# Poisson's ratio of water saturated alluvium in Penang from shallow seismic refraction

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Applications of shallow seismic refraction in groundwater modelling and engineering site investigation are limited, to a great extent, to P-wave energy recorded on single-component vertical geophones or pressure sensitive hydrophones. The use of explosive sources, and mechanical sources designed to mimic in some way explosive sources, the simplicity of single component seismometer recording data, and, the requirement of determining the transit time as best served by the early arriving P-wave seismic energy are reasons for this constrain. On the other hand the particle motion of transverse S-waves depends on different elastic parameters and thus can provide valuable independent information on the *in-situ* pore-fluid content and geotechnical properties of the ground.

The purpose of this study is to examine the characteristics of Poisson's ratio for three different alluvial soil units found in Penang: (a) clean bench sand, Teluk Kumbar (b) marine clays, Balik Pulau and (c) weathered granite soil cover, Bukit Gambir. Values of P and S-wave velocities are determined in the field by the refraction method using an engineering seismograph. Conventional shallow hammer seismics yield adequate signal resolution over a 50 meter line. Horizontal shear waves are generated by striking one end of a thick timber railway sleeper aligned perpendicular to the profile line. Enhanced coupling between the S-wave source and ground is achieved by bolting long metal spikes to the timber sleeper so that it can be driven into the ground. A horizontal geophone is used to record the SH-wave arrivals. A polarity switch feature on the seismograph aids in correct S-wave identification.

In (a) we distinguish a dry sand on top of the fully water saturated sand with Vp; Vs; Vp/Vs; and Poisson's ratio ($\sigma$) of 370 $ms^{-1}$, 1600 $ms^{-1}$, 180 $ms^{-1}$, 360 $ms^{-1}$; 2.03, 4.44, and 0.34, 0.47 respectively. For the marine clays in (b) we obtained a 2 layer dry-wet configuration with Vp = 350 $ms^{-1}$, 1400 $ms^{-1}$; Vs = 190 $ms^{-1}$, 510 $ms^{-1}$; Vp/Vs = 1.84, 2.96; and $\sigma$ = 0.29, 0.42 for the first horizon and a fully water saturated second horizon respectively. For comparison, in (c), the gradational change of velocity with depth in weathered granite cover in a 2 layer model is characterised with Vp = 480 $ms^{-1}$, 830 $ms^{-1}$; Vs = 240 $ms^{-1}$, 420 $ms^{-1}$; Vp/Vs = 2.04, 1.97; $\sigma$ = 0.34, 0.33 for the first and second velocity discontinuity respectively.

Our study suggests that in lithologic characterization, valuable information can be derived from values of both P and S-wave velocities. Poisson's ratio ($\sigma$) and the more simple and easier to use Vp/Vs ratios are sensitive to lithologic types and amount of water saturation or indirectly the porosity in it, and can prove useful in groundwater mapping. The combined use of P and S-wave velocities in depth estimation affords a more stringent control in the presence of intermediate velocity layers, especially in water saturated alluvium.



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