Behavior of Equipment Support Beam Joint Directly Connected to A Steel-plate Concrete(SC) Wall

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1. Introduction

To decrease the time for building nuclear power plants, a modular construction method, "Steel-plate Concrete(SC)", has been investigated for over a decade.

To construct a SC wall, a pair of steel plates are placed in parallel similar to a form-work in conventional reinforced concrete (RC) structures, and concrete is filled between the steel plates. Instead of removing the steel plates after the concrete has cured, the steel plates serve as components of the structural member.

The exposed steel plate of SC structures serves as the base plate for the equipment support, and the headed studs welded to the steel plates are used as anchor bolts. Then, a support beam can be directly welded to the surface of the steel plate in any preferred position.

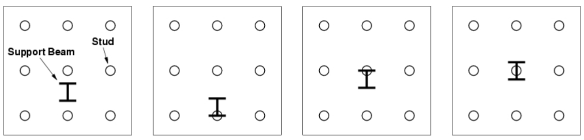
In this study, we discuss the behavior and evaluation method of the equipment support joint directly connected to exposed steel plate of SC wall.

2. Test Procedure

2.1 Outline of Specimen

A typical specimen (Specimen 1 serving as a base case) for this research is shown in Figure 1.

SC wall is composed of a pair of 13 mm thick steel plates with 230 mm stud spacing filled with 300 mm thick concrete. The diameter and length of a stud are 19 mm and 150 mm, respectively. An H-beam of 100x100 x6x8 mm was chosen as the equipment support beam. The support beam was directly welded to the steel plate without an embedded plate.



Specimen 1 Specimen 2 Specimen 3 Specimen 4

Figure 1. Test specimens

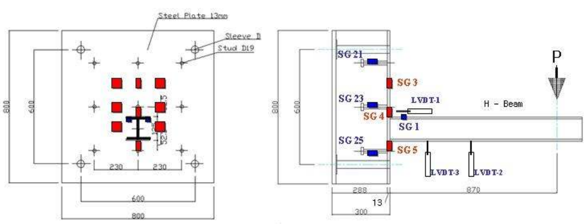


Figure 2. Test specimen and Gauges

2.2 Test Method

Experiments were performed in the structural engineering laboratory at the Korea Electric Power Research Institute. The concrete wall side of the specimen was placed on a rigid testing floor(Figure 2). The load was applied on the H-beam monotonically using a 250 kN actuator until an ultimate failure mode of the joint system or the maximum stroke of the actuator was reached.

Figure 3. Specimen and Thermal Heat Panel

2.3 Test Results

Load versus displacement response is presented in Figure 4. In Figure 3, deformed shapes are presented for a series of applied displacements. In the deformed shape of the plate, the region between the top of the support beam and the upper stud is separated from the concrete.

Plasticity fully developed along the plate above the upper flange of the support beam, which indicates formation of a plastic hinge. Plasticity also developed around the stud above the support beam

Table 1. Stiffness and yield strength

Specimen No.	Stiffness [kN/mm]	Strength [kN]
1	1.34	20.7
2	0.88	13.7
3	1.26	18.7
4	1.09	14.6

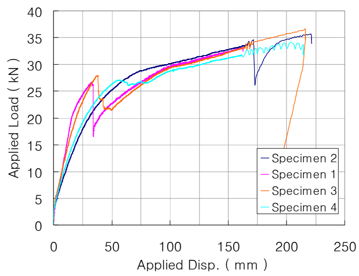


Figure 4. Applied load vs. displacement (Experiments)

3. Analysis

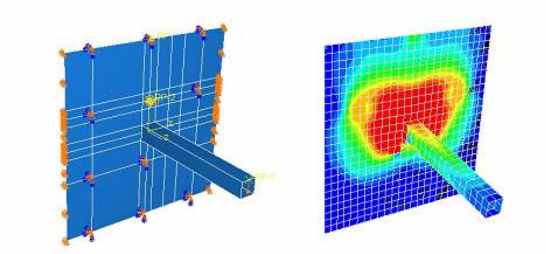
The finite element simulations about 2 specimens (Specimen 1, 4) were performed to confirm the validity of the experimental results.

3.1 Modeling

The finite element mesh for the base specimen is shown in Figure 5. The commercial finite element package, ABAQUS was used for the calculation. The steel plate and the support beam were modeled using 4-noded shell elements (S4R5) available in ABAQUS.

A steel yield strength of 240 MPa and Young's modulus of 210 GPa were used for the simulation.

Concrete was modeled as a rigid base in this simulation. Stud bolt was modeled using constraint stud point(Rigid) and spring(K) in the stud location.



(a) Model (b) Stress Contour

Figure 5. Applied load vs. displacement (Experiments)

3.2 Comparison of test results and simulation

Results are compared between experiment and simulation data for the purpose of the experiment verification.

The strength of each specimen after stud failure converged to the value of Specimen 2. This is due to the fact that the configurations of other specimens at large applied displacements (with or without stud failure) become similar to that of Specimen 2.

The simulation results using spring(K) model for stud in the simulation agree well with the test results.

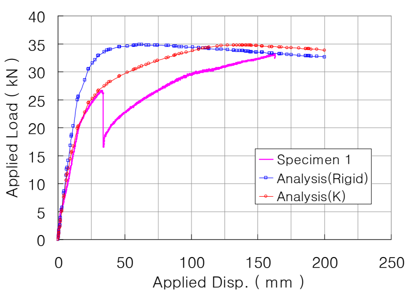


Figure 6. Experiment vs. FEM (Specimen 1)

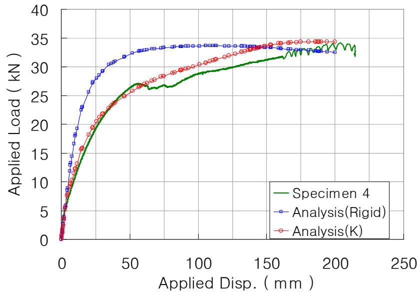


Figure 7. Experiment vs. FEM (Specimen 4)

4. Conclusion

From the analysis of the set of experiments conducted for this research, the following conclusions can be made:

① The damage of the joint system first occurred when the steel plate yielded followed by stud failure for all specimens.
② The effect of the support location on joint system behavior is significant for both elastic stiffness and post yielding actions including stud failure.
③ The simulation results using spring(K) model for stud in the simulation agree well with the test results.

To further investigate the effects of additional loading conditions, including in-plane loading acting on a SC wall, more experiments are needed.

ACKNOWLEDGEMENT

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