Evaluation on Behavior of Single Block Subject to Harmonic Excitation

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1. Introduction

NHDD(Nuclear Hydrogen Development and Demonstration) project team in KAERI(Korea Atomic Energy Research Institute) has been developing a methodology on the seismic evaluation of VHTR(Very High Temperature Reactor). Roughly, there are a block type and a pebble type reactor in VHTR. In the block type reactor, several blocks are stacked and the stacked blocks are arrayed in certain pattern. To evaluate a behavior style and an integrity of the stacked structure subject to a seismic load, a modeling technique to represent the contact surface characteristics between a block and a block support structure and between blocks is necessary. The way to evaluate a load path is also needed. However, it is difficult to deal with a realistic seismic load and to figure out the characteristic of block behavior since it has very complicated time history. In this study, the evaluation of single block subject to a harmonic excitation is conducted for a preliminary evaluation

2. Behavior Evaluation

To evaluate a behavior of single block subject to harmonic excitation, dynamic explicit analyses are performed as we change a harmonic excitation profile. The harmonic excitation can be defined as a function of a harmonic frequency and a magnitude. As the frequency and magnitude change, the excitation profile changes and the block behavior also changes. The block behaviors in each case are compared. A finite element model for the analysis is shown in Fig. 1. The model consists of two parts such as a block part and a support part. The material property of single block is that of IG-110 graphite. It is shown in Table 1. The material property of support part is assumed to be that of carbon steel. It is for the further study such as stacked block structure. The contact surfaces of block and support part are modeled as surfaces with coefficient of friction. The harmonic excitation is applied to the support part as a boundary condition.

Table 1. Material properties of single block

Properties	Value
Density	1.78 g/cm^3
Young's Modulus	0.81x10^5 kg/cm^2
Tensile strength	25.3 MPa
Compression strength	76.8 MPa

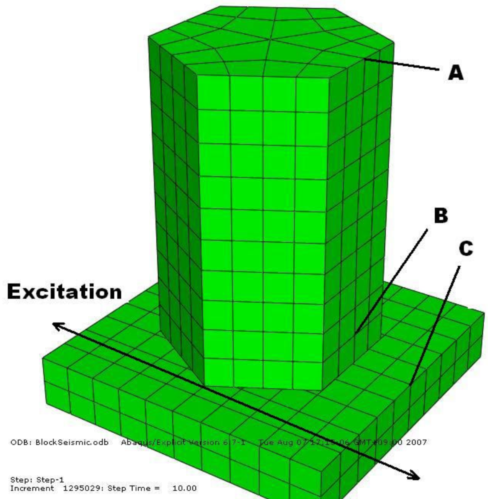

Figure 1. Finite element model

2.1 Evaluation according to frequency change

The behavior of single block is evaluated as the frequency of harmonic excitation changes. The behavior of single block is analyzed according to the frequency of harmonic excitation with the maximum magnitude of 0.3g changes from 1 Hz to 2 Hz, 3 Hz, and 5 Hz. The displacements of the node A located in the top of the block and the node C in the support part are shown in Fig. 2. The displacements of two nodes are almost same and the relative displacement does not occur for each case. So, the displacements for each case are represented in one line in Fig. 2. That means there are no slip and no overturn for every frequency. The stress of the node B located a little far from the support part is shown in Fig. 3. The stress profiles in Fig. 3 are the result after filtering a raw data with a cutoff frequency. The magnitude of the maximum stress does not increase or decrease according to the frequency increase. There is not the general trend.

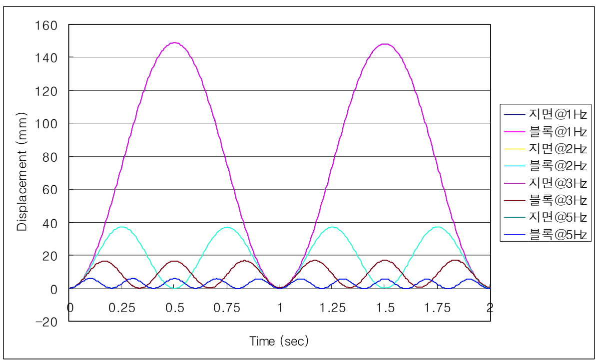

Figure 2. Displacement history according to frequency increase

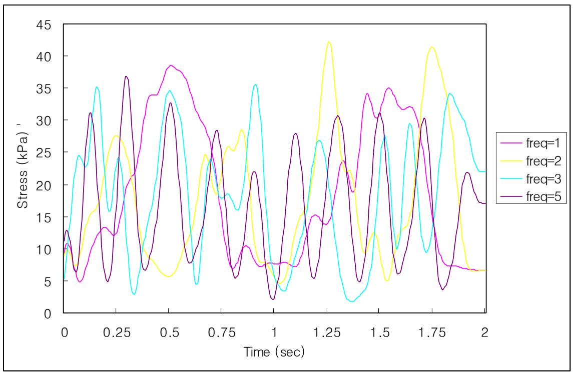

Figure 3. Stress history according to frequency change

2.2 Evaluation according to magnitude change

The behavior of single block is evaluated as the magnitude of harmonic excitation changes. The behavior of single block is analyzed according to the magnitude of harmonic excitation with the frequency of 1 Hz changes from 0.3g to 0.5g, 0.6g, and 0.7g. The displacements of the node A and the node C are shown in Fig. 4. The displacements of two nodes are almost same and the relative displacement does not occur for the cases of 0.3g, 0.5g, and 0.6g. So, the displacements for these cases are represented in one line in Fig. 4. That means there are no slip and no overturn for these cases. When the magnitude increase to 0.7g, however, the relative displacement between the nodes A and B are accumulated and increased as time goes on. That means the block is overturned shown in Fig. 5. When the friction force between the block and the support part is greater than the harmonic excitation, the block is not overturned and the relative displacement is negligible. But when the magnitude of the harmonic excitation passes over the friction force, then the relative displacement is accumulated and increased. Finally, the block is overturned.

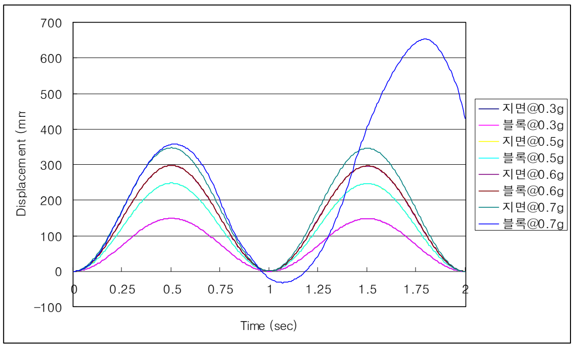

Figure 4. Displacement history according to magnitude increase

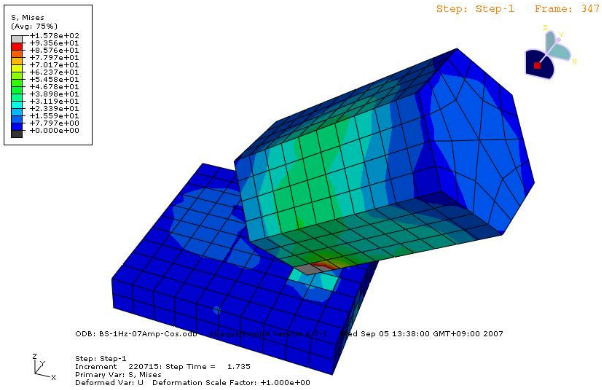

Figure 5. The overturn of a block

3. Conclusion

The behavior of a single block subject to the harmonic excitation is evaluated as the frequency and the magnitude change. The overturn of a single block is mainly governed by a magnitude of harmonic excitation. The relationship between the friction force and the magnitude of excitation plays an important role on the overturn motion. The integrity of a single block is affected by the magnitude more than the frequency of harmonic excitation. The magnitude of occurring stresses is not drastically changed in this confined study focused on the low frequency domain as the frequency increases.

For further works, the behavior of block subject to an excitation with high frequency. And the behavior of a stacked block structure should be evaluated under various excitations.

ACKNOWLEGHMENT

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REFERENCES

[1] G.W. Housner, "The Behavior of Inverted Pendulum Structures During Earthquakes," Vol. 53, No. 2, pp. 403-417, Bull. Seism. Soc. Am., 1963.

[2] T.H. Lee, "Nonlinear Dynamic Analysis of a Statcked Fuel Column Subjected to Boundary Motion," Vol. 32, pp. 337-350, Nuclear Engineering and Design, 1975.

[3] T. Ikushima, T. Nakazawa, "A Seismic Method for a Block Column Gas-cooled Reactor Core," Vol. 55, pp. 331-342, Nuclear Engineering and Design, 1979.

[4] T. Ikushima, T. Honma, H. Ishizuka, "Seismic Research on Block-Type HTGR Core," Vol. 71, pp. 195-215, Nuclear Engineering and Design, 1982.