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Capacity evaluation of developed studs for SC walls subjected to bending moment

Sung-Gook Cho[1a], Jin-Sun Lim[2b], Young-Do Jeong[3c] and Seong-Tae Yi[*4]

[1]INNOSETECH, Incheon 22990, Korea
[2]R&D Center, SAMWOO IMC, Seoul 05660, Korea
[3]R&D Center, POSCO E&C, Incheon 22009, Korea
[4]Department of Civil and Environmental Engineering, Inha Technical College, Incheon 22212, Korea

Abstract. An analytical study in which the nonlinear finite element method (FEM) was applied has been conducted in an effort to evaluate the capacity improvement of a shear connection through the use of developed studs between the concrete and the steel plate in a steel plate concrete (SC) wall subjected to bending moment. For a FE model of SC walls, the nonlinearity of the contact, the connection, and the material properties were considered. The size of the object model was determined through a literature review and by referring to the code requirements. In order to verify the adequacy of the selected analytical model and the feasibility of the proposed analysis method, the results of a laboratory experiment conducted in an earlier study was compared to the results from this analytical research. From this comparison, it was noted that the analytical model expressed the experimental results comparatively well. In addition, analyses that considered different types and arrangement intervals of studs to review whether the studs meet the KEPIC-SNG criteria, the relevant design standard, were carried out. After reviewing the regulations pertaining to the bending moment and buckling strength, the optimum type and arrangement spacing of the developed studs were suggested. The results showed that the performance of developed stud #2 was superior to that of stud #1.

Keywords: steel plate concrete (SC) wall, developed stud, optimum type, bending moment, nonlinear finite element analysis

1. Introduction

For steel plate concrete (SC) structures, because the steel plates perform on behalf of the roles of the bar employed as a structural material and the form used as a construction material in current reinforced concrete (RC) structures, the accompanying workload is reduced. Moreover, because modularity is possible, improved economics

*Corresponding author, Professor, E-mail: yist@inhatc.ac.kr
[a] Ph.D., E-mail: sgcho@innosetech.com
[b] Ph.D., E-mail: jslim@samwooimc.com
[c] Ph.D., E-mail: jdy@*poscoenc*.com

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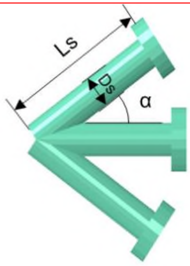
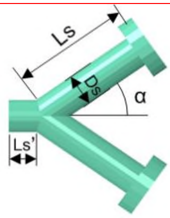
and quality are maximized (Choi, 2007). When a SC structure is applied to a shear wall, because the structural performance is improved more effectively compared to the use of RC, it can contribute to improved seismic stability of nuclear power plant (NPP) structures (Cho *et al*., 2012).

A three-dimensional finite element (FE) model was proposed for a stud capacity assessment of SC walls subjected to bending moment. A comparison and verification of the finite element analysis (FEA) results conducted in this study relative to experimental results obtained from an actual specimen in a previous study (Cho *et al*., 2012) were also undertaken.

The general stud (GS) is improved, as shown in Fig. 1, in order to decentralize the pulling force onto the stud during the bending behavior of SC walls. Several analyses (Clubley *et al*., 2003; Queiroz *et al*., 2007; Nguyen and Kim, 2009) similar to that in this study have also been performed. Currently, however, research results for the developed studs (Fig. 1) do not exist. The developed stud #1 (hereafter ‘DS#1’) consists of three studs; two are arranged above and below, respectively, the general stud. The developed stud #2 (hereafter ‘DS#2’) consists of two inclined studs. During the actual construction process, the stud and the steel plate can be connected by welding or bolting; however, it was assumed in this research that the stud is perfectly attached to the steel plate.



(a) developed stud #1 (DS#1)



(b) developed stud #2 (DS#2)

Fig. 1 Types of developed studs

2. Verification of the finite element model

Figs. 2(a) and (b) show comparisons of the results from the FEA and the load-displacement curves obtained from monotonic loading tests in the length and thickness directions of the SC walls (Cho *et al*., 2012). In the legend, SXP represents a specimen loaded in the thickness direction of the walls, SYP denotes a specimen loaded in the length direction of the walls, and FEM designates the finite element analysis results. With respect to the thickness direction of the walls, the analysis results are similar to the experiment results, whereas with regard to the length direction, the stiffness of the analysis model appeared somewhat greater than that in the experiment results because, in this direction, all of the concrete inside the SC members showed shear failure. As a result, the concrete demonstrated anisotropic characteristics due to the energy dissipation that arose with the development and progress of cracks. The rib used to support the basic plate and the steel plate was ruptured, peeling off during the experiment; however, this was not considered in the analyses. By comparing the analysis results and the experiment results, it was found that nonlinear behavior of this