Site Effect Assessment method for Seismic Microzonation in Indonesia

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1. Introduction

Historically and recently, Indonesia has been frequently affected disastrous earthquakes and tsunamis, which have brought big amount of damage and victims to the society. It is impossible to avoid the occurrence of natural phenomena, but the efforts are dispensable to mitigate disasters as smallest as possible. This is assumed as the responsibility of society in order to assure its safety.

Seismic Microzonation, one of the basics of earthquake disaster management, has begun in 1970's. In Indonesia, several examples are executed so far. But, its utilization to actual reduction measures against earthquake disaster is probably insufficient.

On one hand, Seismic Microzonation has become consisting not only hazard, risk assessments, but also planning of disaster management. Seismic hazard assessment includes identification of seismic sources, analysis of path process and site effect of subsurface ground. Risk assessment includes estimation of damage and loss to building, lifeline facilities, casualties and properties. And planning of earthquake disaster management is consisted of investigation of resilience of society and measures against disasters. Since the entire review all above becomes enormous, this paper focuses on site effect assessment in Indonesia, presumed as a basic topic of seismic hazard assessment, referring recent examples in the world.

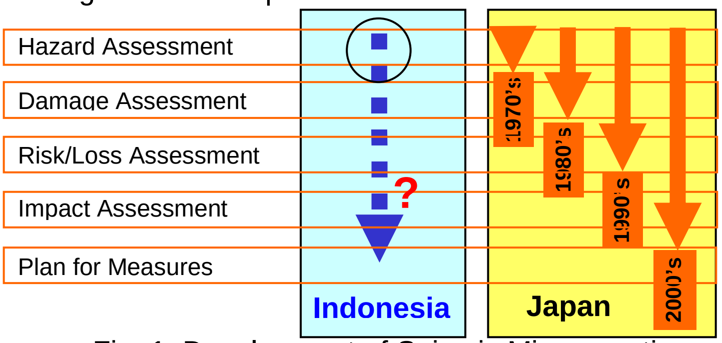

Fig. 1 Development of Seismic Microzonation

2. A Simple Review of Current Seismic Hazard Assessment in Indonesia

Summary of current situation in Indonesia, on seismic source, path effect and site effect, consisting seismic hazard assessment, which process is shown in Fig.2, is expressed below, through obtained information.

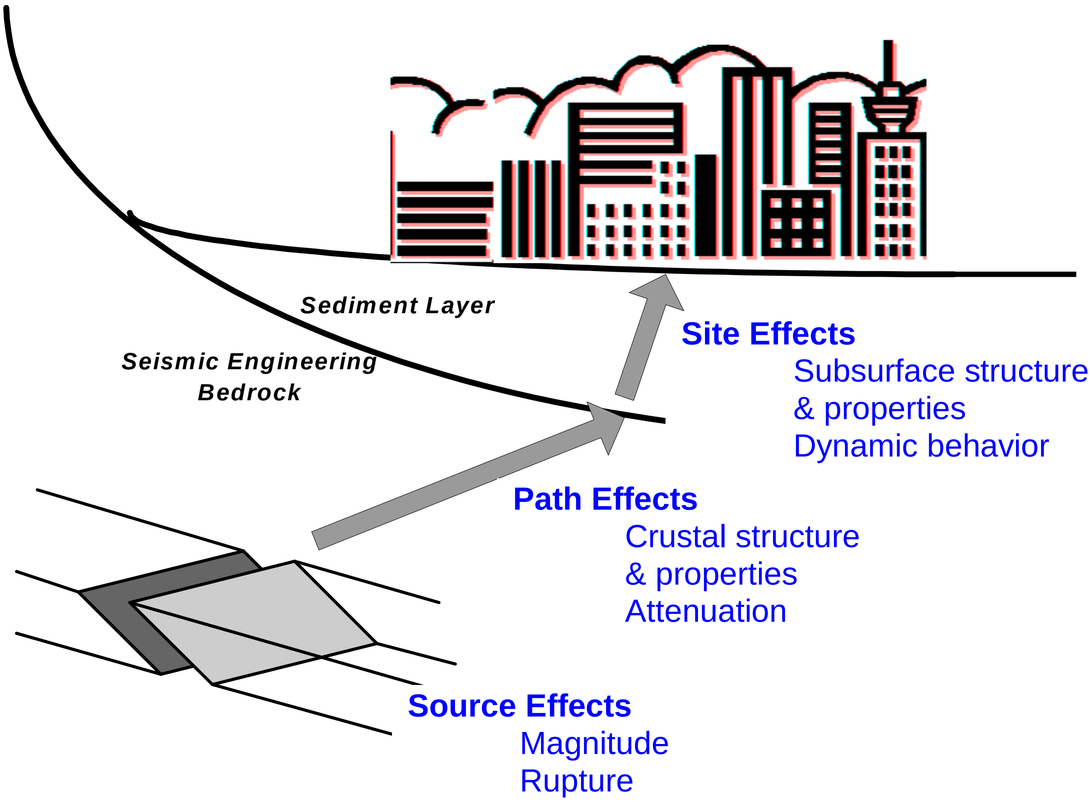

Fig. 2 Process of seismic hazard assessment

2.1 Review on Seismic Source Assessment

Regarding to seismic sources as cause of seismic hazard, seismic observations including strong motion have been conducted, and seismicity analysis has been done based on the results. Expected values of seismic ground motion at many places have been calculated. According to this probabilistic processing, the result values have been applied to the seismic code regulation. But, in order to promote earthquake disaster measures effectively, analysis of earthquake hazard with this is insufficient, because probabilistic values do not always give realistic values of seismic motion due to actual earthquakes. Therefore, not only probabilistic result, but also clarification of both deterministic processing due to the specific seismic sources of seismicity and active faults for each area and their recurrence characteristics should be identified. Although there are such deterministic detailed seismic motion analyses such as at Yogyakarta where disastrous earthquakes attacked recently, and for aseismic design of large critical structures at Jakarta, Bandung. When these are excluded, examples of deterministic analyses using seismic sources are not many.

In addition, sequential investigation for active faults has been advanced, but issues to be solved are still many such as identification of location and scale, evaluation of activities etc. Details will be mentioned at another opportunity.

2.2 Review on Path Effect Assessment

In regard to path effect, both the Indonesian individual attenuation equations, and seismic motion analyses which used structure and properties of deep ground and the crust are found little. In this sense, not only analyses using structure and properties of deep ground, but also seismic motion characteristics propagating in deep ground and crust will be one of the important topics in the future.

2.3 Review on Site Effect Assessment

For site effect assessment, the most important portion of seismic hazard, the related information is little in Indonesia. In other words, though soil investigation for the important structures has been done, examples of investigations of subsurface ground structure and physical properties, various types of explorations for a certain wide area like cities are not so many.

Geological/geomorphic maps are generated at some places. But by the reason of insufficient amount of soil data, there are also some designating predominant periods and amplification by several microtremor H/V observations as the conclusion simply. Even though the contours of H/V result have to be interpreted with characters and formulated process of ground and topography. And also it must be clearly recognized that developmental characteristic of H/V result is quite limited.

In Indonesia, geotechnical engineering and soil dynamics seem to be analyzed insufficiently. Some hazard maps show that the compilation process and expressions are quite relative.

3 Examples of Site Effect Assessment in Seismic Microzonation

Methods of the site effect assessment in seismic microzonation, in other words spatial assessment of amplification at subsurface ground, are reviewed from current world examples. The main targets should be both stratigraphic constitution of subsurface ground from engineering bed layer to ground surface, and evaluation of physical properties especially dynamic properties. Therefore, quantity of soil data and spatial interpretation will be the key for the resolution of assessment. Often spatial assessment is conducted using grids as the unit, which size used differs usually from 1km to 50m, depending on the purpose and the size of total area.

As shown in Fig. 3, the most abundant in soil data for total number of grids is the case of Istanbul city (2007) among existing examples.

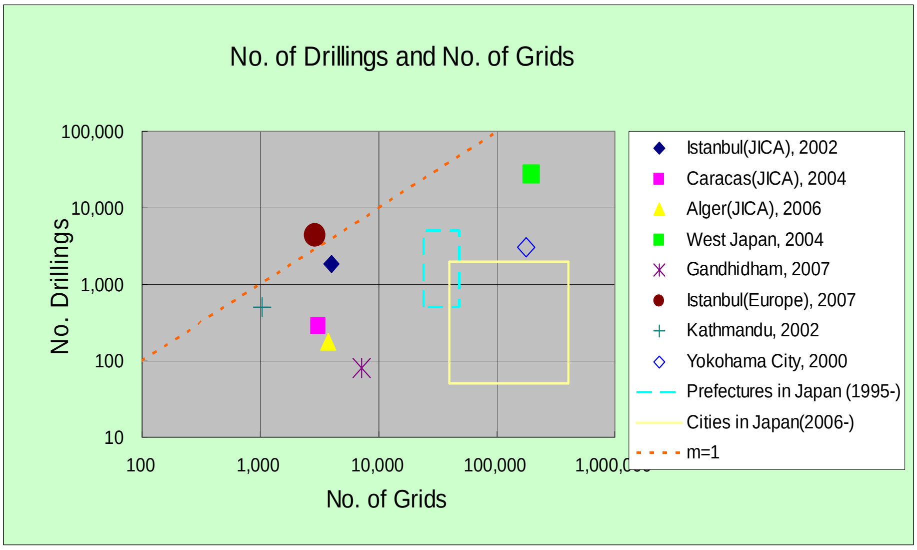

Fig. 3 Plots between number of grids & drillings in existing seismic microzonation

On the other hand, even though the ground data is very little, there is an example of spatial assessment in Japan. First, a spatial geomorphic map is generated based on little soil data, then amplification of subsurface ground is estimated at every 50m grid using empirical equations developed in Japan, though its resolution is not high.
From Fig. 3, the minimum requirement of necessary ground data for a certain resolution level, such as response analysis with velocity layer ground models, will be presumed at least 1 soil data for each 50-100 grids. For dynamic data, shear wave velocity (Vs), it is recommended with density of at least 1 velocity data for each 250-500 grids, 1/5 of soil data.

3.1 A Case of Istanbul City Where Soil data is Abundant

Although it depends on impendence of occurrence of earthquakes or amount of budget, when soil data especially dynamic data is rich, appropriate assessment becomes possible.

The budget rate of earthquake disaster management versus GDP in Istanbul city is much more than average in the world, because it is clear to wear big loss once the disaster occurs, also because the citizens well agree the way of thinking to apply what can actualize disaster reduction even a little bit. Of course, one of the primary factors should be the impendence of the next big event.

Southern part of European side of Istanbul city has its area of approximately 190 sqkm, number of grids around 2,900 for 250m grids, with drilling at least each grid, totally more than 4,000. With regards to dynamic property, Vs as the representative, total number of PS logging was around 300 and ReMi observation based on microtremor was for each grid.

After the velocity layer model was determined for every grid, response analysis was conducted and amplification at subsurface ground is evaluated.

3.2 A Case of India Where Minimum Required Soil Data is Procured

Gujarat State of India, hit by large earthquake disaster in 2001, has made great efforts for disaster management. It established guidelines for seismic microzonation method for the state, proposing methods corresponding to plural technological levels. An actual seismic microzonation has been executed from 2006 to 2008 for Gandhidham and Anjar cities including an important port.

Although effective soil data was absent locally, newly drillings, PS loggings and microtremor H/V observations were conducted with cooperation by ISR, the Institute of Seismological Research there. In this case the quantity of minimum requirement was presumed, 80 drillings, 16 PS loggings were executed for the object area of 420 sqkm with 250m grids. Furthermore, from 40 points H/V microtremor, the distribution of their predominant period around 1 seconds assisted the estimation of engineering bed layer (Vs=2,200m/s) depths and distribution. Both the amplification at predominant period and shorter predominant period from H/V observation has never been used. The relation between Vs from PS logging and N value from SPT, Standard Penetration Test, were used for soil modeling.

Approximately 7,000 subsurface soil model at 250m grids were established from above analyses. Comparing amplification at subsurface ground due to between the empirical method using average Vs data and response analysis, it is confirmed that they were similar but that by response analysis showed more detailed and wider range. And finally the analyzed results were verified by the existing historical earthquake records.

3.3 A Case of Japan where little or limited soil data

The case where the soil data is little, is often because of suburbs or sound ground, but sometimes urban cities recently are developing to the area whose ground is weak.

All over Japan, same as Indonesia, is earthquake prone. At local governments where soil data is little, recently earthquake hazard maps are drawn using empirical rations with 50m grids as a unit, which is referred for disaster management planning even though the resolution is not high. The national government is recommending more detailed study including actual soil investigation and analyses by the local governments which recognize necessity and importance of them.

The technique used is simple and consisted of the two empirical relations between geomorphic types and AVS30 (average Vs down to 30m depth), and between AVS30 and amplification at subsurface ground. Therefore, if there are both geomorphic map and investigation results at standard position for confirming difference for locality, minimum level evaluation is possible. Though this results can be seen clear, its resolution is exactly not high. Also, its resolution is better than the results due to pulling contours simply from H/V microtremor results.

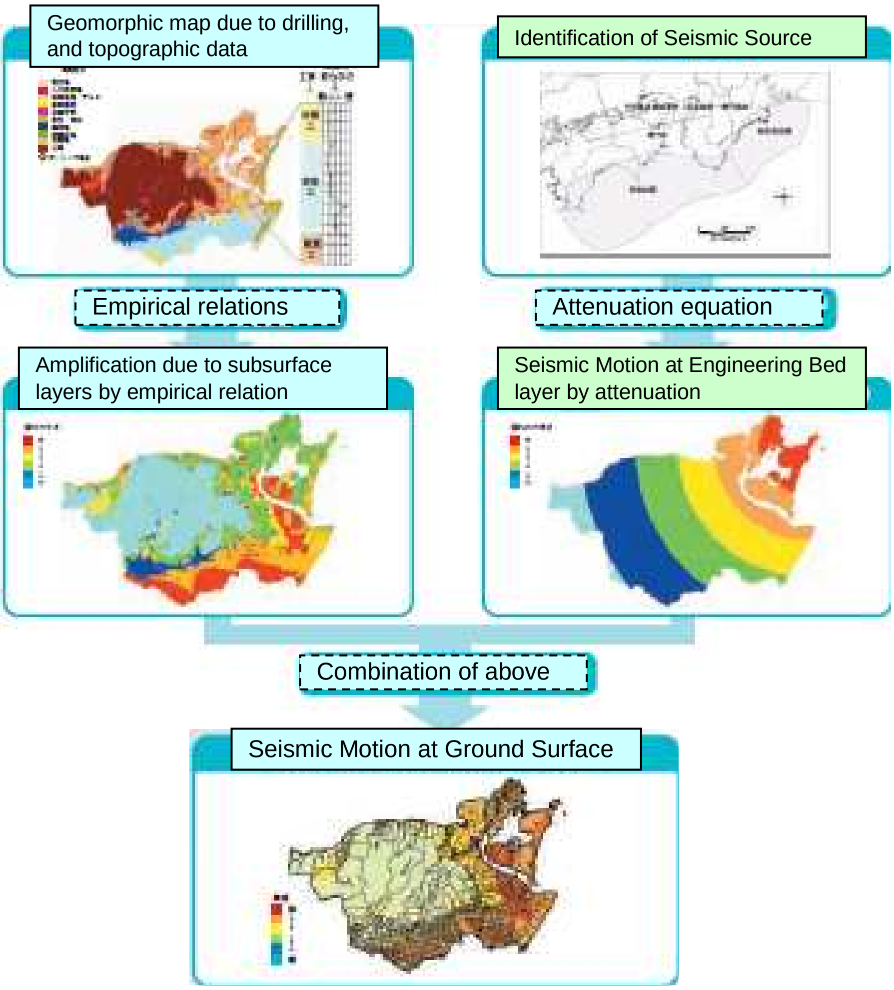

Fig. 4 An example of simple geomorphic map method for 50m grids in Japan

4 A View of Site Effect Assessment of the Seismic Microzonation in Indonesia

Since condition and available data of soil differ area by area, it is obvious from existing cases that it is necessary to apply appropriate methodology conforming respectively. However, also it is necessary to try to adopt higher resolution method such as response analysis, adding soil investigations for dynamic properties as far as possible. When number of soil data is limited, efforts to approach required resolution are inevitable, utilizing geological and geotechnical engineering interpretation. Only interpolation of obtained data is nonsense.

Followings are a summary of recommendations for studies on site effect assessment in Indonesia in the future.

a) Where existing soil data is limited as a whole, archive of available data is indispensable for more effective usage.

b) In the big urban city where the ground data is relatively rich, it is desired adding more dynamic ground data, and executing more accurate response analyses as far as possible.

c) At the area where the available ground data is little, it is necessary to keep accumulating the ground data. However, currently conducting geomorphic analysis of the entire area, evaluating surface ground relatively, and investigating in detail at the standard places, even though number is small. It is important and desired to raise the accuracy level. H/V microtremor observations may be useful, but they must be auxiliary.

d) To add one serious issue, since the past result is the fact, it is indispensable to make advancement of historical seismology. Piling up historical data should raise persuasion arguments.

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