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Evaluation of Restrainer's Influence on Stacked Block Structure

Woo-Seok Choi [a*], Dong-Ok Kim [a], Jae-Man Noh [a], Yong Wan Kim [a]
[a]*Korea Atomic Energy Research Institute*
[*]*Corresponding author: wschoi@kaeri.re.kr*

1. Introduction

The core of a VHTR is a stacked structure of graphite blocks. 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[1-2]. 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. For the development of a seismic analysis methodology, a preliminary evaluation of one single block and single column stacked block structure under harmonic excitation had been performed[3]. But, the evaluation for a restrainer was not included in this previous study though a restrainer exists in actual design to prevent a lateral motion of stacked blocks. In this study, the influence of restrainer and pin/socket components on a single column stacked block subject to a harmonic excitation is evaluated.

2. Evaluation of Restrainer's Influence on Single Column Stacked Block Structure

The behavior of a 10 story single column stacked block (10SSCSB) in a confined space under a harmonic excitation is considered. To evaluate the behavior of a single column stacked block structure, finite element (FE) models for 10SSCSB are established. FE models with and without pins and sockets and with and without restrainers are fabricated. The harmonic excitation has 1 Hz of its frequency and 0.3g of its magnitude. A FE model for 10SSCSB with pins and sockets and with restrainer is shown in Fig. 1. The left and the middle figure in Fig. 1 show pins in the top surface and sockets in the bottom surface, respectively. The right figure shows restrainers. The lowest block is restrained by core support structure. The restrainer located on the highest block prevents the lateral motion of stacked block structure. 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. 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. 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. 2 (b). This is also represented in Fig. 3. In Fig. 3, 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 but without restrainer, the overall behavior of the structure is similar to a single slender block as shown in Fig. 2 (c) since the ten respective blocks are connected and restrained to each other by pins and sockets. But the upper part of the stacked structure strikes the wall. In Fig. 4, 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. But there exists a relative displacement difference between blocks and the ground.

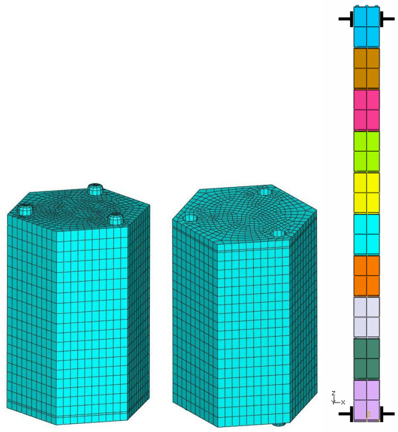

Fig. 1. FE model of the 10-story one-column stacked block

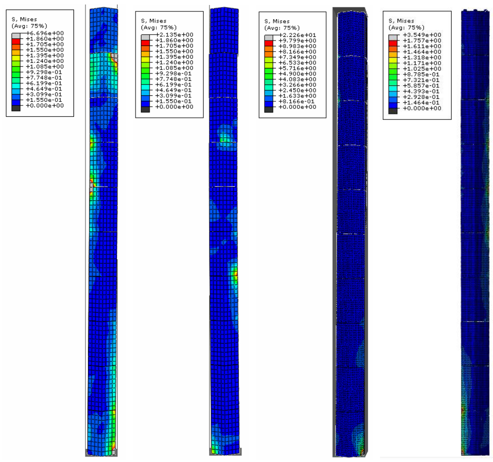

Fig. 2. Overall behavior comparison of the 10SSCSB
(a) Case of "w/o pins and restrainer" @ 0.47 sec.,
(b) Case of "w/o pins and restrainer" @ 1.0 sec.,
(c) Case of "w/ pins but w/o restrainer" @ 0.45 sec.,
(d) Case of "w/ pins and restrainer" @ 0.09 sec.

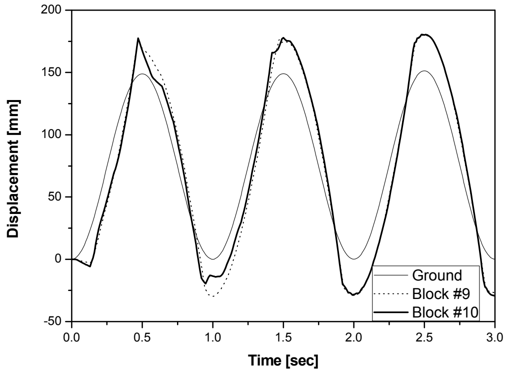

Fig. 3. Displacement history of blocks #9 and #10 and the ground in the case without pins-sockets and restrainer

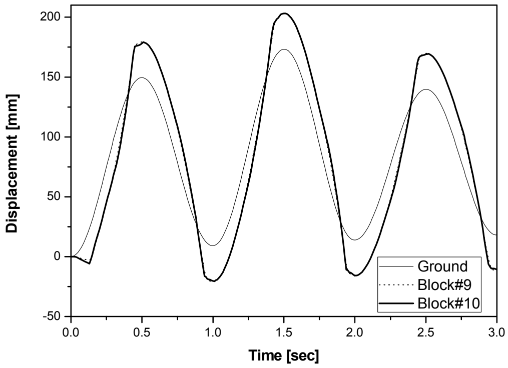

Fig. 4. Displacement history of blocks #9 and #10 and the ground in the case with pins-sockets but no restrainer

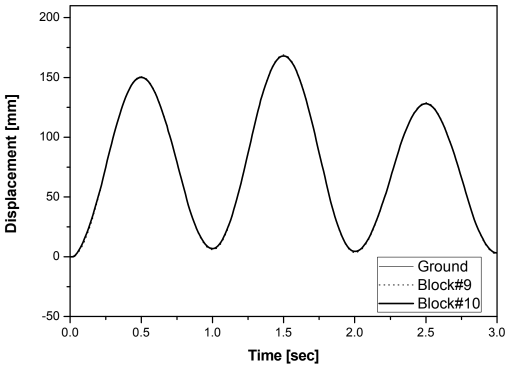

Fig. 5. Displacement history of blocks #9 and #10 and the ground in the case with pins/sockets and restrainer

In the stacked block structure with pins and sockets and with restrainer, a stacked blocks moves like a single slender block in right perpendicular posture in Fig 2 (d). There is no relative displacement difference among block #9, block #10, and the ground as shown in Fig. 5.

The stress contour of the lowest block is represented in Fig. 6. The maximum stresses happened in blocks for each case presented in Table I. Major stress results from the striking between the blocks or between a block and a rigid wall in each case. 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. 6. In the case with pins and restrainer together, little lateral motion makes small stress. The magnitude of the stress in each case is much smaller than the compression strength of graphite of 76.8 MPa. The Tresca stress at the pin surface in the lowest block is plotted in Fig. 7. This means not only the shear force but also many other forces such as a pressure are applied to the pins.

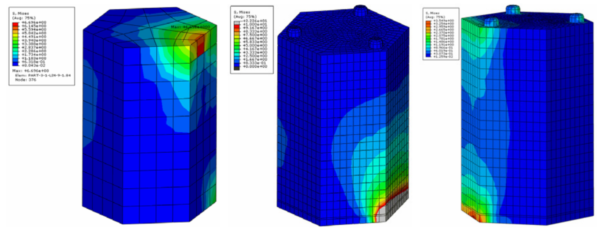

Fig. 6. Stress profile of the lowest block at a critical time

Table I: Maximum stress in each case

Cases	Max. Stress	Time
“w/o pins and restrainer”	6.70 MPa	0.47 sec.
“w/ pins but w/o restrainer”	22.3 MPa	0.45 sec.
“w/ pins and restrainer”	3.55 MPa	0.09 sec.

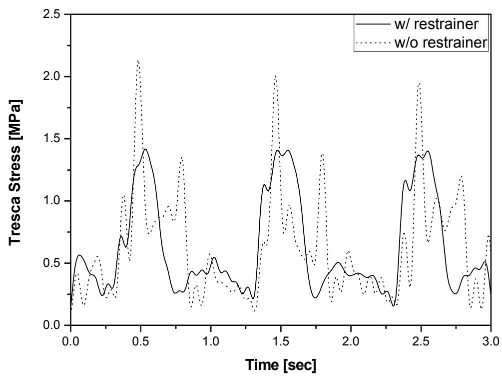

Fig. 7 Tresca stress at a pin’s surface in the lowest block

3. Conclusions

The behavior of a 10SSCSB structure with/without pins and with/without restrainer was evaluated. The behavior of the stacked block with pins is similar to a single long block. For the case with pins, there was no deviation. In the stacked block with restrainer, a lateral motion was prevented. 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. With restrainer, stress level decreased since there was little lateral motion due to restrainer.

REFERENCES

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