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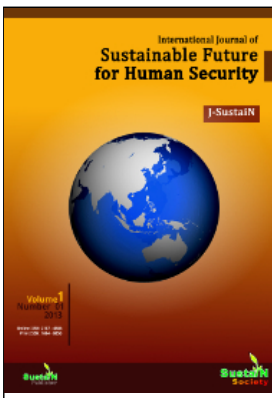
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Estimation of S-wave velocity structure for sedimentary layered media using Microtremor array measurements in Palu City, Indonesia

Pyi Soe Thein[ab]*, Subagyo Pramumijoyo[b], Kirbani Sri Brotopuspito[c], Junji Kiyono[d], Wahyu Wilopo[b], Aiko Furukawa[d], Agung Setianto[b] and Rusnardi Rahmat Putra[d]

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Abstract

In this study, 8 array microtremor measurements have performed in Palu City, Indonesia for S-wave velocity profiles, which will be used in seismic hazard mapping. Four accelerometers were used in each array observation site. One was installed at a center of the circle with a radius, r. Other three were arranged on the circle with a shape of regular triangle. Sequential observations were conducted three times by changing the array radius; r=3, 10 and 30 meters. The ground profile was estimated by means of the dispersion curves obtained using the Spatial Autocorrelation (SPAC) methods. The Particle Swarm Optimization (PSO) technique was introduced to determine the dispersion curves. Unified two-layered model were reconstructed by averaging the first three layers obtained from array observation. The shear wave velocity of the top layer is Vs ≤ 300 m/s. Based on layer models identified, sedimentary layer was estimated around Palu City. Understanding the parameters of sedimentary layersis important for seismic hazard mitigation and environmental planning in Paul City.

Keywords: Microtremor; Shear wave velocity; Particle Swarm Optimization (PSO); dispersion curve and Sedimentary layers

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1. Introduction

Sulawesi Island, eastern Indonesia, is located at the junction between the converging Pacific-Philippine, Indo-Australian Plates and the Sunda land, i.e. the south-eastern part of the Eurasian Plate. One of the major structures in Central Sulawesi is the Palu- Koro Fault system, which extends NNW-SSE direction and cross cuts Sulawesi along more than 300 km. It goes from the North Sulawesi trench, passes through Palu bay southward, turns to the SE, connects to the Matano and Lawanopo faults, and further eastward; both faults join to Tolo trench[1]. City of Palu at the northern tip of Palu depression becomes the capital of Central Sulawesi province, Indonesia, so that the demographic development increases significantly. However, this city is located in the active seismic zone. Palu depression is up to 7 km wide and bordered by N-S oriented, up to 60 m high steep triangular facets and truncated alluvial fans at West side, and gently steps faults at East side. Based on USGS catalog and Indonesian Institute of Meteorology, Climatology and Geophysics, more than hundred earthquakes with magnitude more than 6 were recorded in Sulawesi area. These earthquakes clustered at the northern arm of Sulawesi and along the Palu-Koro Fault System. Several earthquakes are known along Palu-Koro Fault system such as Gimpu earthquake (1905), Kulawi earthquake (1907), Kantewu earthquake (1934), off shore Donggala earthquake (1968) causing tsunami that destroyed 800 houses and killed 200 people at Donggala district. Considering the seismic activity along the Palu-Koro Fault system, it should be significantly important to mitigate the natural hazard of Palu city, especially on earthquake mitigation.

2. Historical Seismicity and Tsunami events in Palu depression

Seismicity of Sulawesi as recorded by global seismic networks, as well as local Indonesian networks and historic data, indicates low shallow depth activity in Central Sulawesi[2]. The evidences of the earthquake that damaged in the past are well demonstrated or observed through the tectonic features such as fault, shear zones, fault scraps, or from historical documented records of eye witness accounts, etc. There are many historical and recent earthquakes that are well-known, not only for its magnitude but also for the casualties it brought forth. The historical and recent earthquakes data show that Palu depression area is very vulnerable to earthquake disasters. The epicenter distribution within 200 km of Palu City Province and its vicinity for the years 1968–2014 are compiled from USGS website (Fig. 1(a))[3]. The projections in this figure are based on digital elevation model from SRTM satellite image in 30 meter resolution. The variation in sizes of the circle suggests relative magnitude.

6 tsunami events were recorded by the Makassar Strait around Sulawesi region. All the tsunamis experienced in the Makassar Strait related to earthquakes involved the Palu-Koro fault zone, the north Sulawesi subduction zone system, and the Pasternoster fault zone[4] (Fig. 1 (b)).

• December 1, 1927 earthquake*:* This earthquake originated at -0.7 S° and 119.7 E° with the magnitude of 6.3. It shocked West Central Sulawesi, Palu City area, resulted in 15 m height tsunami occurred, killed14 people, and injured30 people and 0.5 to 12 m subsidence.

• April 11, 1967 earthquake*:* This earthquake occurred at -3.3 S° and 119.4 E° with the magnitude of 6.3 and thrust fault mechanism. Tinambung area felt maximum intensity of VIII –VIII, resulted in 58 people were killed, 100 people were injured and the water suddenly retreated.

• August 14, 1968 earthquake: It originated at -0.7 N° and 118.8E° with high intensities magnitude of 7.4 and normal fault mechanism. West Central Sulawesi, Palu bay felt maximum intensity of VIII –VIII, resulted in 10 m height tsunami occurred, 200 people died and 2-3 m subsidence in Mapaga village.

• February 2, 1969 earthquake: This earthquake happened at the epicenter of -3.1 S° and 118.5 E° with the magnitude of 6. South Sulawesi, Majene area felt maximum intensities of VIII with thrust fault mechanism, resulted in 2 to 6 m height tsunami occurred, 64 people were killed and over 1,200 buildings were wrecked. Eighty percent of the brick structures were damaged, and some completely collapsed. Ground fissures were noted in several places. Several wooden houses located at the end of a bay were swept away by the waves. The press reported that the tsunami took 600 lives.

• January 8, 1984 earthquake: This earthquake occurred at -2.77 S° and 118.8 E° with the magnitude of 6.6. The maximum intensity of the earthquake was VII in Mamuju area with thrust fault mechanism.

• January 1, 1996 earthquake: This earthquake happened at -0.83 N° and 120.1E° with moderate and high intensities in regional scale with the magnitude of 7.7. It shocked West coast Central Sulawesi area, resulted in 1 to 3.4 tsunami height occurred, 0.5 to 2 m subsidence, 9 people were killed and 63 people were injured.
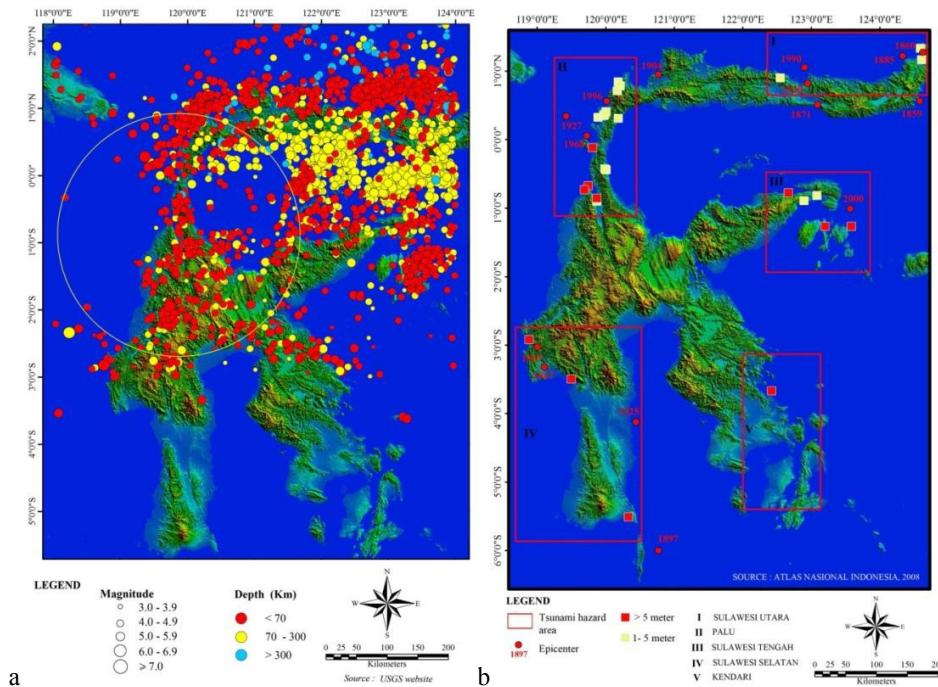
Fig. 1. (a) The epicenter distribution within 200 km of Palu City Province and its vicinity for the years 1968–2014 are compiled from USGS website; (b) Tsunami hazard map showing that along the archipelago of Sulawesi.

3. Geology of Palu City

Sulawesi, Eastern Indonesia, is a K-shaped island lying at the junction of Eurasia, Indo-Australian and Pacific plates, in a complex region where subduction and collision have been and are still active. Evolution of Neogene kinematics along the Palu-Koro fault was confirmed based on microtectonics approach, i.e., sinistral strike-slip due to E-W compression, radial extensions caused by telescoping vertical movement of Neogene granitoid, and then left lateral with normal component displacement due to N-S extension/ E-W compression which is actually still active[5].Palu depression area is filled by most of clay, silt, and sand deposits as alluvial deposits, except on the border east or west which consists of gravelly sands as colluvial wedges. The composition of gravel is granitic fragment to the northwest, mostly of schist on the west and to the east the gravel consists of schist, igneous and sedimentary rocks. West escarpment to the north consists of granite and granodiorite units, and to the south consists of schist-phyllitic units. East escarpment consists of molasses[6].

4. The GIS Based Model proposed for Microzonation

The GIS based model that can be used to create the infrastructure of seismic microzonation studies on Palu City that have a risk in terms of natural disaster, particularly earthquake. In addition, a relational database was designed to cope with the damage resulted from natural hazards for this study. This model was applied so as to take the measures needed for the City of Palu located on the segments of the Palu-Koro Fault Zone (PKF), a settlement with earthquake risk on the natural disaster. During the creation of the system, geological, geotechnical data and data produced from aerial photos were integrated and assessed on a GIS environment. The infrastructure for seismic

microzonation was created using this model. The potential areas for strong ground motion were detected in the study area. Thus, the future results were produced to assist in seismic microzonation.

5. Microtremor Single Measurements

Amicrotremor is a very small ground motion that can be recorded on the ground surface. It can be produced by a variety of excitations (e.g., wind, traffic, breaking sea waves). A full microtremor record can be described by one vertical and two horizontal components. The analysis was conducted using the recording by microtremor device. First, the horizontal and vertical spectrum ratios (HVSR) were computed for all sites. The peak period of the HVSR is known to correspond to the resonant period of the site. This method postulates the shape of the Fourier spectrum[7].The number of single point observations was 151. The sampling frequencies were 100 Hz or 500 Hz and the observation times were 10 to 15 minutes. Although there are 151 observation points, the points are not adequate to cover all the target area. If each value of the predominant period obtained is considered to be the realization of a stochastic random field, space interpolation will be conducted by ordinary kriging technique[8]. The predominant periods of 1.0 - 1.8 seconds were on the alluvial fan area. The spatial correlations between predominant periods on the west side mountain, of which slope is steep, are shorter than those in the east side mountain and change more rapidly.

6. Microtremor Array Measurements

The microtremors array survey was conducted at 8 sites in Palu City (Fig. 2). A three-component accelerometer with data logger, GPL-6A3P, produced by the Akashi Co. Ltd., was used.

Fig. 2. Three survey lines for array observation (Line A, Line B, and Line C)

Four accelerometers were used in each array observation site. One was installed at a center of the circle with a radius, r. Other three were arranged on the circle with a shape of regular triangle. Observation duration time was 20 ∼30 minutes and sampling frequency was 100Hz. Sequential observations were conducted three times by changing

the array radius; r=3, 10 and 30 meters. For seismic hazard analysis, the information of underlying sedimentary layers and related shear wave velocity structures are very 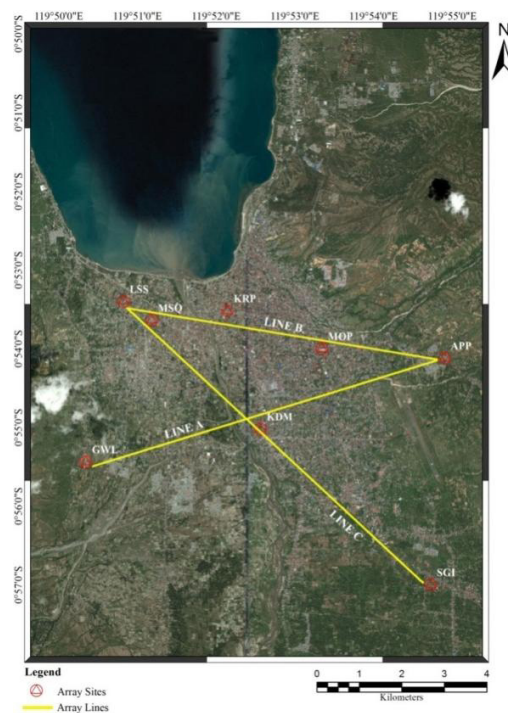essential parameters. The dispersion curves of surface waves (phase velocity vs. frequency functions) are determined by the ground structure defined in terms of S and P wave velocities, thickness and densities of the materials. Microtremor wave field, consisting of ambient vibrations due to human activities and atmospheric phenomena spreading on the ground as elastic waves, contains a high power ratio of dispersion curves. The velocity of surface wave is well known to vary as a function of frequency (or period) due to dispersive characteristics[9]. Therefore, the substructure can be estimated from the observed dispersion curve. The dispersion curves were calculated using the SPAC and CCA method. Then, a substructure profile was identified from the dispersion curve by using the Particle Swarm Optimization[10,11].The dispersion curves obtained are shown in Fig. 3 (a), (b), (c) for each survey. For line A, the phase velocity corresponding to the shallow ground with a high frequency range is about 369 m/s at APP, 423 m/s at GWL, 318 m/s at KDM, 318 m/s at KRP, 279 m/s at LSS, 348 m/s at MOP, 285 m/s at MSQ and 317 m/s at SGI. The soft ground extended beneath LSS, which is the nearest site to the coast. The ground beneath the sites which are higher than GWL has relatively hard surface soil compared with the plain along the coast. Since the minimum phase velocity in the high frequency range is around 300 m/s, the soil profile is very similar along line B and line C. The dispersion curves obtained here had no discrepancies in the distribution of topography, altitude and predominant period. Subsurface sedimentary layers were estimated by the dispersion curves.
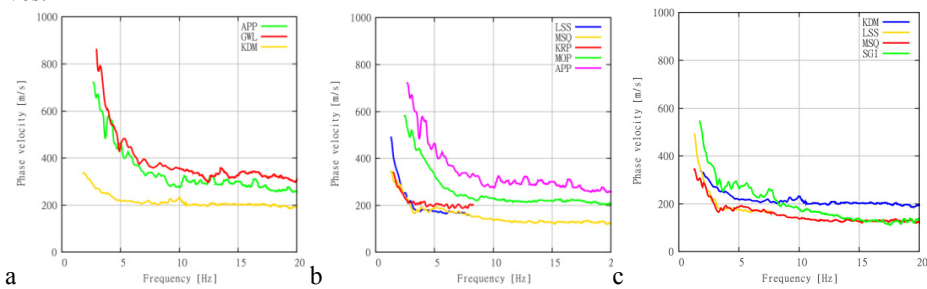
Fig. 3. Dispersion curves obtained for each survey line (a) Line A, (b) Line B and (c) Line C.

7. Estimation of Vs Structures by Particle Swarm Optimization (PSO)

The particle swarm concept originated as a simulation of simplified social system. The original intent was to graphically simulate the choreography of bird of a bird block or fish school. However, it was found that particle swarm model can be used as an optimizer, PSO simulates the behaviors of bird flocking. Suppose the following scenario: a group of birds are randomly searching food in an area. There is only one piece of food in the area being searched. All the birds do not know where the food is, but they know how far the food is in each iteration. So what is the best strategy to find the food? The effective one is to follow the bird which is nearest to the food. PSO learned from the scenario and used it to solve the optimization problems. In PSO, each single solution is a "bird" in the search space. It is called "particle". All of particles have fitness values which are evaluated by the fitness function to be optimized, and have velocities which direct the flying of the particles. The particles fly through the problem space by following the current optimum particles. PSO is initialized with a group of random particles (solutions) and then searches for optima by updating generations. In every iteration, each particle is updated by following two "best" values. The first one is the best solution (fitness) it has achieved so far (the fitness value is also stored). This value is called pbest. Another "best" value that is tracked by the particle swarm optimizer is the best value, obtained so far by any particle in the population. This best value is a global best and called gbest. When a particle takes part of the population as its topological neighbors, the best value is a local best and is called lbest. The subsurface structure of the model was estimated by solving a nonlinear minimization problem with the fitness function below.

$$v_{id}^{t+i} = \omega v_{id}^t + c1r1(vp_{id}^t - vx_{id}^t) + c2r2(p_{gd}^t - x_{gd}^t) \tag{1}$$

$$x_{id}^{t+i} = x_{id}^{t+1} + v_{id}^{t+1} \tag{2}$$

where v_{id}^{t} is particle velocity of the ith component in dimension d in the interaction, x_{id}^{t} is the particle position of the ith component in dimension d in interaction, c_1 and $c_2$are constant weight factors, ρ_i is the best position achieved by particle i,ρ^g , is the best position found by the neighbor of particle i, r_1 and r_2 are random factors in the [0,1] interval and ω is the inertia weight. Before performing the inversion analysis, the subsurface structure was assumed to consist of horizontal layers of elastic and homogeneous media above a semi-infinite elastic body. The shear wave velocity and thickness of each layer are the parameters determined by the inversion analysis. The results enable us to determine the condition of shallow subsurface structures[12,13]. The outline of the SPAC method for the phase velocity calculation of Rayleigh waves is as follows:
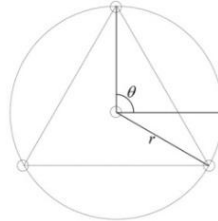
Fig. 4 Microtremor array observation Schema.

$$F(\omega) = \frac{1}{2\pi} \int_{-\infty}^{\infty} f(t) \cdot exp(-i\omega t)\, dt = A_f(\omega) \cdot exp\left(-i\emptyset_f(\omega)\right) \tag{3}$$

$$G(\omega) = \frac{1}{2\pi} \int_{-\infty}^{\infty} g(t) \cdot exp(-i\omega t)\, dt = A_g(\omega) \cdot exp\left(-i\emptyset_g(\omega)\right) \tag{4}$$

$A_f(\omega)$, $A_g(\omega)$and $\emptyset_f(\omega)$, are different between the amplitude of $\emptyset_g(\omega), F(\omega), G(\omega)$respectively. Further, cross correlation in the frequency region of the two waveforms will be as follows:

$$CC_{fg} = F(\omega) \cdot \overline{G(\omega)} = A_f(\omega) \cdot A_g(\omega) \cdot exp\left(i\Delta\emptyset(\omega)\right) \tag{5}$$

It shows the phase difference of $\Delta\emptyset(\omega)$

$$\Delta\emptyset(\omega) = \frac{\omega r}{c(\omega)} \tag{6}$$

$c(\omega)$is the phase velocity from the phase difference.

$$CC_{fg} = A_f(\omega) \cdot A_g(\omega) \cdot exp\left(i\frac{\omega r}{c(\omega)}\right) \tag{7}$$

The complex coherence of the two wave forms is defined by the following equation:

$$COH_{fg}(\omega) = \frac{CC_{fg}(\omega)}{A_f(\omega) \cdot A_g(\omega)} = exp\left(i\frac{\omega r}{c(\omega)}\right) \tag{8}$$

$$Re\left(COH_{fg}(\omega)\right) = cos\left(i\frac{\omega r}{c(\omega)}\right) \tag{9}$$

$$(\omega, \varphi) = \frac{c(\omega)}{cos\varphi} \tag{10}$$

$$SPAC(\omega, r) = \frac{1}{2\pi} \int_{0}^{2\pi} exp(i\frac{\omega r}{c(\omega)} cos\varphi) d\varphi \tag{11}$$

$$Re(SPAC(\omega, r)) = \frac{1}{2\pi} \int_{0}^{2\pi} cos(i\frac{\omega r}{c(\omega)} cos\varphi) d\varphi \tag{12}$$

$$J\left(\frac{\omega r}{c(\omega)}\right) = \frac{1}{2\pi} \int_{0}^{2\pi} exp(\frac{\omega r}{c(\omega)} cos\varphi) d\varphi \tag{13}$$

where $Jo(x)$ is the zero-order Bessel function of the first kind of x, and $c(\omega)$is the phase velocity at frequency ω. The SPAC coefficient $\rho(r, \omega)$ can be obtained in the frequency domain using the Fourier transform of the observed microtremors.

$$Re(SPAC(\omega, r)) = J\left(\frac{\omega r}{c(\omega)}\right) \tag{14}$$

From the SPAC coefficient$\rho(r, \omega)$, the phase velocity is calculated for every frequency from the Bessel function

argument of equation (14), and the velocity model can be inverted**.** Layer thickness and the average S-wave velocity in Fig. 4 are in each array site. For the average S wave velocity model obtained by averaging the estimated ground structure of the array site is calculated by a weighted average using a S-wave velocity structure estimated as a weighted layer thickness.

$$V_s = \sum V_{si} \frac{Hi}{H} (15)$$

8. Results of Inversion and Discussion

8.1. Line A

The *Vs* structure along line A is shown in Fig. 5 (a). Looking at a surface layer at GWL, the thickness of the first layer with *Vs* ≤300 m/s is about 26 m, however, the corresponding layer cannot be seen for KDM and APP. The thickness of the sediment is about 300 m/s at GWL, on the other hand, those at GWL, KDM and APP are 30m, 10m and 3m of the array sites respectively, but the layer disappears at the site near the mountain, GWL. As seen in the distribution of the predominant period of the H/V spectra, it can also guess at the existence of a rapid change in the subsurface structure between GWL and KDM.

8.2. Line B

The *Vs* structure along line B is shown in Fig. 5 (b). For all the sites, the velocities of the first, second, and third layers are ≤3 00 m/s, 300 ≤ 1300 m/s and ≥1300 m/s. The thickness of the first layer is around 20 m to 60 m. The sediment thickness is about 125 m and almost uniform. This tendency is in good agreement with the results of the predominant period distribution characteristics.

8.3. Line C

The *Vs* structure along line C is shown in Fig. 5 (c). At the sites in the plain, LSS, MSQ, KDM and SGI, the thickness of the layer with *Vs* ≤ 300 m/s is around 20 m to 60 m. Although it could construct a four-layered model for each line, it is still difficult to compile all the information because some layers of a site cannot be connected to the other sites; therefore, a three-layered model is introduced as an alternative.

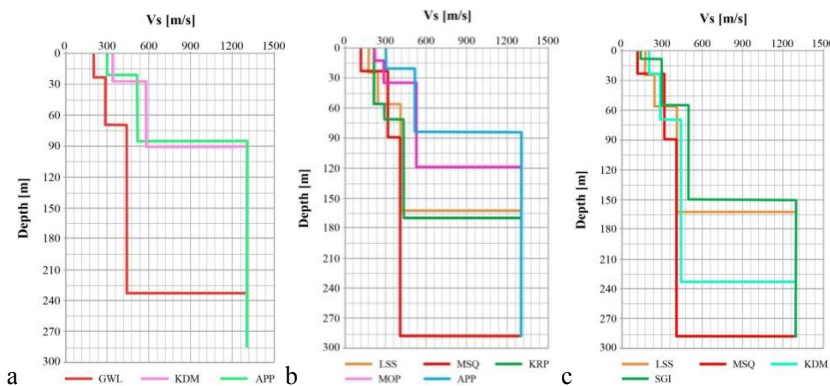
Fig. 5. Vs structures of the ground along the survey lines (a) Line A, (b) Line B and (c) Line C.

9. Site Classification of Palu City

The site classification is provided according to SNI -1726-2002, in which soil condition is classified into three types: (1) soft soil, (2) medium dense soil, and (3) hard or dense soil based on final S-wave velocity structures

shown in Table 1. Vsis determined by using the regular triangle shape circular array. As shown in Table 3, the average S-wave velocity of the depth Vs, at all eight sites is between 279.0 and 423.7 m/s, except from APP and GWL sites, all sites belong to medium dense soil. APP and GWL sites belong to dense soil. The S-wave velocity structures of Central Sulawesi province, especially in Palu City have been successfully evaluated and these are one of the main inputs for 1D Equivalent Linear Seismic Response Analysis. For the theoretical simulation of strong ground motion, it is prime importance to get information of underground structures, especially for sedimentary layers overlying on bedrock, like in Palu City. Shear wave velocity structure is one of the most important parameters for seismic response analysis. The thickness of sediments or depth of bedrock was determined together with S-wave velocity structures. In this process, there are two variables; S-wave velocity and thickness of each sediment layer. The observed depth information from boreholes is very reliable and thus only the S-wave velocity was changed to get equivalent H/V ratios to the observed ones from microtremor measurements. After that, both reliable depth and S-wave velocity structure of each boring site were obtained. The mean velocity structure with normalized depth is regarded to represent the whole studied area and is used for other sites by changing the normalized depth to the actual depth which can give proper equivalent H/V ratio. 1D seismic response analysis had been performed with three main inputs; material properties, layer properties and earthquake motion.

Table 1 Soil Classification based on V_s from the regular triangle shaped circular array and SNI 1726-2002.

No	Area	V_s(m/s)	Weak soil Vs < 175 (m/s)	Medium dense soil $175 \leq V_s \leq 350$ (m/s)	Dense soil $V_s \geq 350$ (m/s)
1	APP	369.7			✓
2	GWL	423.7			✓
3	KDM	318.1		✓	
4	KRP	318.0		✓	
5	LSS	279.0		✓	
6	MOP	348.0		✓	
7	MSQ	285.7		✓	
8	SGI	317.8		✓	

10. Sedimentary Layered Media

In this study, two simple layers model were proposed by averaging the first three layers of all array sites in Palu. Shear wave velocity of the first layer modelled is ≤ 300 m/s. Distribution of the sedimentary layer was calculatedby combining with the first peak of *H/V* data. The technique used was the 1/4 wavelength principle, which can approximately be extended to multi layered media.

$$H = \frac{1}{4} \cdot \overline{V}_s \cdot T \tag{16}$$

where, *H* is a thickness of a layer, *Vs* is shear wave velocity and *T* is predominant period. Subsurface profile and Vs structure for APP site are shown in Fig. 6.The distribution of thickness for the first layer of which *Vs* is ≤ 300 m/s in Palu area is shown in Fig. 7 (a). The rapidly varying area of the subsurface condition and dense observation area are enclosed. ASTER GDEM lands at image shows some topographic features of Palu City (Fig. 7(b)).
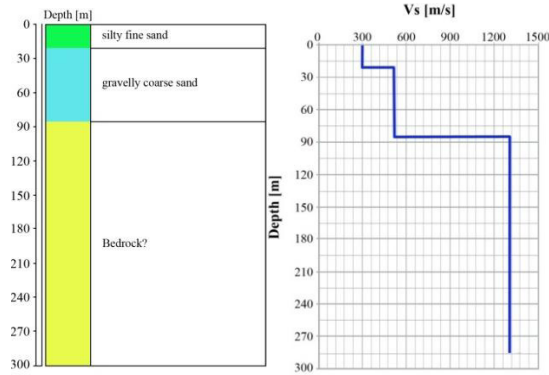
Fig. 6. Subsurface profile and Vs structure at APP, Palu City

The range of the shear wave velocity for the first, second and third layers is assumed (I) $Vs \leq 300$ m/s, (II) $3000 \leq Vs \geq 13000$ m/s and (III) $Vs \geq 13000$ m/s. The ground model is constructed as follows: The rectangular area (about 28 km*10 km) and it was divided into 1 * 1 meshes (1 km square). According to the Kriging technique, the values of predominant periods, Ts, at the center of each mesh are interpolated by using the finite number of peak periods read from the observed H/V spectrum. The shear wave velocities, Vs, of layer-I and layer-II are calculated by the weighted average, for which the weight is the reciprocal of square of distance from the array observation points, APP, GWL, KDM, LSS, MOP, MSQ and SGI, as

$$\overline{V}_s = \frac{\sum \frac{V_{si}}{x_i^2}}{\sum \frac{1}{x_i^2}} \tag{17}$$

where i defines the array site ($i=1,2,...,7$), and xi indicates the distance between an array observation site and the center of the mesh. Table2 shows the estimation of the predominant period[s] and the average shear wave velocity for the array sites.

Fig. 7. (a) Depth of the engineering bed rock; (b) ASTER GDEM lands at image shows some topographic features of Palu City.

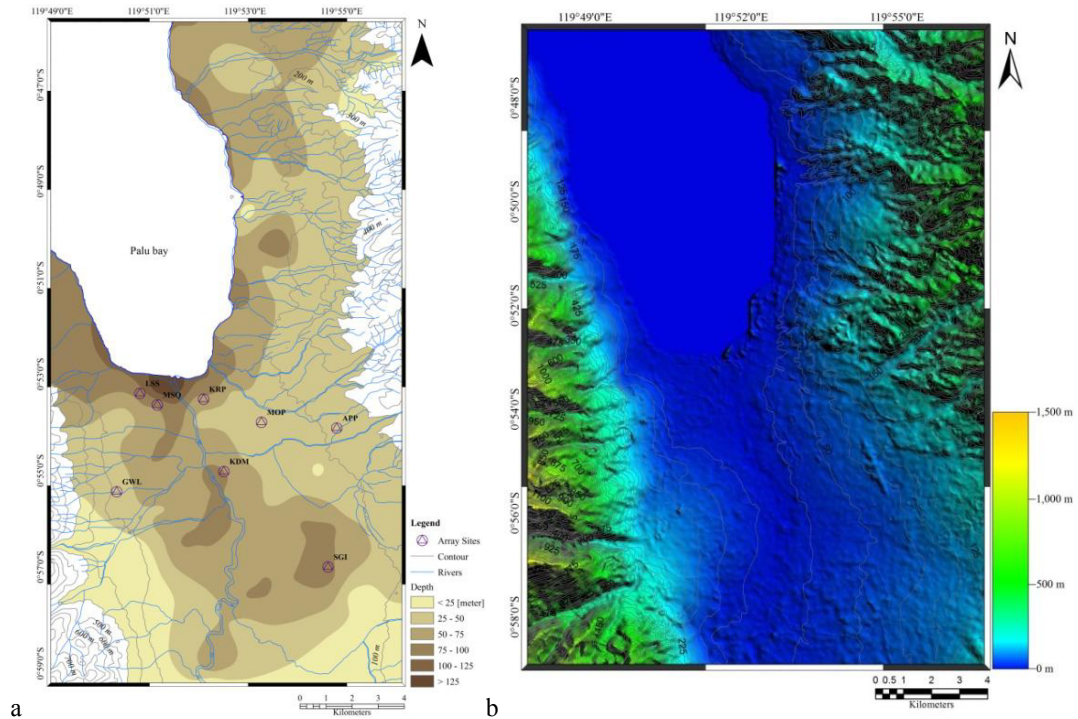Table 2 Estimation of the predominant period[s] and the average shear wave velocity for array sites

No	Array Sites	Longitude	Latitude	Topography	Geology	Period[s]	Vs[m/s]
1	APP	119°54.120' E	0°54.886' S	Hilly	Molasse	0.6	369.7
2	GWL	119°50.367' E	0°55.469' S	Hilly	Alluvial deposits	0.56	423.7
3	KDM	119°52.535' E	0°55.024' S	Flat	Alluvial deposits	1.07	318.1
4	KRP	119°52.153 'E	0°53.529' S	Flat	Alluvial deposits	1.32	318.0
5	LSS	119°50.807' E	0°53.382' S	Flat	Alluvial deposits	1.14	279.0
6	MOP	119°53.347' E	0°54.020' S	Flat	Alluvial deposits	0.59	348.0
7	MSQ	119°51.203' E	0°53.626' S	Flat	Alluvial deposits	1.23	285.7
8	SGI	119°54.720' E	0°57.004' S	Flat	Alluvial deposits	1.3	317.8

11. Conclusion

Microtremor observations and research analyses provide useful data for earthquake disaster mitigation in Palu City. The procedure employed and conclusions obtained in this study are as follows.

Microtremor observations were carried out for constructing a subsurface ground model and strong ground motion in Palu City. Single point and array observations were conducted at 151 and 8 sites respectively, which covered almost the whole city area. H/V spectra was calculated at all the single-observation sites and a distribution of predominant periods was obtained. The dispersion curves of a Rayleigh wave were obtained from the data of array observations. The Kriging method can be used for the interpolation of subsurface information such as shear wave velocity and depth of irregular boundary. By conducting an inversion analysis for the calculation of dispersion curves, the subsurface structure beneath the site can be estimated. A four layered model was constructed in each

array observation point. Unified two-layered model was reconstructed by averaging the first three layers obtained from array observation. The shear wave velocity of the top layer is $Vs \leq 300$ m/s. By combining above two-layer model and the results of single point observation, the distribution of sedimentary layers was calculated.The average S-wave velocity of the depth Vs at all eight sites is between 279.0 m/s and 423.7 m/s. Except from APP and GWL sites, all sites belong to medium dense soil. APP and GWL sites belong to dense soil. Palu City had deposited on a thick alluvial layer in the coastal area (with a sedimentary layers between 75 and greater than 125 m) that thins toward the mountains (with a sedimentary layers less than 25 m). The subsurface geology also changes slowly from soft sedimentary layers in the coastal area to igneous intrusion and metamorphic rock in the mountains. Understanding the parameters of shear wave velocity, soil classification and sedimentary layers is important for disaster risk prevention and environmental planning in Palu City. The outcome of this research should be an earthquake microzonation zone of Palu City.

Acknowledgements

References

1. B. Priadi.,(1993): Geochimie du magmatisme de l'Ouestet du Nord de Sulawesi, Indonesia:Tracage des sources et implications geodynamique. Doctoral thesis, Universite Paul Sabatier, Toulouse, France.
2. O. Bellier., M. Villeneuve., D. Seward., Th. Beaudouin., M.Se´brier., and E. Putranto.,(2006): Fission track and fault kinematics analyses for new insight into the Late Cenozoic tectonic regime changes in West-Central Sulawesi (Indonesia). Elsevier journal, Tectonophysics.
3. USGS, (2014), Historical Worldwide Earthquakes.
4. G. S. Prasetya., W.P Delange., and T.R Helay.,(2001):The Makassar Strait Tsunamigenic Region, Indonesia, Natural Hazards 24: 295–307.
5. S. Pramumijoyo., S. Indarto., C. Widiwijayanti., and J. Sopaheluwakan.,(1997): Seismic Parameters of the Palu-Koro Fault in Palu Depression Area, Central Sulawesi. Indonesia J. SE Asian Earth Sci.
6. R.A.B. Soekamto.,(1995): Regional Geological Map of Palu Sheet, Indonesia, Scale 1:250,000, Geological Research Center, Bandung.
7. Y. Nakamura., (2000): Clear Identification of Fundamental Idea of Nakamura's Technique and Its Application. World Conference of Earthquake Engineering.
8. J. Kiyono and M. Suzuki., (1996): Conditional Simulation of Stochastic Waves by Using Kalman Filter and Kriging Techniques, Proc. of the 11th World Conference on Earthquake Engineering, Acapulco, Mexico, Paper No.1620.
9. K. Aki., (1957): Space and time spectra of stationary stochastic waves, with special referent to microtremor, Bull. Earth. Res. Inst., Vol.35, No.3, pp.415-456.
10. J. Keneddy and R. C. Eberhart., (1995): Particle swarm optimization, Proc. of IEEE International conference on Neural Networks, Vol.4, pp.1942-1948.
11. T. Noguchi, T. Horio, M. Kubo, Y. Ono, J. Kiyono, T. Ikeda and P. R Rusnardi., (2009): Estimation of Subsurface Structure in Padang, Indonesia by Using Microtremor Observation, Report on Earthquake Disaster Prevention Field, Tono Research Institute of Earthquake Science, Seq. No.26, pp.1-16.
12. Y. Ono., J. Kiyono., R. P. Rusnardi., and T. Noguchi., (2010):Microtremor observation in Padang city, Indonesia to estimate site amplification of seismic ground motion, Proc. of International Symposium on a Robust and Resilient Society against Natural Hazards and Environmental Disasters and the third AUN/SEED-Net Regional Conference on Geodisaster Mitigation, pp.386-391.
13. R. P.Rusnardi., J. Kiyono ., A. Furukawa. , and Y. Yoshimoto., (2013): Soil Characteristic in Palu, Indonesia, International Symposium on Earthquake Engineering, JAEE, Vol.2.

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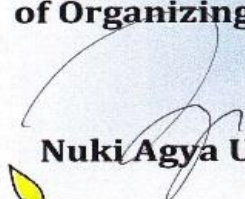
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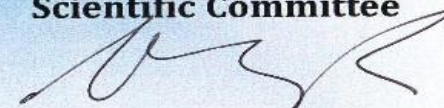ON SUSTAINABLE FUTURE FOR HUMAN SECURITY (SustaiN)**

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