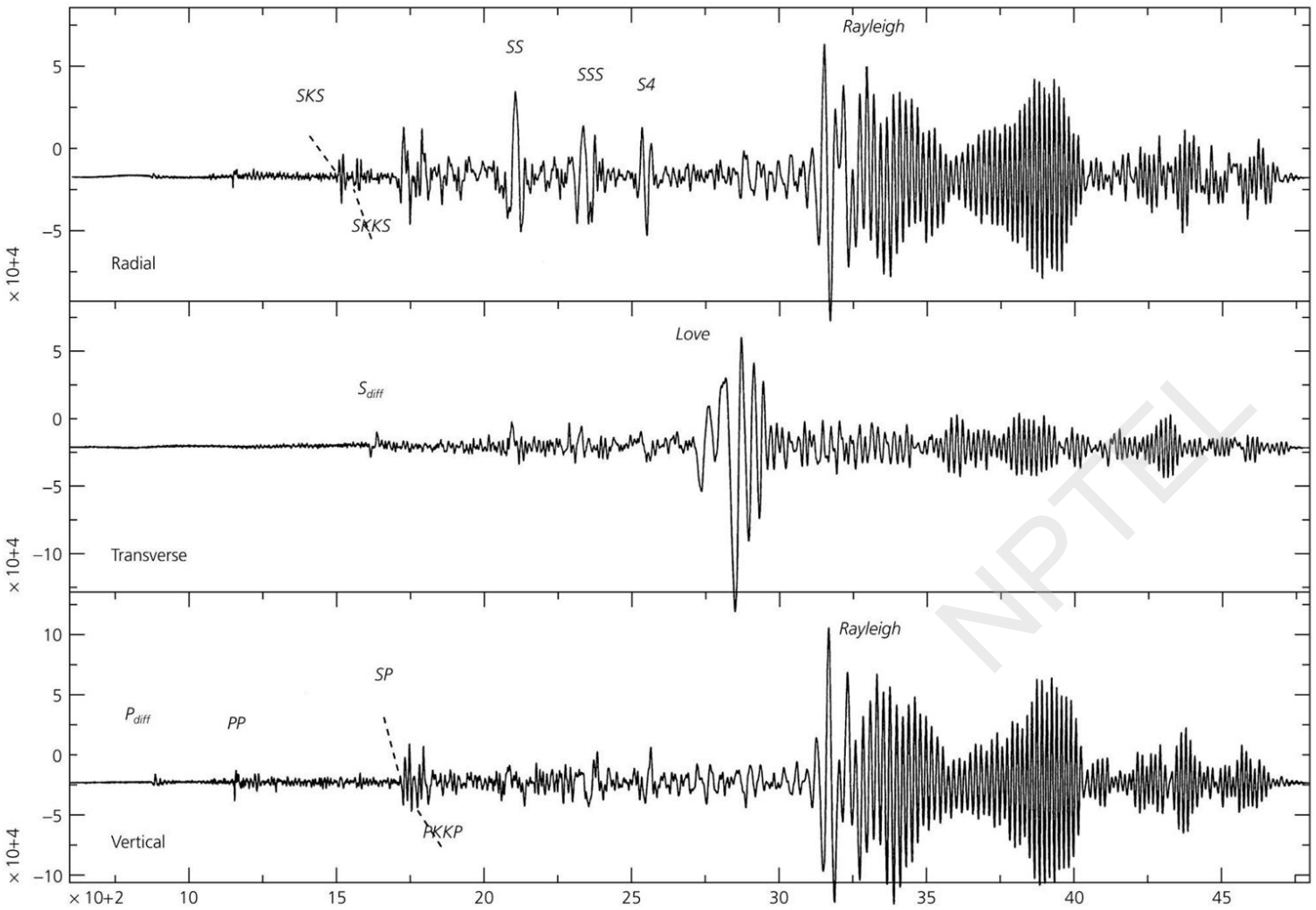
There are two types of surface waves.

1. **Rayleigh Wave**
2. **Love Wave**





https://gpg.geosci.xyz/content/seismic/wave_basics.html

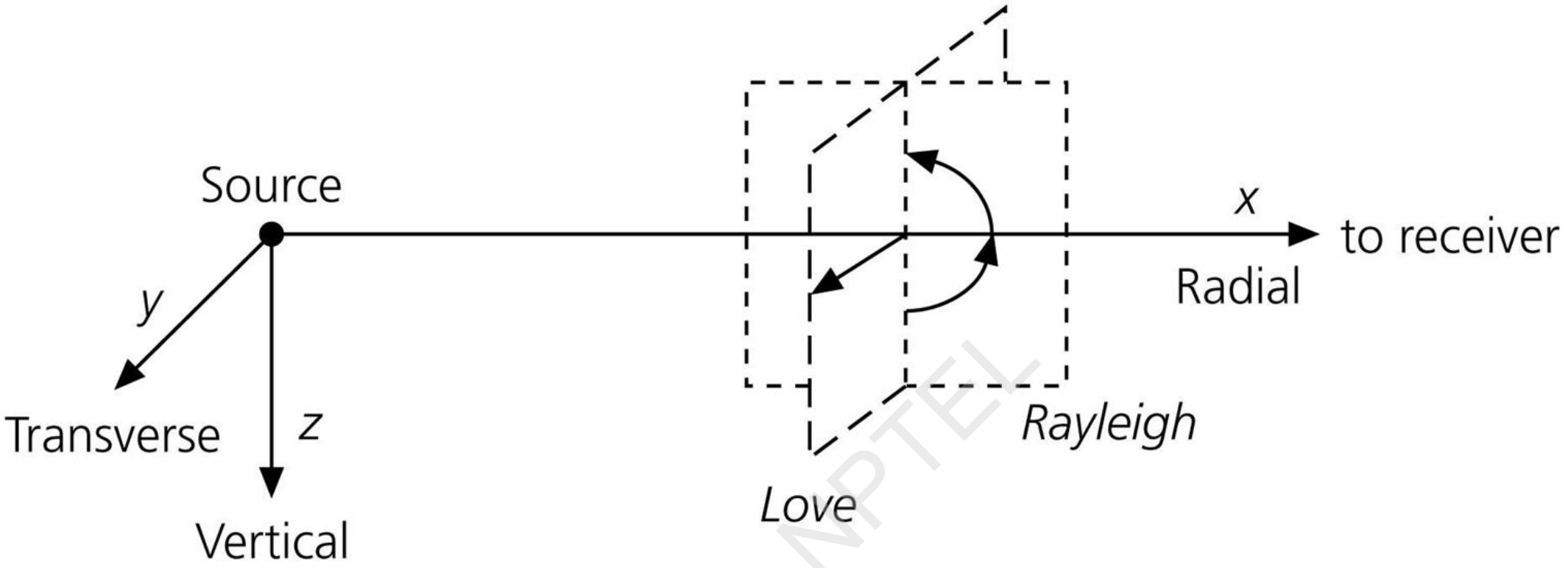


Three-component seismogram of a magnitude M_w7.7 shallow earthquake in the Vanuatu trench recorded 12,250 km away at station CCM. Note the large size of surface waves compared to the preceding body waves. The Love wave is observed on the transverse component, and the Rayleigh wave is primarily seen on vertical and radial component

Surface Waves

Figure shows a large surface wave train arriving on a seismometers transverse component, followed by another wavegroup on the vertical and radial components.

- Love waves result from the SH waves trapped near the surface.
- Rayleigh waves are combination of P and SV motion



Geometry for surface waves propagating in a vertical direction in a vertical plane containing the source and receiver. rayleigh (P-SV) waves appear on the vertical and radial components. Love (SH) waves appears on the transverse component

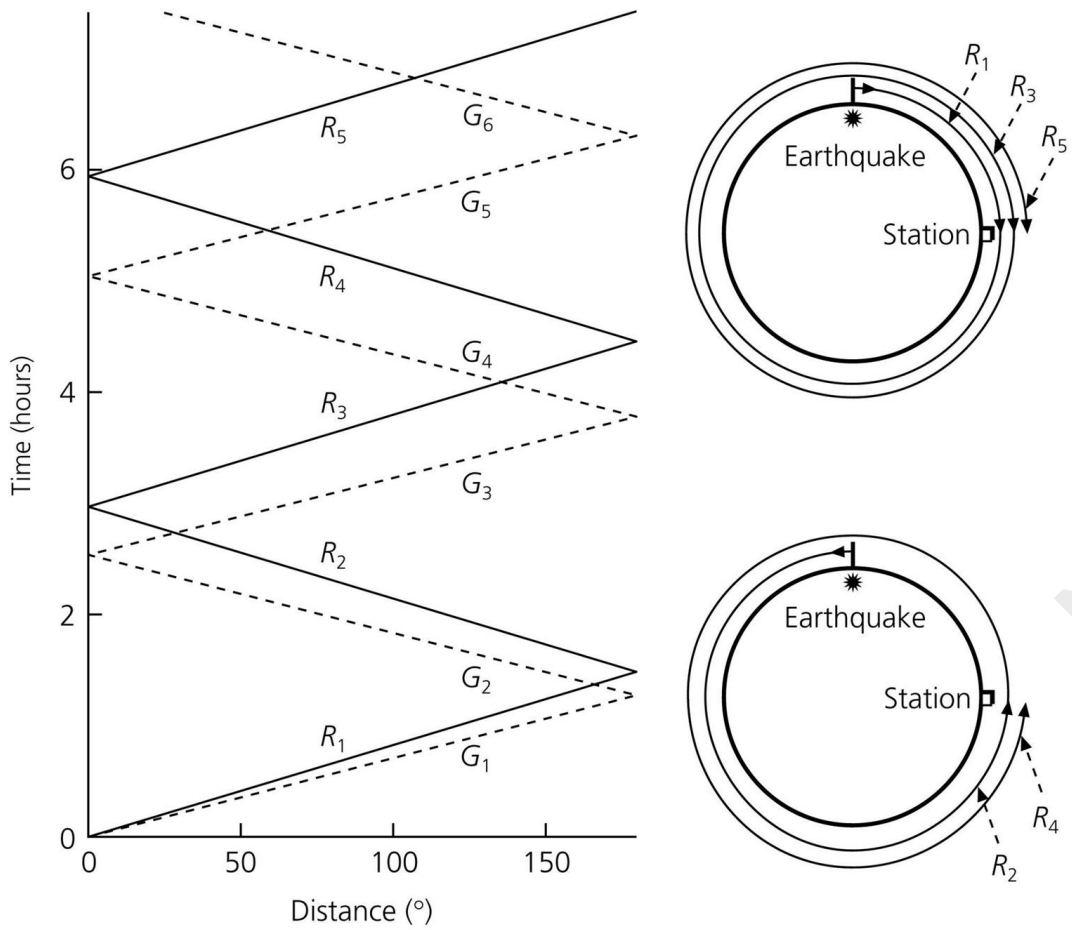


Fig. 2.7-3 Multiple surface waves circle the earth. Right: Odd-numbered arrivals (R_1, R_3, etc.) take the shortest path from the earthquake to the station, whereas even-numbered arrivals (R_2,R_4, etc.) travel in the opposite direction. Left: Travel times for multiples Rayleigh (R_n) and love waves (G_n)

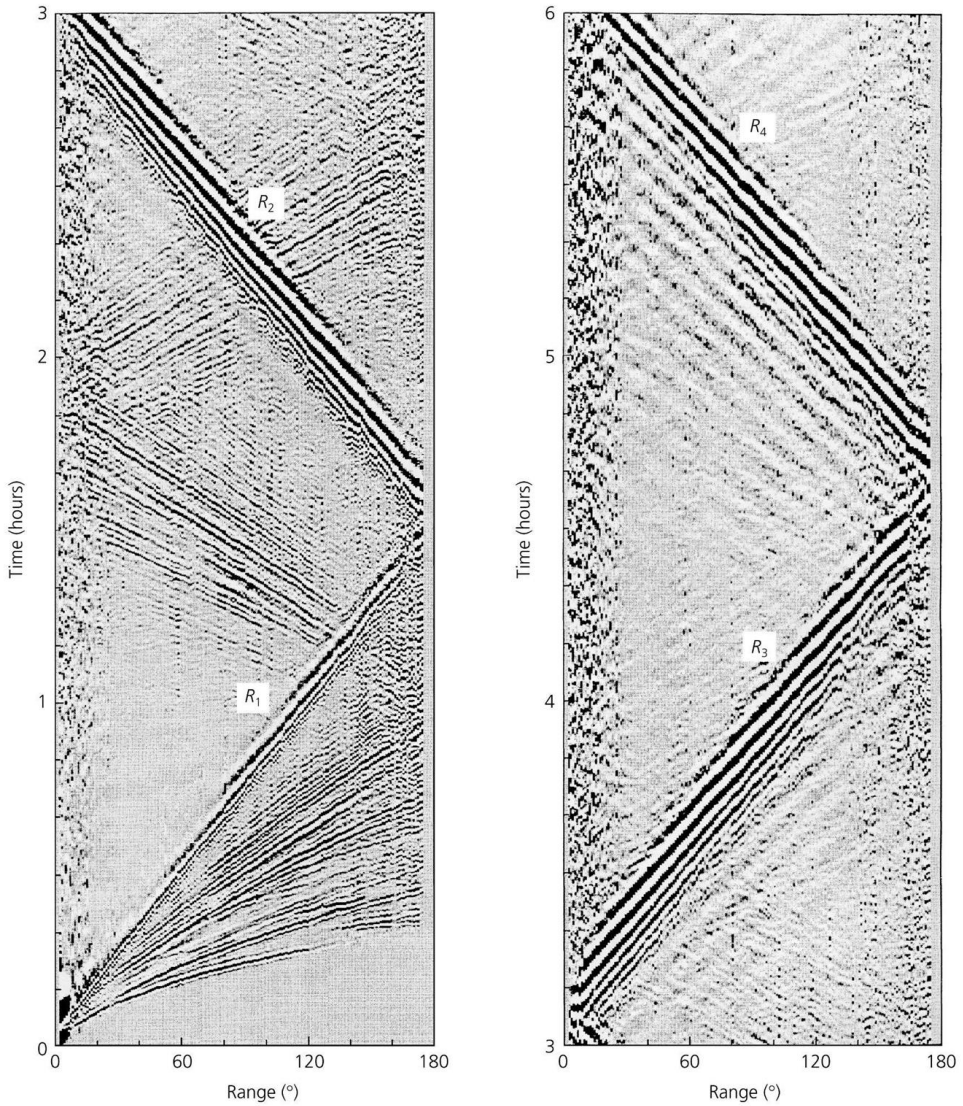


Fig. 2.7-4 Record section formed from the vertical seismograms at stations of the IDA (International Deployment of Seismometers) network. The R_1 through R_4 arrivals are spread in time due to dispersion and contain lines of energy that crosses the largest amplitude at small angles. The lines shows the phase velocity, and overall amplitude pattern show group velocity. Body wave arrival appear before and after R_1 (Shearer, 1994)

Surface waves

- Surface waves can circle the globe many times after a large earthquake.
- Figure shows multiple surface waves, which are denoted as Rayleigh Waves (R_n) and Love waves(G_n)
- An important feature of surface waves is dispersion, the fact that waves of different periods travel at different velocities.
- As a result, the surface wave arrivals are not sharp lines, but are spread out in time.

Summary

- Their energy spreads two dimensionally and decays with distance ‘r’ from the source approximately as r^{-1}, whereas the body waves spreads three dimensionally and decays approximately as r^{-2}.

- Surface waves can cause damage to large buildings at relatively far distances (~50 km). Body waves near an epicenter typically are higher than 1Hz which is near the resonant (and most damaging) frequency for small buildings like houses.

- The two types of surface waves we are most concerned about in global and regional seismology are Rayleigh and Love waves.

- Love waves results from SH waves trapped near the surface and rayleigh waves are combination of P and SV motion.

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THANK YOU !