Near-surface evaluation of Bora office area using MASW methods on land-streamer

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Abstract. A limited seismic investigation of the Bora Office Area, was conducted using multiple seismic methods including multi-channel analysis of surface waves (MASW), using land streamer originally designed by the author. The main feature of the land streamer tool is the non-stretch woven belt on which geophone units are mounted to form a multichannel geophone array similar. As a result, it was concluded that it might be possible to avoid higher-mode contamination at low frequencies at sites with high (Vs), it can be seen that the distribution of Vs values varies over the range of 240 m/s to 420 m/s. In general, can be divided into 2 layers based on the value of Vs 100 - 250 m/s as soft rock and > 250 m/s as hard rock. There is a soft rock at a depth range of 0 to 5 m with a velocity value of 140-260 m/s, and hard rock layers at a depth range of below 5m with a velocity value of 280 - 400 m/s.

1. Introduction

Bora regency is found at the profoundly complex Indonesian structural collage that isolates the merging Eurasian, Indo-Australian and Philippine Ocean Plates. For example, subsidence, landslides and physical change related to earthquakes or significant rainfalls cause the loss of life and wealth nearly every year. To stop such a ground disaster, subterranean data is needed. Therefore correct geotechnical investigation strategies are vital for constructing a safe and property society that consists of buildings, railways and highways supported by applied science technology [1].

MASW method is a tool for estimates the S-wave speed structure beneath the seismic receiver array and analyzing unstable data within the frequency-velocity domain. Its application esteem shifts, unremarkably near to study examination. The result from an MASW study and investigation is imperative for an arrangement of 1-dimensional S-wave speed profiles. Since the information is collected on a line and tested at closely divided interims, it's common to blessing the data within the sort of a 2-dimensional segment of S-wave speeds along the study line, rather than a 1-dimensional profile with profundity [2].

The measuring of MASW with arrive streamers seem moreover be essentially satisfactory since surface waves may be the most extreme sum as relate arrange of greatness bigger than body waves and in differentiate to the klick long streamers sent in marine overviews, streamers for shallow arrive studies can be comparatively brief and have horrendously closely dispersed geophones, a request for shallow studies that directly makes their cost preventive for a few applications. In reaction to this point, the
creator planned an instrument that coordinates the geophone cluster that will be towed and asphalt, named it the Land Streamer [3].

MASW unsteady strategies are effective instruments for depicting near-surface, how each standard ammo is amazingly time strongly and exorbitant, requiring the format of geophones and cables, and their regular development along a study line. The arrive Streamer apparatus will scale back field work exertion, and limit site occupation time, for a refraction study. Particularly in urban regions, wherever surface are basically fixed and intensely utilized, the device illustrates its suitability in such open ranges as lanes, sidewalks, and work environment zones.

2. Geology of Palu Region

The position of Sulawesi island is located at interims the amazingly complicated Indonesian structural collage that isolates the joining Eurasian, Indo-Australian and fight of the Philippine Ocean Plates. This region is characterized by four particular lithotectonic belts, that are delimited by large-scale structural disengagements and overthrust blame following from different geographical time collision between rifted microcontinental piece, maritime part (ophiolites) and island circular segment parts.

They include from west to east: (i) the northwest (NW) Sulawesi Tertiary magmatic circular segment and related silt, (ii) the Central Sulawesi transformative belt, (iii) the East Sulawesi Ophiolite, and (iv) the accumulated mainland part of Banggai-Sula islands and the Tukang Besi-Buton stage (Figure 1).

![Figure 1. Tectonic map of Sulawesi showing major structures in the region. Red dots indicate earthquake hypocenters with a magnitude greater than 4.5 and a depth less than 30 km between 1980 and 2016. The moment tensor of the Mw 7.5 2018 earthquake and earthquake hypocenters are from the USGS Earthquake Catalog. b DEM map showing morpho-structural elements of Palu Basin. Palu Valley is bounded by two mountains in the East and West. Structural elements in Palu Valley are compiled from previous authors [9].](image)
Figure 2. Detailed geological map and cross-section of Palu-Koro region (modified from Sopaheluwakan et al, 1995). The sample localities and mode occurrences of the rocks are also shown [9].

3. Data acquisition

MASW result dispersion could be a seismic methodology for shallow sub-structure characterization victimization shear wave (Vs). It utilizes the Rayleigh-type surface waves that have property of dispersion in the main passion about near-surface Vs structure. Therefore, by analyzing the dispersion of surface waves, one will acquire a near-surface S-wave velocity profile [8]. Multi-channel recording of surface waves makes information acquisition more practical and permits dispersion analysis additional simply than typical single or double channel recording method [4], we have a tendency to applied and with success developed the Land Streamer kind recording tool to fast the sub-section performance. Dispersive section velocities are picked from the converted information into the speed-frequency domain. A stratified S-wave velocity profile is calculated from the dispersion curve [6].

The most include of the Arrive Streamer apparatus is that the non-stretch woven belts on that geophone units are mounted to form a multichannel (24) geophone cluster. The instrument is frequently towed essentially by hand or by a vehicle that carries the unsteady framework. The woven belts, which were initially outlined for slings, take the total pressure, and keep the dividing between geophone units on them affixed once towed. Each geophone unit homes a double flat component tensor, and is affixed through the belt to concrete baseplate (Figure 3). In spite of the fact that each geophone unit is coupled to the level by a the concrete baseplate instead of being immovably planted inside the ground, the Arrive Streamer (dimension 12.5 cm x 8.5 cm) apparatus gives moderately clean information unaffected by activity commotion, indeed on street [10].

The MASW survey used a purpose-made two4-channel land streamer with 4.5Hz geophones spaced at 2 meters geophone interval. The supply used a 5 kg weight with a hammer. The procedure was perennial on every of the survey lines (Figure 4). The info was analyzed victimization the SurSeis software system by Kansas geologic and acquisition data with DoReMi measuring system by SARA electronic instrument (Figure 5).
We can see from Figure 6, the processing results for Line D. Line D has a length of 900 m in the NW-SE direction. The results of the dispersion curves for line D taken in the 0 m, 420 m and 846 m shots look clean with a little Low Ground Noise 20 - 45 Hz. Meanwhile, based on the results of the inversion of the velocity model, there is a very significant change in velocity from 0 m to 10 m, which is 200 m/s which is categorized as soft rock [5]. At a depth of 10 m to 25 m the value of Vs velocity varies widely horizontally, where at the 0 m to 450 m position from the initial shot position there is a decrease in speed of 50 to 100 m/s which can be interpreted as a
low-velocity layer. And for line D, the hard rock looks different in average depth at a depth of 30 m with an average velocity of \( V_s = 420 \text{ m/s} \) [5].

![Figure 5](image)

**Figure 5.** Measurement MASW (a) DoReMi seismograph equipment (b) Land streamer (c) Wooden hammer (d) & (e) acquisition data MASW surface-wave data acquisition using land streamer

Whereas in Figure 7 shows the 2D inversion results from Line D, it can be seen that the distribution of \( V_s \) values varies in the range of 140 m/s to 400 m/s. In general, line D can be divided into 2 layers in which an interface is dipping by 5 degrees based on the value of \( V_s \) (100 - 250 m/s as soft rock and> 250 m/s as hard rock). In line D, there is the soft rock in the depth range of 10 to 40 m with a velocity value of 140-200 m/s, and hard rock layers at a depth range of 11 to 45 m with a velocity value of 260 - 400 m/s. Topographic corrections were performed using the LIDAR data on the inversion section of the \( V_s \). The results can be seen in Figure 7 at the bottom.

Shortening geophone of the Land Streamer is one of the effective ways to obtain high-resolution images of the near surface. We focussed on depths shallower than 30 m, Where various kinds of engineering works have been intensively conducted, particularly in urban area.
Figure 6. Phase velocity - frequency images converted through the MASW. (a) Dispersion curve image for the source 0 m (b) Dispersion curve image for the source 420 m (b) Dispersion curve image for the source 846 m.

Figure 7. The profile of S-wave velocity in the line D calculated from MASW data (up) while not topography correction (down) with topography correction.
5. Conclusion
The MASW ashore streamer examination was conducted to determine the valuable ways for geotechnical security assessment. The results of the study obtained 2 main layers. 2 layers supported the value of $V_s$ 100 - 250 m/s as soft rock and $> 250$ m/s as exhausting rock, there's a soft rock within the depth vary of ten to forty m with a rate worth of 140-200 m/s, and hard rock layers at a depth range of 11m to 45 m with a velocity value of 260 - 400 m/s. The MASW with Land Streamer is a powerful tool for close to surface investigation. The Land Streamer apparatus gives moderately clean information, outstandingly on asphalt, unaffected by activity noise. Subsequently, the instrument can extend the opportunity of applying high-resolution unsteady refraction surveys in greatly developed regions. The result of the instrument is fantastically compact and clear to assemble, so we are going to set it up and start up measuring interior thirty minutes, limit the time required onsite.

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