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Behavior Comparison of Stacked Graphite Blocks with and without a Pin and Socket

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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 for the seismic evaluation of a VHTR (Very High Temperature Reactor). To evaluate the behavioral style and the integrity of a 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 among the blocks is necessary. However, it is difficult to deal with a realistic seismic load and to figure out the characteristics of a block's behavior since it has a very complicated time history. In this study, the evaluation of a single column stacked block subject to a harmonic excitation is conducted for a preliminary evaluation. These studies include an evaluation for the effect of the pin and socket components between the blocks on the overall behavior of the stacked blocks.

2. Behavior Evaluation of Single Column Stacked Block Structure

To evaluate the behavior of a single column stacked block structure, finite element (FE) models for a 3 story single column stacked block (3SSCSB) and a 10 story single column stacked block (10SSCSB) are established. FE models with and without pins and sockets are fabricated. The harmonic excitation has 1 Hz of its frequency and 0.3g of its magnitude.

2.1 Behavior Evaluation of 3SSCSB

The behavior of 3SSCSB under the harmonic excitation is evaluated for a confined space. A FE model for 3SSCSB with pins and sockets is shown in Fig. 1. The middle and the right figure in Fig. 1 show pins in the top surface and sockets in the bottom surface, respectively. When an excitation acceleration is applied to 3SSCSB, the friction force between the blocks maintains the shape of a stacked block structure. When the excitation force becomes bigger than the friction force, the stacked block structure overturns. On the contrary, in the case of a stacked structure of blocks with pins and sockets, an upper block and a lower block are connected and restrained by the pins and sockets. So, the behavior in this case is similar to that of a single long block. A shear stress occurs in the pins and sockets to prevent a relative displacement between the blocks. But it also overturns finally.

For the stacked structure without pins and sockets for a confined space, stresses between the blocks and between the block and a rigid wall occur when the block structure changes its motion such as from the right to the left or from the left to the right. Though the major stress results from the striking between the blocks or between a block and a rigid wall in both cases with pins and without pins, an additional stress occurs in the pins and sockets in the case with pins and sockets. Since the relative displacement is restrained by the pins and sockets, the overall range of the stress magnitude in the case with pins is higher than that in the case without pins as shown in Fig. 2. In Fig. 2, the large stress occurs in the connected part between the blocks when the stacked block impacts to the wall. The shear stress applied to a pin at the lowest block is represented in Fig. 3.

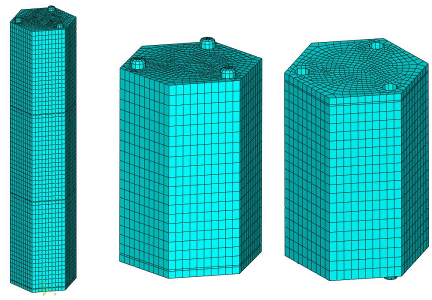

Fig. 1. FE model of the 3-story one-column stacked block

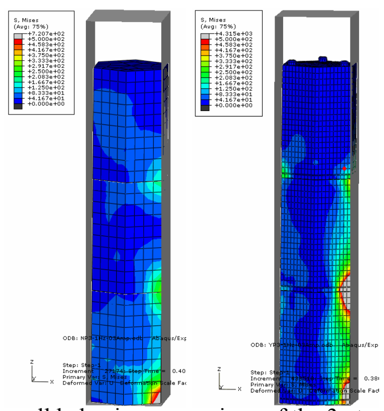

Fig. 2. Overall behavior comparison of the 3-story stacked block structure w/ and w/o pin and socket

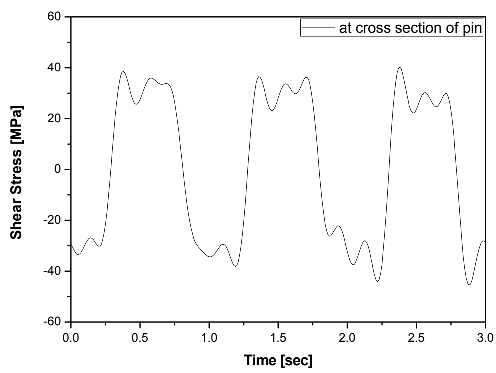

Fig. 3. Shear stress applied to a pin in the lowest block

2.2 Behavior Evaluation of 10SSCSB

The behavior of 10SSCSB under a harmonic excitation is evaluated for a confined space. When an excitation acceleration is applied to 10SSCSB, stress from the striking between the blocks and between the block and a rigid wall occurs for the confined space. The rigid wall simulates the neighboring block column in a multi-column multi-story stacked structure which is in the core of a VHTR. In the stacked block structure without pins and sockets, the structure remains in its initial shape temporarily, by the friction force only. As time passes on, a relative displacement accumulates in all the blocks. Especially, the block in the upper part has a big deviation from the initial location as shown in Fig. 4. This is also represented in Fig. 5. In Fig. 5, a relative displacement occurs between the top end block (block #10) and the block right under it (block #9) at around 0.5 seconds.

In the stacked block structure with pins and sockets, the overall behavior of the structure is similar to a single slender block as shown in Fig. 4 since the ten respective blocks are connected and restrained to each other by pins and sockets. In Fig. 6, the displacement of the block # 10 in the same direction as the excitation is almost the same as that for the block #9. That means the relative displacement is perfectly restrained.

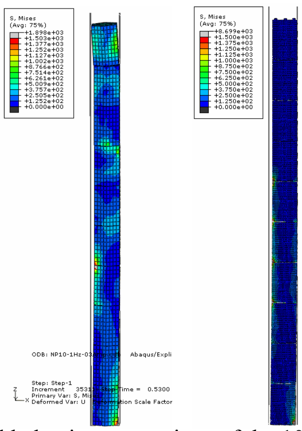

Fig. 4. Overall behavior comparison of the 10-story stacked block structure w/ and w/o pins and sockets

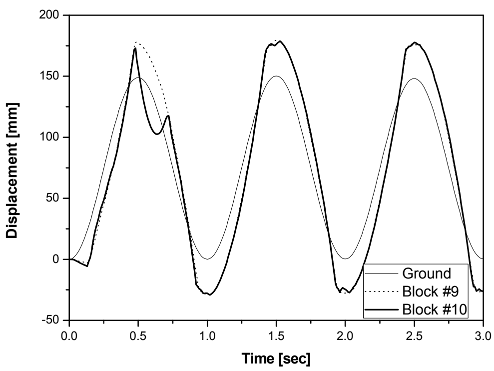

Fig. 5. Displacement history of blocks #9 and #10 in the case without pins and sockets

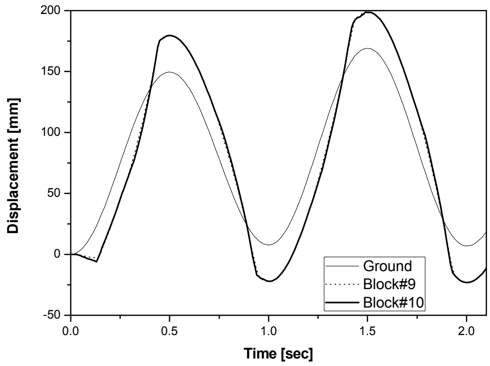

Fig. 6. Displacement history of blocks #9 and #10 in the case with pins and sockets

The stress contour of the lowest block is represented in Fig. 7. The magnitude of the stress in the case with pins is bigger since the weight and the impact of all the blocks are delivered to the lowest block. The structural integrity of the blocks under seismic load based on the stress approach should be evaluated in a further study. For the top end block, its maximum stress occurs by it striking the rigid wall.

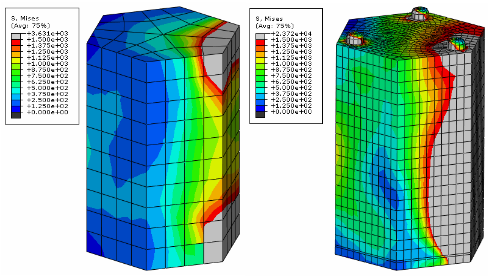

Fig. 7. Stress profile of the lowest block at a critical time

3. Conclusions

The behavior of a 3SSCSB and a 10SSCSB structure with pins and without pins was evaluated. The behavior of the stacked block with pins is similar to a single long block. For the case of 10SSCSB without pins, the top end block had a large deviation from its initial shape. For the case with pins, there was no deviation. The global stress range was bigger in the case with the pins since the weight and the impact of all the upper blocks linked to each other by the pins and sockets are delivered to the lower blocks. For further works, the behavior of a stacked block structure subject to an excitation with a high frequency such as a real seismic load should be evaluated. The structural integrity based on the occurring stress in the blocks should also be evaluated. And the items to be considered for the design of a pin and a socket should be treated.

REFERENCES

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