

## Shear Waves from Vibrators

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Relationships between shear waves and vibrator sources are somewhat conflicting and amazing.

Manufacturers easily made the mass vibrating horizontally but the problem of the horizontal vibrator is coupling: inversed pyramids or vertical blades (fig 1) are necessary to transmit horizontal stresses. There is still a limit that is the breaking of the ground material in between the blades. In practice, it is most often difficult to conduct seismic exploration with shear vibrators because shear penetration and seismic response are very sensitive to the rigidity or the wetness of the ground. One more particular of shear transmission: upsweep cannot be used because lower frequency means larger base-plate displacement, thus poor coupling for smaller displacement of higher frequencies.



Fig 1

When surface conditions are favorable, an horizontal vibrator is a perfect source for transmitting shear waves and compressional waves as well. This is because whatever the direction vertical blades hurt the ground they produce compressional stresses. Thus a sweep from a vertical vibrator transmits at once horizontally polarized waves according to its pilot signal and compressional waves according to its second harmonic. This is a very economical way to run multi-component exploration. It is consistent with the average value of  $V_p/V_s$  ratio and also with the average frequency range ratio between compressional or shear propagation (fig 2). The P wave response obtained this way is generally quite satisfactory sometimes better than the S mode one.

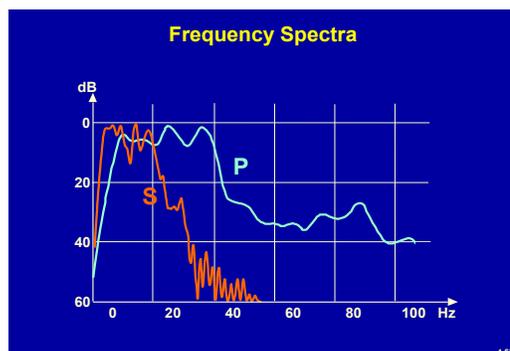


Fig 2

Now what about the vertical vibrator?

Modeling studies and observations show that more than 70% of vertical vibrator energy is transmitted to the ground as shear waves in the Sv mode (fig 3). A substantial part of this energy is dispersed, producing surface waves, but Sv body waves are also transmitted, which means that two ways exist for recovering Sv mode response:

- Sv-Sv reflections from in-line horizontal receivers,
- Sv-P mode from the vertical receivers. Of course, azimuthal information will be lost in this way.

According to Zoeppritz's relation, Sv to Sv mode is more energetic. Recovery of the weaker SvP converted mode energy would be more delicate but could become possible when considering the present potential of seismic industry: high degree of coverage fold, sophisticated digital processing tools. Routines developed for PSv processing, whose efficiency is progressively improved, are easy to adapt for processing SvP mode data.

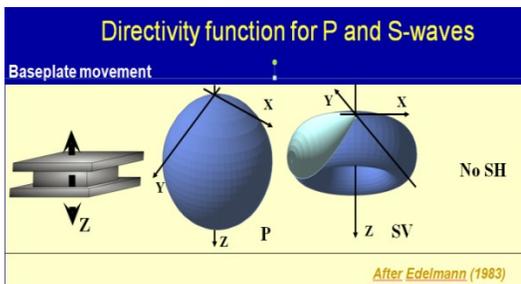


Fig 3

My conclusion: multi-mode seismic (PP+SvP) could be extracted from conventional vertical vibrators and vertical receivers provided processing routines are carefully applied.