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Natural frequency and damping ratio of newly suggested studs for SC walls subjected to forced oscillation

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Abstract. This study analytically reviewed the behavior of steel plate concrete (SC) walls subjected to forced oscillation to investigate the effects of shape and arrangement spacing of studs on the behavior of SC walls. To perform it, 9 cases of finite element analyses considering the different shape and spacing of studs in SC walls were carried out. For a FE model of SC walls, the nonlinearity of the contact, the connection, and the material properties were considered. In order to verify the adequacy of the selected analytical model and the feasibility of the proposed analysis method, the laboratory experimental results conducted by other researchers were compared to the results from this analytical research. From the analyses, it was noted that the damping ratio obtained from the time history analyses showed overall the high value in Half-power Bandwidth method and the lowest value in Fitted Exponential Curve method.

Keywords: steel plate concrete (SC) wall, developed stud, shape, spacing, natural frequency, damping ratio, nonlinear finite element analysis, KEPIC-SNG

1. Introduction

Steel plate concrete (SC) structures are composed of composite body filled with thick concrete between thin steel plates. And, in-plane and out-of-plane strength required in the member by using the steel plate instead of the reinforcing bar used in the existing reinforced concrete (RC) structures is secured and it is a structure that can be expected from the role of the form. More specifically, for this structure, the initial stiffness as the shear wall against repeated loads such as seismic loads is large and the ductility of the surface steel sheet up to the yield and fracture is amounting to approximately 1.5 times the RC structure (Akiyama et al., 1989). However, even today, the researches for SC structures (Lee and Kim, 2010; Cho et al., 2014; Lim et al., 2015) compared to RC or steel structures are relatively not sufficient. Most studies carried out in South Korea and overseas are for the static behavior and, on the dynamic behavior, it was only partially performed.

For RC, steel structures, and SC structures, when the steel plate has reached a yield point, there is sufficient non-linearity in order to reduce the design load. However, since the seismic design based on the conventional linear analysis cannot reflect the characteristics, these structures can be said that these structures include the irrational conservatism. Because of this, when designed according to the linear analysis, it is reasonable to consider is the energy

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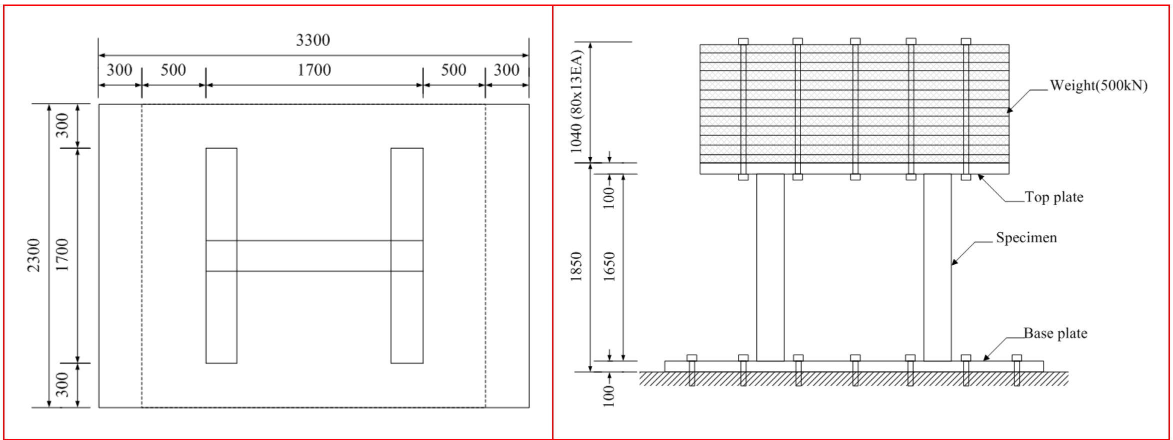
absorption in terms of the damping ratio and various studies research for this on this always need.

2. Nonlinear finite element analyses of SC shear walls

FEA was conducted to assess the influence of the stud shape and spacing on the composite behavior of SC shear walls subjected to forced oscillation. Finite element (FE) models of SC walls are established with three stud distances and three stud shapes. To build the finite element model, a finite element analysis model by Lim *et al*. (2015) was referred and, as the experimental results for the verification of the analysis model, the research results of Kim and Lee (2010) were used. Meanwhile, the studies based on numerical analyses using a computer (Ren *et al*., 2015a,b; Shahidul Islam and Khennane, 2013) have been a lot done. In this study, to account for the time history analysis, non-linearity of the material, and contact *et al*. for forced oscillation load, the feasible FEA (ABAQUS/Explicit) was used.

2.1 Shape and element of FE model

For comparison with the results obtained by existing tests, in this study, it is judged that the size of the simple shaped wall specimen used in laboratory tests is more reasonable than the complex shaped real structure. Namely, the SC-S specimens (shear-dominated SC structure specimens) of specimens of Lee and Kim (2010) were selected, as shown in Fig. 1.



(a) Plan view | (b) Side view

Fig. 1 Oscillation test specimen (Lee and Kim, 2010) (unit: mm)

2.2 Steel plate and stud

As the material characteristics of the steel plate and the stud, the elastic modulus and the Poisson's ratio are set to 207000MPa and 0.3, respectively, while the elasto-plastic behavior is assumed to comply with the von Mises failure criteria. The stress-strain relationship of the steel plate and the stud is shown in Fig. 4 based on the research by Prakash *et al*. (2011). The yielding strength and the tensile strength of the steel plate were 240MPa and 400MPa, respectively, while the yielding strength and tensile strength of the stud was 550MPa and 710MPa, respectively.

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