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The Mechanical Properties by an In-situ Subsoil Investigation for the Structural Analysis of a Cold Neutron Laboratory Building

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1. Introduction

The main purpose of this paper is to provide the dynamic elastic constants as input data for the seismic analysis of a CNLB (Cold Neutron Laboratory Building) which is classified in seismic category II grade (Non-seismic category I). The CNLB is being installed near the existing reactor building in HANARO which has being operated since its initial criticality in February of 1995. Therefore, it is required to maintain the structural integrity of the reactor building during any cases related to design earthquakes. When the design earthquake is occurring, the CNLB is securely prevented form its some kinds of structural collapse or uncontrolled displacement caused by a dynamic response. That's why the CNLB is classified in seismic II category conforming to SSE (Safe Shutdown Earthquake) design loads.

In order to analysis the structural stability of the CNLB, it is required to obtain the in-situ mechanical properties on the ground foundation. They can be obtained through the means of a direct or indirect investigation of the subsoil. This paper presents the dynamic elastic constants determined from a in-situ subsoil investigation which will be applied to evaluate the structural integrity of the CNLB.

2. In-situ Investigation

The seismic design of a structure, which is either related to a nuclear reactor or classified in the seismic category, should be qualified to conform to the regulatory guide and the related design codes. The seismic design procedure of a nuclear facility is basically divided into five steps such as the definition of a input motion, the soil-structure interaction analysis, the dynamic response analysis, and the seismic design of a structure and finally the seismic qualification of the equipment. First of all, the design input motion of the ground basement to be used for evaluating the site characteristics should be defined by considering the ground condition. Second, the in-situ dynamic elastic constants should be determined by the subsoil investigation like as the boring test, the standard penetration test, the RQD measuring of rock, and the elastic wave velocity test by the refraction method.

At this step, in order to qualify the seismic integrity, it is required to determine the dynamic elastic constants for each ground condition. The constant will be provided as input data to the mathematical model for the seismic analysis. According to the ground condition and the type of foundations, the constant will be defined as several types representing the coefficients of an elastic non-uniform compression, elastic uniform shear, and non-uniform shear. The ground condition depends on the weathering damage to the rock. It can be classified in fresh rock, slightly weathered rock, moderately weathered rock and highly weathered rock.

3. Determination of the Mechanical Properties

In order to determine the mechanical properties, which means the coefficients of an elastic, depending on the rock condition, an in-situ subsoil investigation was conducted by a direct and indirect method.[1] The initial data which came from the physical and mechanical investigation results were transformed to basic geological properties as a compressive strength, unit mass and the elastic wave velocity. They can be used to classify the grade of rock such as F (Fresh rock), SW (Slightly Weathered rock), MW (Moderately Weathered rock), and HW (Highly Weathered rock). The dynamic elastic properties can be calculated by using the poisson's ratio as a function of the ratio between the parallel wave velocity and the surface wave velocity acquired from an elasticity wave investigation. Fig. 1 shows the correlation of the elastic velocity of the MW and the SW. Although the elastic wave test was done for all kinds rock conditions in tested regions, the results of both MW and SW have a reliability as engineering data.

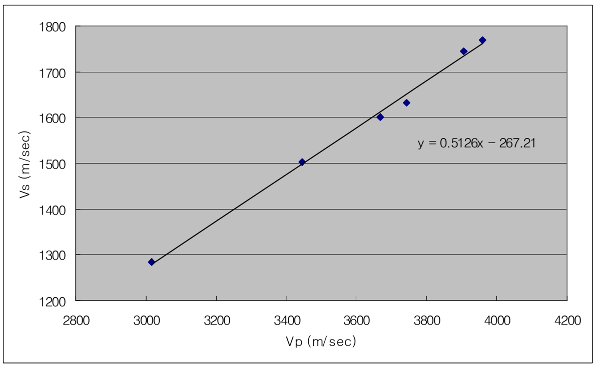

Fig. 1. Correlation of the elastic wave velocity of moderately and slightly weathered rock

In the case of the highly weathered rock, its consistency and strength is not enough to measure the elastic wave so therefore the data was eliminated in Fig. 1. These results indicate that the variance of the elasticity wave has little narrow band. So, it could be considerably assumed that the tested rocks have a good enough quality to provide mechanical properties.

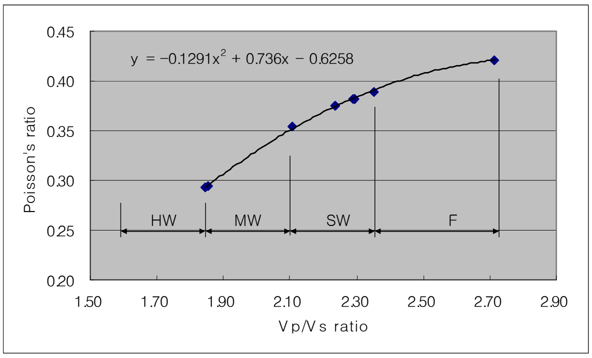

Fig. 2. Poisson's ratio as a function of Vp/Vs ratio

Fig. 2 presents the poisson's ratio as a function of the Vp/Vs ratio. The correlation between Vp and Vs means that only the elastic velocity from the simple test will be easily used to obtain the poisson's ratio of a rock without any test. The dynamic elastic constants were determined in below table 1. They are taken by using the elasticity wave velocity and the poisson's ratio derived by the Vp/Vs ratio. They will be provided in the structural analysis model as in-situ spring coefficients. It is intended to estimate the behavior of the CNLB subjected to SSE earthquake loads.

Table 1. Determination of dynamic elastic constants

	Slightly Weathered	Moderately Weathered	Remark
Mass (g/㎤) Poisson's ratio (ν) Elastic constant (GPa) Conpressive strength (Mpa)	2.57 0.24~0.26 10.7~10.8 98~121	2.55 0.29~0.30 10.6~10.8 87~115	Static
P-wave velocity (Vp: m/sec) S-wave velocity (Vs: m/sec) Dynamic poisson's ratio (ν) Dynamic shear constant (GPa) Dynamic elastic constant (GPa)	3,500~6,000 1,200~2,300 0.23~0.24 10.3~11.9 27.8~29.4	1,900~4,000 690~1,900 0.27~0.42 4.8~8.7 13.6~22.8	Dynamic

4. Conclusion

The main purpose of this paper is to provide the dynamic elastic constants for the seismic analysis of a CNLB (Cold Neutron Laboratory Building) which is classified in seismic category II grade (Non-seismic category I). In order to determine the mechanical properties, which means the coefficients of elasticity, depending on the rock conditions, an in-situ subsoil investigation was conducted by a direct and indirect method. The dynamic elastic properties were calculated by using the poisson's ratio as a function of the ratio between the parallel wave velocity and the surface wave velocity acquired from the elasticity wave investigation. The results derived by the above procedure have a good enough quality to provide mechanical properties. They will be provided in the structural analysis model as in-situ spring coefficients and they could be helpful to estimate the structural behavior during the SSE loads. The structural analysis report of CNLB had submitted to the regulatory bodies in the end of 2005, and the construction of the CNLB was successfully approved in April 2006. [2]

Acknowledgement

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REFERENCES

[1] HEC, 'Subsoil Investigation Report', 2004. 8
[2] KAERI/TR-3168/2006, 'The Design of a Cold Neutron Laboratory Building', 2006. 4