日本建築学会大会学術講演梗概集
（東海） 2021 年 9 月

Experimental study on the influence of openings on strength and stiffness of RC walls Part 2: Experiment results

Keyword:
RC shear wall　　Opening in walls
Strength reduction　　Stiffness reduction

○Zasiah Tafheem [1]　　Hamood Alwashali[2]
Masaki Maeda[3]　　Matsutaro Seki[4]
Kazuya Tsurugai[5]　　Naoyuki Aizawa[5]
Yoshihiro Ogata [5]

1. Introduction

Part 1 of the study showed the experimental plan and Part 2 (this part) shows and discusses the experimental results.

2. Failure mechanism

2.1 Crack pattern and failure mode

The diagonal cracks at a shear strain of 0.6%, at which specimens had already reached peak maximum strength, are shown in Figure 1. The direction and cracks pattern for all specimens are diagonal cracks as expected by pure shear loading. It was noticed that number of cracks for specimens with additional reinforcement was greater when compared with specimens without additional reinforcement eg. a comparison between S80 and S80A, or S160 and S160A. Specimen with a large opening (S240) had fewer cracks but with a larger width. The failure mechanism after the final cycle is shown in Figure 2. As for the specimens with opening, the final failure was a sudden abrupt degradation of strength caused by the crushing of concrete along the corner of openings.

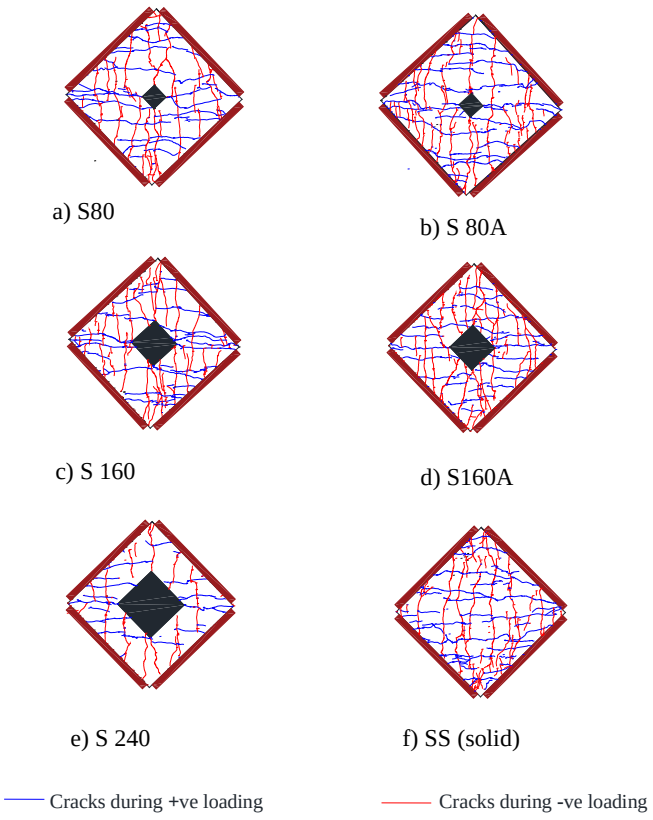

Figure 1. Crack observed at shear strain of 0.6%

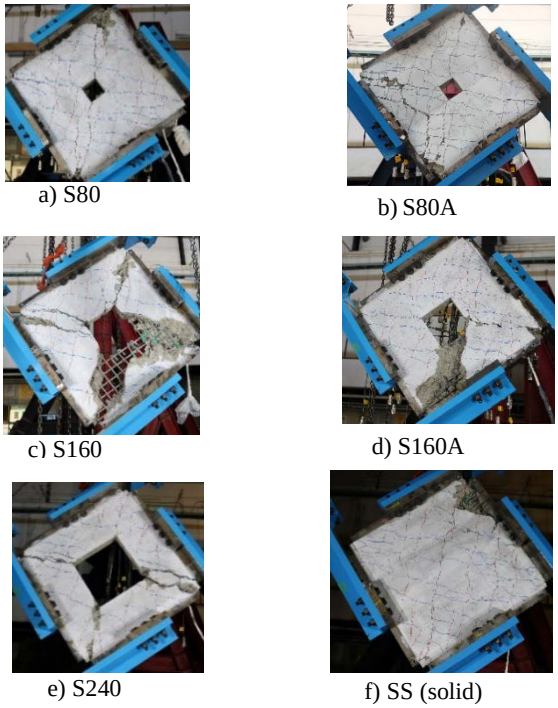

Figure 2. Photos of test specimens at final failure

2.2 Hysteresis curves

The lateral load versus shear strain of all specimens is shown in Figures 3. The first cracks appeared at a shear strain of 0.0125~0.025% accompanied by gradual degradation of stiffness. The first yield of reinforcement observed by strain gauges attached at specimens was in the range of shear strain of 0.08%~0.15% and commonly observed at the edge of the corners of specimens. At shear strain of 0.4%~0.6%, almost all reinforcement yielded.

2.3 Influence of opening size

A comparison of backbone curves of specimens with the variable opening size is shown in Figure 4. A comparison of secant stiffness is shown in Figure 5. There is a gradual decrease in stiffness and strength as the openings get larger. However, the specimen S240 which had opening area ratio larger than 0.4, had a larger degradation of stiffness as well as strength when compared with S80 and S160. A comparison of reduction in strength and stiffness recommended by the AIJ guideline [2] with test results (specimens without additional reinforcement) is shown in Figure 6. AIJ [2] gave a lower bound of strength even for specimens without additional reinforcement, except for specimen S240 with opening area ratio >0.4.

開口開口壁の耐力及び剛性の低下に及ぼす与える影響の検討
その 2　実験の結果

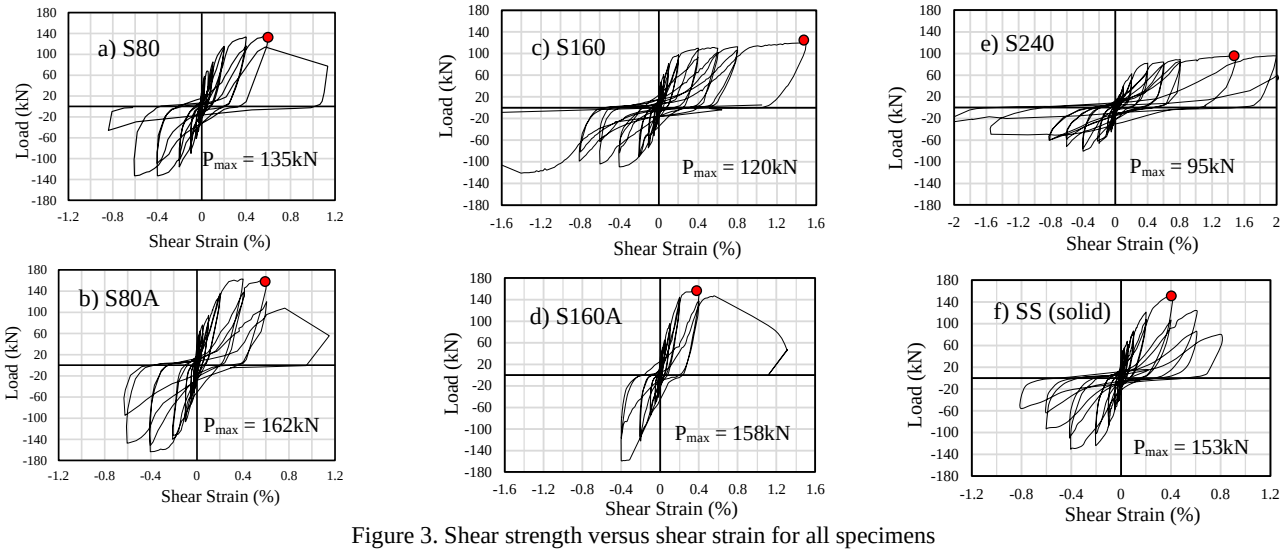

Figure 3. Shear strength versus shear strain for all specimens

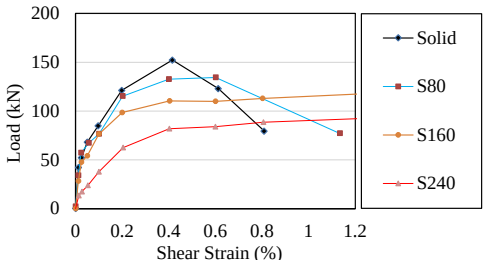

Figure 4. Backbones for specimen without additional reinforcement

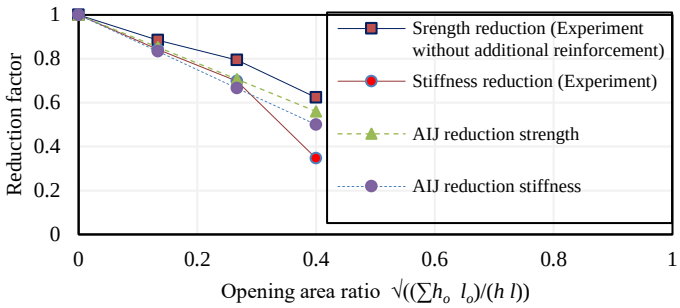

Figure 6. Comparison of the reduction of strength and stiffness of specimens without additional reinforcement

2.4 Influence of additional reinforcement around opening

A comparison of specimens with and without additional reinforcement is shown in Figure 7 and Figure 8. Specimens with additional reinforcement around the opening had strength almost similar to that of the solid specimen as shown in Figure 9.

3. Conclusion

Experimental results of six small-scaled panels with openings tested under pure shear were presented. Two parameters were investigated: the size of the opening and the influence of additional reinforcement around the opening. It was observed that there is a gradual almost linear decrease of stiffness and strength as the openings get larger, except for. specimen with large opening S240 which had a opening area ratio larger than 0.4, had a larger abrupt degradation of stiffness as well as strength. Additional reinforcement proved to be effective regarding the influence of opening on strength.

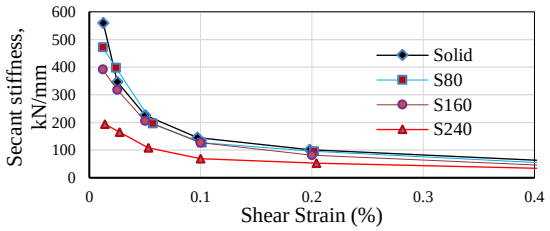

Figure 5. Comparison of secant stiffness

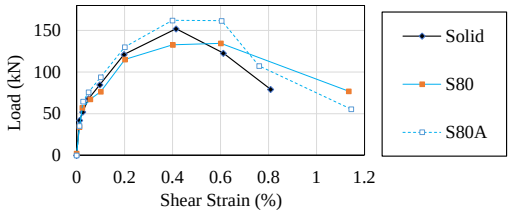

Figure 7. Comparison of backbone curves of SS, S160,

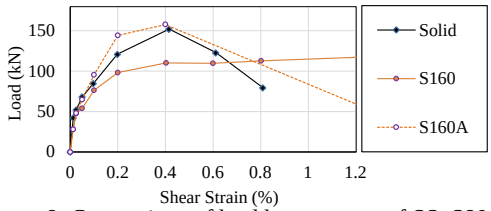

Figure 8. Comparison of backbone curves of SS, S80, S80A

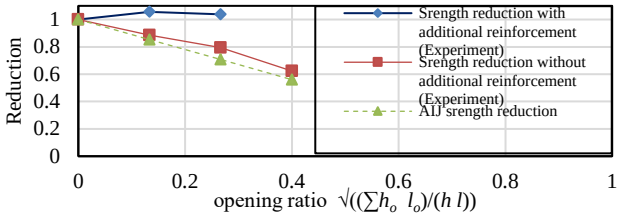

Figure 9. Reduction of strength with additional reinforcement

. References

1-Vecchio, F., Collins, M. P., "Stress-Strain Characteristics of Reinforced Concrete in Pure Shear," Proceedings, IABSE Colloquium (Delft, 1981),

2- AIJ standard for lateral load-carrying capacity calculation of reinforced concrete structures. 2018 (in Japanese).

3- Alwashali et al., "Experimental Study on Residual Seismic Capacity of RC Squat Walls", 17th World Conference on Earthquake Engineering, 2020.

1*東北大学大学院工学研究科 博士課程後期
2*東北大学大学院工学研究科 助教・博士（工学）
3*東北大学大学院工学研究科 教授・博士（工学）
4*建築研究所 特別客員研究員・博士 (工学))
5*東北電力株式会社

1*Graduate student, Graduate School of Eng., Tohoku Univ.
2*Assistant Professor, Graduate School of Eng., Tohoku Univ., Dr. Eng.
3*Professor, Graduate School of Eng., Tohoku Univ., Dr. Eng.
4*Visiting Research Fellow, Building Research Institute, Dr. Eng.
5*Tohoku Electric Power Co., Inc.