붙임 2

# Behavior and Design of Steel Plate Composite (SC) Wall – to –Reinforced Concrete (RC) Wall Mechanical Connections

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## 1. OBJECTIVE

This project will investigate the behavior and develop design guidelines for steel plate composite (SC) wall to reinforced concrete (RC) wall connections. RC walls of nuclear power plants designed by KEPCO E&C are connected with SC walls in some places in an attempt to utilize SC structures in the next generation of its nuclear power plant design. The SC wall-to-RC wall connections are subjected to design demands and have to provide adequate load transfer from one structure to the other. The connections shall be stronger than the weaker of the two connected walls to ensure appropriate force transfer mechanisms without brittle failure associated with the connection limit states. The specific objectives of this project are to (i) develop the design method for SC wall-to-RC wall connections, (ii) experimentally verify the performance criteria and design approaches of the designed SC-to-RC connections, (iii) conduct analytical parametric studies to evaluate the effects of various design parameters, and (iv) provide technical support with regulatory review and approval for the structure design.

## 2. WORK SCOPE

A series of integrated Tasks will be conducted in this project.

**Task 1: Development of design method**

*Task 1-1: Review of previously conducted SC wall-to-RC wall connection tests* Previously conducted SC wall-to-RC wall connection tests will be reviewed in this task. The development of the tested specimens and the connection design method (if any) will be carefully reviewed. The experimentally measured connection responses will be collected and reviewed as well as material properties. The findings from this task will be used in Tasks 1-2 and 1-3.

*Task 1-2: Development of performance criteria and design method for SC wall-to-RC wall connections* In this task, performance criteria and design methods for SC wall-to-RC wall connections will be developed within the contents of AISC N690 specification and KEPIC SNG. The method will be based on the full-strength connection design philosophy discussed in AISC N690 and AISC DG32, which develops the expected strength of the weaker of the two connected parts. When full strength connection design is implemented, ductile behavior is ensured with yielding and inelasticity occurring in the weaker of the connected elements. It is critical to identify the force transfer mechanisms for each of design demands (axial tension, axial compression, out-of-plane shear, out-of-plane flexure, and inplane shear). The required strength is estimated based on the capacity of the weaker of the connected elements. Then, the appropriate force transfer mechanisms are provided and connections are designed to transfer the required strengths.

*Task 1-3: Development and benchmarking of analytical models*

This task will focus on the development of analytical models for predicting the connection behavior and failure of SC wall-to-RC wall connections. ABAQUS [6], a commercially available finite element analysis software, will be used for the models. The analytical models will be benchmarked using the results from previously conducted SC wall-to-RC wall connection tests. After benchmarking the analytical models, a series of pre-test analysis will be conducted to predict the connection behavior and to analytically verify the connection design methods for SC wall-to-RC wall connections developed in Task 1-2.

**Task 2: Conducting experimental investigation**

This task will perform experimental investigation to verify the performance of connections designed using method developed in Task 1. The objective of the experimental investigation is to confirm the performance, strength, ductility, and failure mode of the SC wall-to-RC wall connection test specimens. A total of six tests will be conducted. The test parameters include the loading type and connection detail

(wing plate location). Tentative test setups for conducting these tests are schematically illustrated in Figures 1-3. Figure 1 shows the schematic view of the test setup for the out-of-plane flexure tests. By conducting the cyclic out-of-plane flexure tests, the performance of SC wall-to-RC wall connections subjected to axial tension, axial compression, and out-of-plane flexure can be confirmed. Figure 2 shows the schematic view of the test setup for the out-of- plane shear tests that will address the performance of SC wall-to-RC wall connections subjected to out-of-plane shear. Figure 3 shows the schematic view of the test setup for the in-plane shear tests that will address the performance of SC wall-to-RC wall connections subjected to in -plane shear.

Table 1. Tentative test matrix

| Specimen | Loading | Wing plate location |
|---|---|---|
| 1 | 1 Cyclic out-of-plane flexure | Top |
| 2 | 1 Cyclic out-of-plane flexure | Bottom |
| 3 | 1 Cyclic out-of-plane shear | Top |
| 4 | 1 Cyclic out-of-plane shear | Bottom |
| 5 | 1 Cyclic in-plane shear | Top |
| 6 | 1 Cyclic in-plane shear | Bottom |

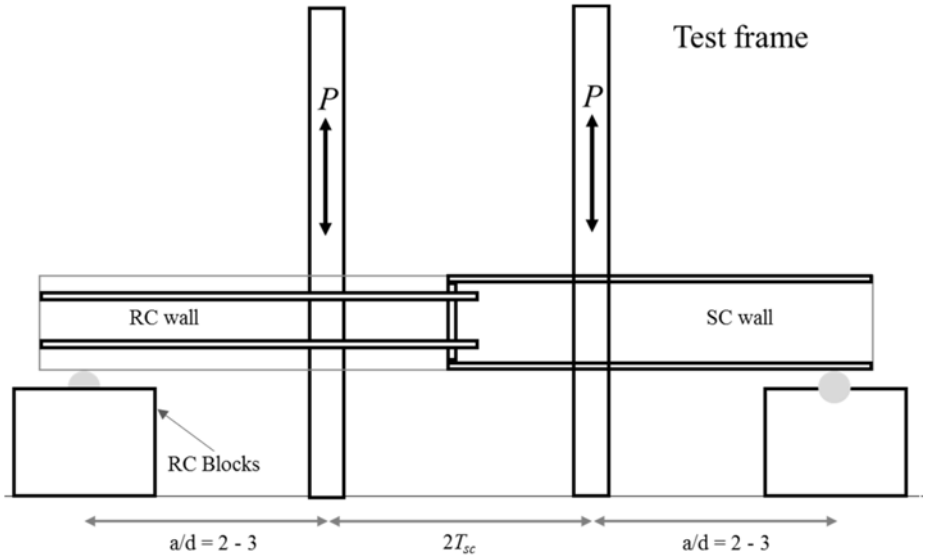


Figure 1. Schematic view of cyclic out-of-plane flexure test setup

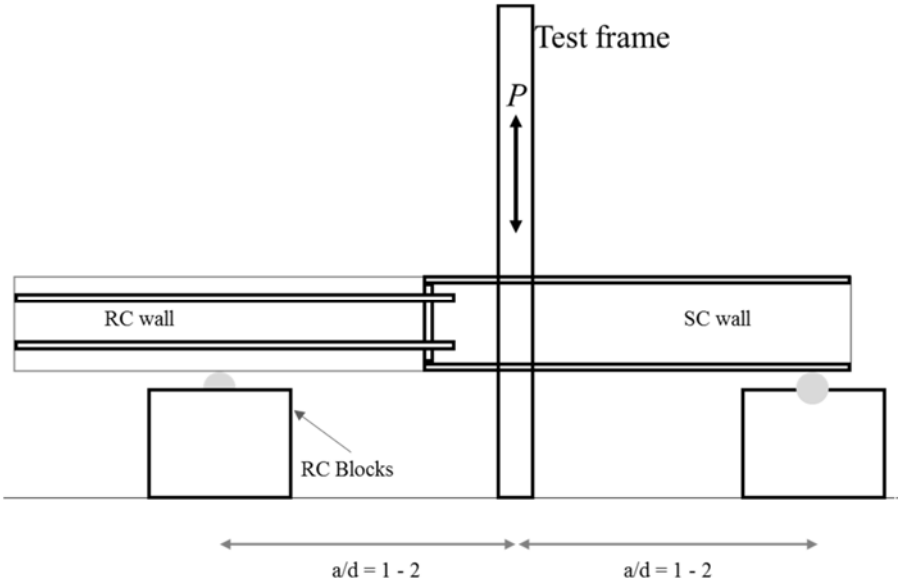


Figure 2. Schematic view of cyclic out-of-plane shear test setup

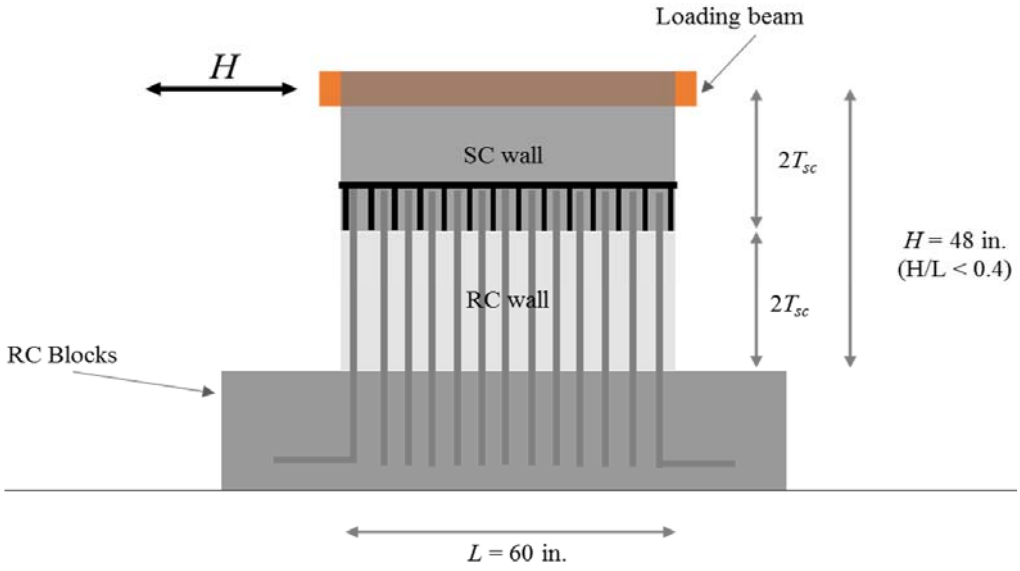


Figure 3. Schematic view of cyclic in-plane shear test setup

**Task 3: Conducting analytical parametric study**

The benchmarked analytical models from Task 1-3 will be used to conduct an analytical parametric study to investigate the influence of various design parameters associated with SC wall-to- RC wall connections. The parameters include material (reinforcement ratio, steel yield stress, concrete strength), geometric (plate thickness, tie spacing). The results from the parametric analyses will be postprocessed to reexamine and revise (if needed) the mechanics and assumptions of the design method from Task 1 of this project.

**Task 4: Report**

Task 4 includes the development of interim and final reports presenting a summary of the project progress and the results of this project as well as the design method for SC wall-to-RC wall connections. At a minimum, the report will include:

- Executive Summary
- Design method for SC wall-to-RC wall connections
- Results of experimental investigation
- Modeling approach and assumption
- Results of analytical investigation
- Summary and conclusions

**Task 5: Technical Meeting**

This task will include a series of technical meetings and conference calls. The objective of this task is to i) share findings from the project with the sponsor (KEPCO E&C) and ii) mange the project schedule efficiently. Three technical meetings are included in this task to discuss the progress of this project. In addition, monthly conference calls are included this this task.

**Task 6: Technical Support**

This task will include technical support to KEPCO E&C. The support will focus on providing expert opinion on resolving request for additional information (RAI) associated with licensing activity for nuclear power plant design of KEPCO E&C. This may include a number of visiting to South Korea

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## 4. PROJECT SCHEDULE

**Project Schedule**

The project schedule is summarized in Table 2. As shown, the total estimated project duration is 12 months. Task 1 will be conducted in the first three months. Task 2 will be performed in the following seven months. Task 3 will be followed and it will be conducted for two months.

Table 2. Proposed project schedule

| Task | Activities | Month | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| Task 1-1 | - | | | | | | | | | | | | | | |
| Task 1-2 | - | | | | | | | | | | | | | | |
| Task 1-3 | - | | | | | | | | | | | | | | |
| Task 2 | Fabrication | | | | | | | | | | | | | | |
| | Casting and curing | | | | | | | | | | | | | | |
| | Test setup 1 | | | | | | | | | | | | | | |
| | Prep-Specimen 1 | | | | | | | | | | | | | | |
| | Testing Specimen 1 | | | | | | | | | | | | | | |
| | Prep-Specimen 2 | | | | | | | | | | | | | | |
| | Testing Specimen 2 | | | | | | | | | | | | | | |
| | Prep-Specimen 3 | | | | | | | | | | | | | | |
| | Testing Specimen 3 | | | | | | | | | | | | | | |
| | Prep-Specimen 4 | | | | | | | | | | | | | | |
| | Testing Specimen 4 | | | | | | | | | | | | | | |
| | Test setup 2 | | | | | | | | | | | | | | |
| | Prep-Specimen 5 | | | | | | | | | | | | | | |
| | Testing Specimen 5 | | | | | | | | | | | | | | |
| | Prep-Specimen 6 | | | | | | | | | | | | | | |
| | Testing Specimen 6 | | | | | | | | | | | | | | |
| Task 3 | - | | | | | | | | | | | | | | |
| Task 4 | - | | | | | | | | | | | | | | |
| Task 5 | - | | | | | | | | | | | | | | |
| Task 6 | - | | | | | | | | | | | | | | |

## Deliverables

The deliverables for the project are listed in Table 3.

Table 3. Deliverables

| Deliverable | Associated Task | Submission Form | Submission Date |
|---|---|---|---|
| Interim report | Task 4 | Report | 7 month after the project initiation |
| Final report | Task 4 | Report | 14 month after the project initiation |
| Technical meeting 1 | Task 5 | - | 1 month after the project initiation |
| Technical meeting 2 | Task 5 | - | 7 month after the project initiation |
| Technical meeting 3 | Task 5 | - | 1 month before the project completion |
| Conference call | Task 5 | - | Every month |
| Technical support | Task 6 | - | - |