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An analytical study on post-tensioned transfer plate system and its punching shear

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ABSTRACT

The analysis of punching shear at the transfer plate-column connection according to the different modeling methods of the post-tensioned transfer plate system is presented in this study. Although the plate floor-separated analysis model is typically applied for the practical design of the post-tensioned transfer plate (Yoon et al., 2010), validity of the separated analysis model has not been verified. To supplement this gap or improve modeling method, two representative residential buildings were analyzed.

1. INTRODUCTION

Recently in Korea, transfer plate structure is commonly adopted to address the needs for large open space on lower floors in buildings such as apartments or hotels. Yoon et al. (2010) recently reported that the application of post-tension on transfer plate could reduce the thickness of plate. Unlike the transfer girder and transfer plate, studies on post-tensioned transfer plate are scarce and proper design method has not yet been established.

In design practice, the separated analysis method, where only transfer plate and single story of columns below are modeled individually, is adopted for analysis and design of transfer plate (Fig. 1). Using prestressed concrete analysis software, flexural and punching shear design is conducted based on the separated analysis model. However, the separated analysis model may not be appropriate to simulate the behavior of whole building as it does not satisfy the compatibility. In this study, the separated analysis model is compared with the complete model that includes entire structural systems and post-tensioned transfer plate. The commercial structural analysis software, ETABS, is used for the study.

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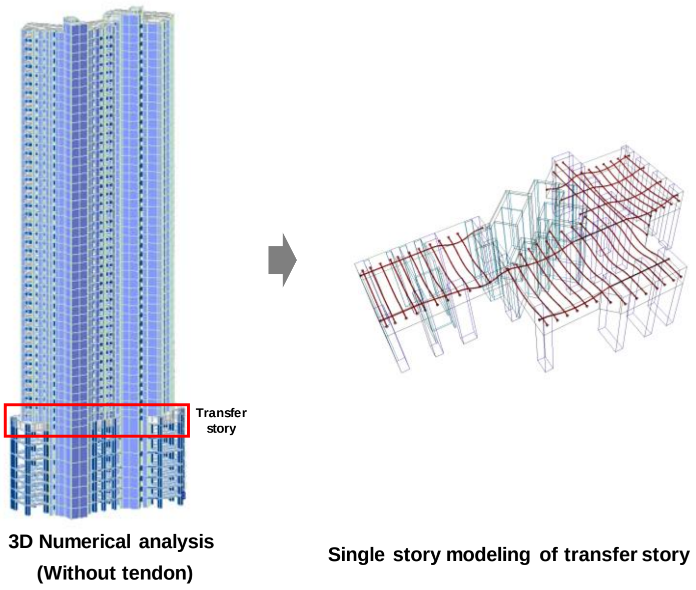


Fig. 1 Analysis and design process for post-tensioned transfer plate system

2. ANALYTICAL MODEL

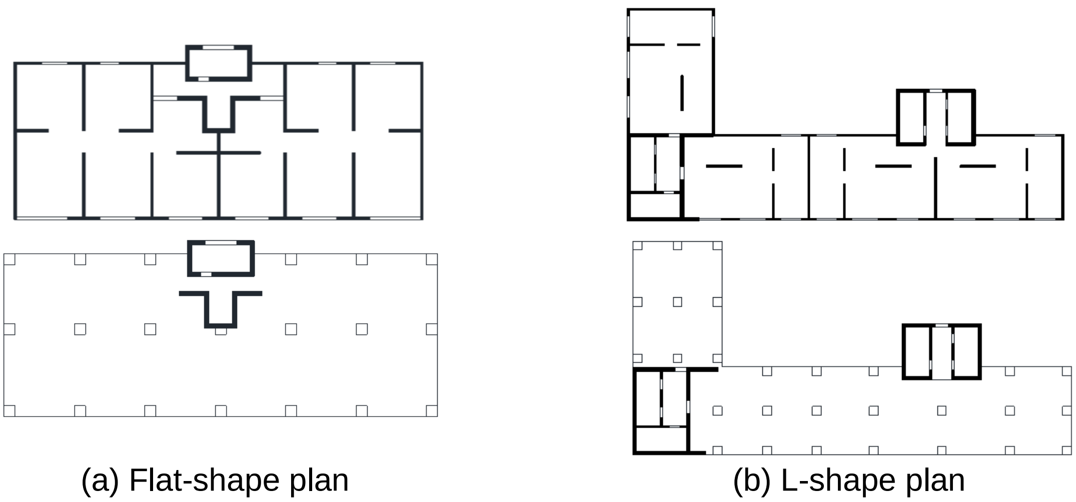
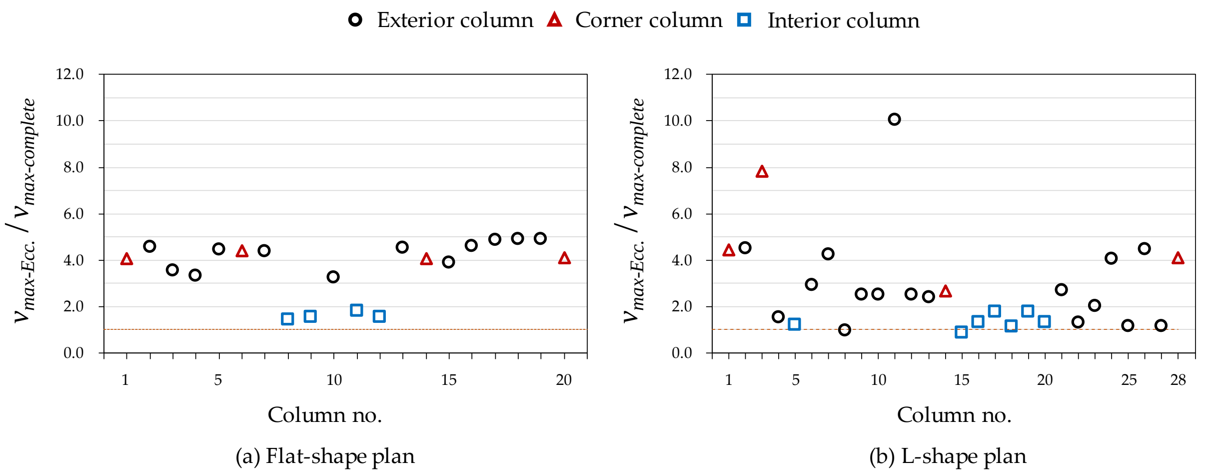


Fig. 2 Two plans for analytical model

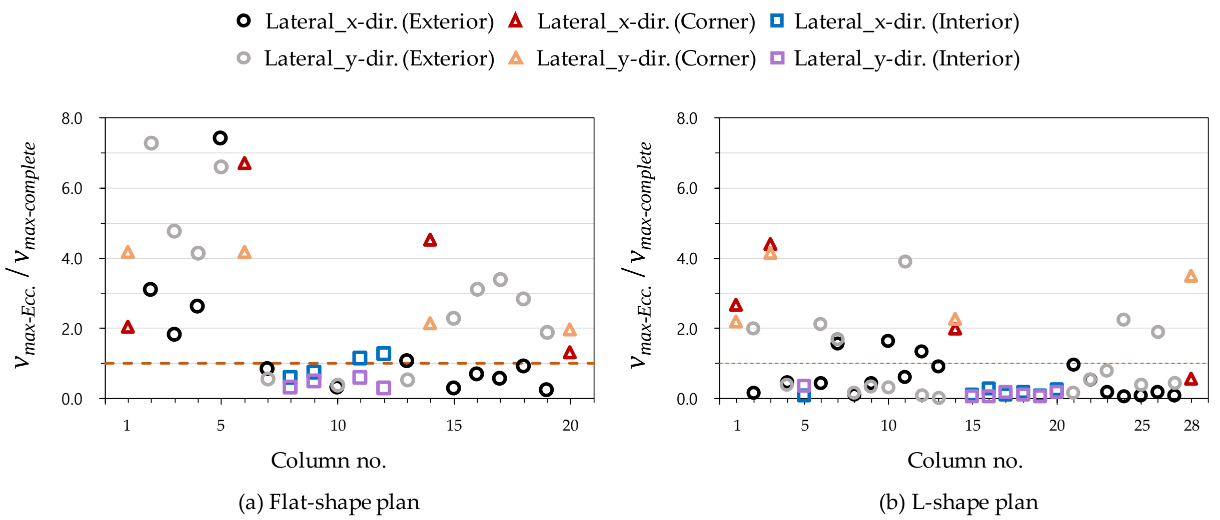
Figs. 1(a) and (b) are typical plans for the low-to-mid rise and high-rise apartments in Korea, respectively. Since the purpose of this study is to compare the behavior of the transfer plate according to modeling method, it is assumed that the number of upper shear walls is 20 stories. For concrete strength, 24 MPa and 30 MPa are assumed for transfer members (transfer column and transfer plate) and other members (shear walls and coupling beams), respectively. According to the related study (Park et al., 2001), the thickness of transfer plate is proportional to the height of superstructure. In addition, 15% of reduction in thickness is assumed when prestress is applied to the plate. Thus, the thickness of the transfer plate with 20 stories of upper shear wall system is assumed to be 1300 mm.

3. ANALYSIS RESULTS



(a) Flat-shape plan (b) L-shape plan

Fig. 3 Maximum punching shear ratio according to the modeling method (gravity load only)



(a) Flat-shape plan (b) L-shape plan

Fig. 4 Maximum punching shear ratio according to the modeling method (lateral load only)

Figs. 3 and 4 show the ratio of the maximum shear stresses on the critical section at each transfer column between the two modeling methods. Fig. 3 shows the ratio for two plan shapes under gravity load only. For the flat-shape plan case, the ratio ranged from 3.2 to 4.9 for the exterior column (black circle), from 4.0 to 4.4 for the corner column (red triangle), and from 1.4 to 1.9 for the interior column (blue square). For the L-shape plan, the exterior column had the ratio from 0.9 to 10.0, the corner column from 2.6 to 7.8, and the interior column from 0.9 to 1.7.

Fig. 4 shows the ratios when only the lateral load is applied. In case of flat-shape plan, the ratio from 0.23 to 7.4 was noted for the exterior column, from 1.3 to 6.7 for the corner column, and from 0.26 to 1.2 for the interior column. In case of the L-shape plan, the exterior column showed the ratio from 0.1 to 3.9, the corner column from 0.6 to 4.4, and the interior column from 0.1 to 0.3.

4. CONCLUSIONS

Based on the comparison of punching shear stress on the critical section of the transfer column under gravity load only, the shear stress of the separated model was significantly larger than that of the complete model. Especially at the exterior and corner columns, the stress of the separated model was more than double compared to the complete model. In case of lateral load only, no clear tendency was found for both flat-shape and L-shape plans. Only at the exterior and corner columns, the shear stress was somewhat overestimated in the separated model. This is because the separated model cannot take into account the contribution of the shear wall located within the critical section of the transfer column.

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