NARLabs
National Applied Research Laboratories
National Center for Research on Earthquake Engineering

含邊界構材之鋼板混凝土複合牆反覆載重試驗研究

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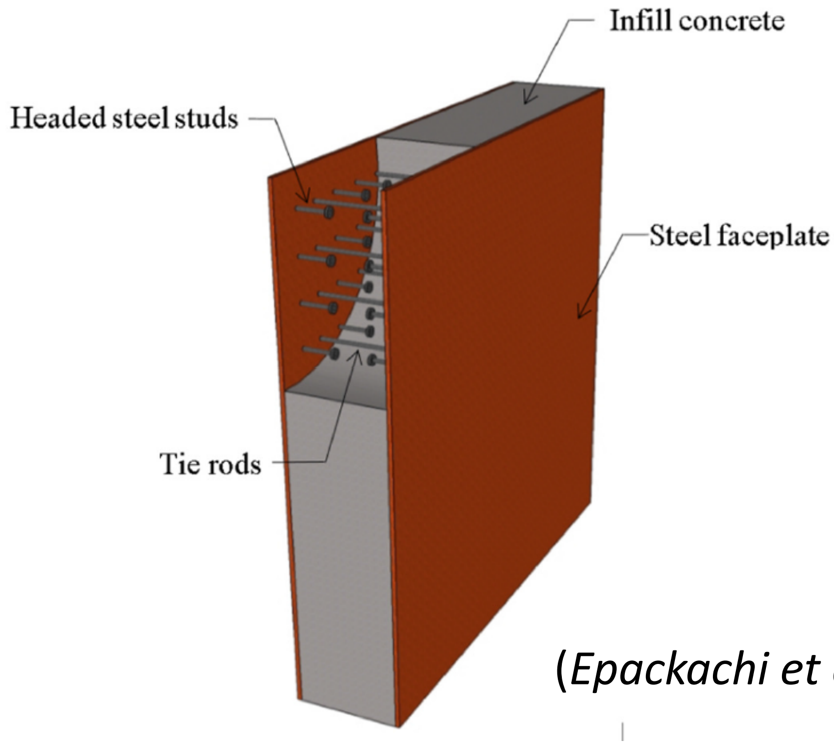
2018國家地震工程研究中心實驗成果研討會
2018年7月16日

Outlines

- Introduction
- Experimental Program
- Experimental Results
- Conclusions

Steel-Plate Composite Walls

- **Steel-plate composite (SC) walls recently have been used for the construction of nuclear power plants.**
- **SC walls are composed of**
  - **Steel faceplates**
  - **Infill concrete**
  - **Connectors**
    - — Tie rods
    - — Shear studs
- Connections
  - — Panel
  - — RC foundation



(*Epackachi et al.*, 2015)

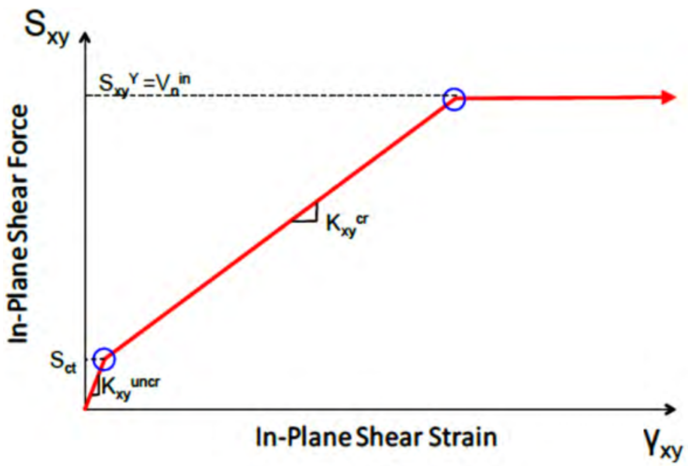
Strength of SC Walls

- **AISC N690s1** *(2015)*

$$V_y = \kappa \cdot A_s \cdot F_y$$

$$\kappa = 1.11 - 5.16 \cdot \bar{\rho} \le 1.0$$

$$\bar{\rho} = \frac{1}{31.6} \cdot \frac{A_s \cdot F_y}{A_c \sqrt{f_c'}}$$



- **In-plane shear strength** *(Booth et al., 2015)*

$$V_{ub} = \boxed{V_y} + \boxed{\Delta V}$$

- shear force required to yield the steel plates
- incremental shear resisted by the concrete in diagonal compression up to the failure of the wall

$$\Delta V = 0.33 \cdot 0.5 \cdot (f'_c - f_{cy}) \cdot A_c$$

$$f_{cy} = \frac{E'_c \cdot S_{xy} \cdot (\nu_s + 1)}{2 \cdot t_p \cdot E_s + t_{sc} \cdot E'_c}$$

Purpose

- To investigate the elastic and ***inelastic*** behaviors of SC walls with boundary elements for different failure mechanism
- To address the inelastic response of five SC walls with boundary elements subjected to reversed, in-plane cyclic loading.
- To study two kinds of failure modes
  - Four **shear-critical** walls
    - with an aspect ratio of **0.75 & 1.04**
    - thickness of **3 cm & 5 cm** for boundary elements
  - One **flexure-critical** wall
    - with an aspect ratio of **1.22**
    - thickness of **2 cm** for boundary elements

Test Specimen

Design variables

Shear critical: SCB1–SCB3; Flexural critical: SCB4–SCB5

	H×L×T(cm)	t_p (cm)	t_e(cm)	RR(%)	S(cm)	SR	AR	f'_c(kgf/cm^2)
SCB1	90×120×25.9	0.45	3	3.47	11	24.44	0.75	210
SCB2	90×120×25.9	0.45	3	3.47	11	24.44	0.75	350
SCB3	104×100×22.5	0.45	3	4	10	22.22	1.04	210
SCB4	104×100×22.5	0.45	5	4	10	22.22	1.04	210
SCB5	146×120×25.9	0.45	2	3.47	11	24.44	1.22	210

- **Reinforcement ratio (RR) :** $\rho = 2T_p / T$

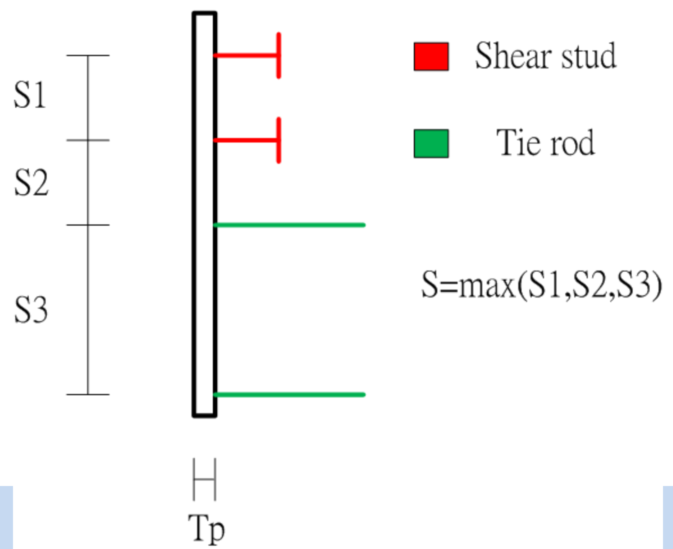
  T_p : Steel plate thickness

  T : Overall thickness
- **Faceplate slenderness ratio (SR) :** S / T_p

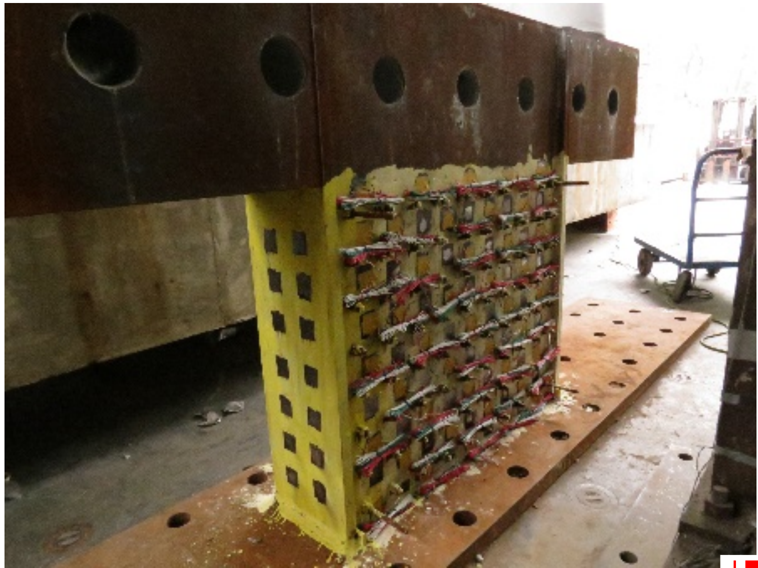
  S : Connector spacing = max(S_1, S_2, S_3)

  S_1 : Stud spacing

  S_3: Tie rod spacing
- **Aspect ratio (AR) :** H / L



Test Program



Test Program

- Test setup

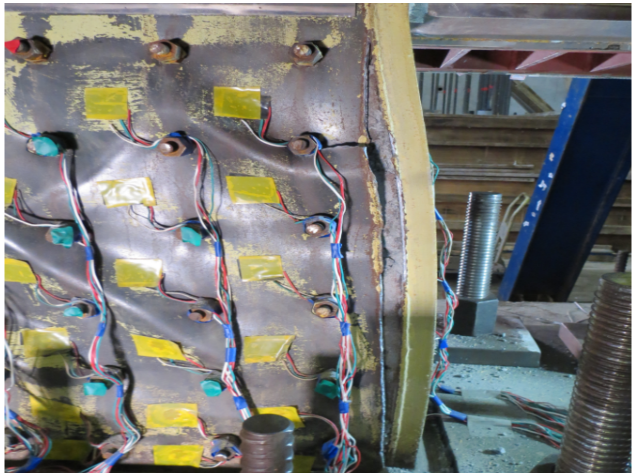
Concrete cracks at the End of Test (Flexural critical)

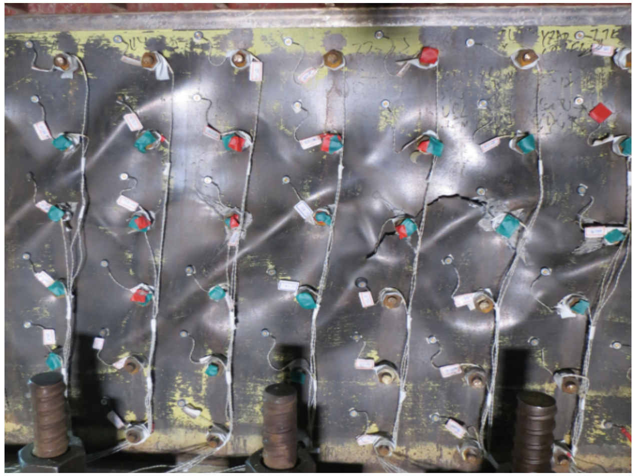
SCB5

Damage to Faceplates (End of Test)

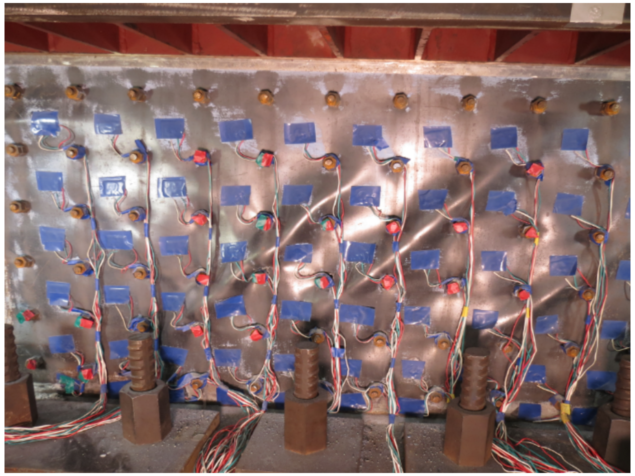
(Shear critical)

SCB1





SCB2



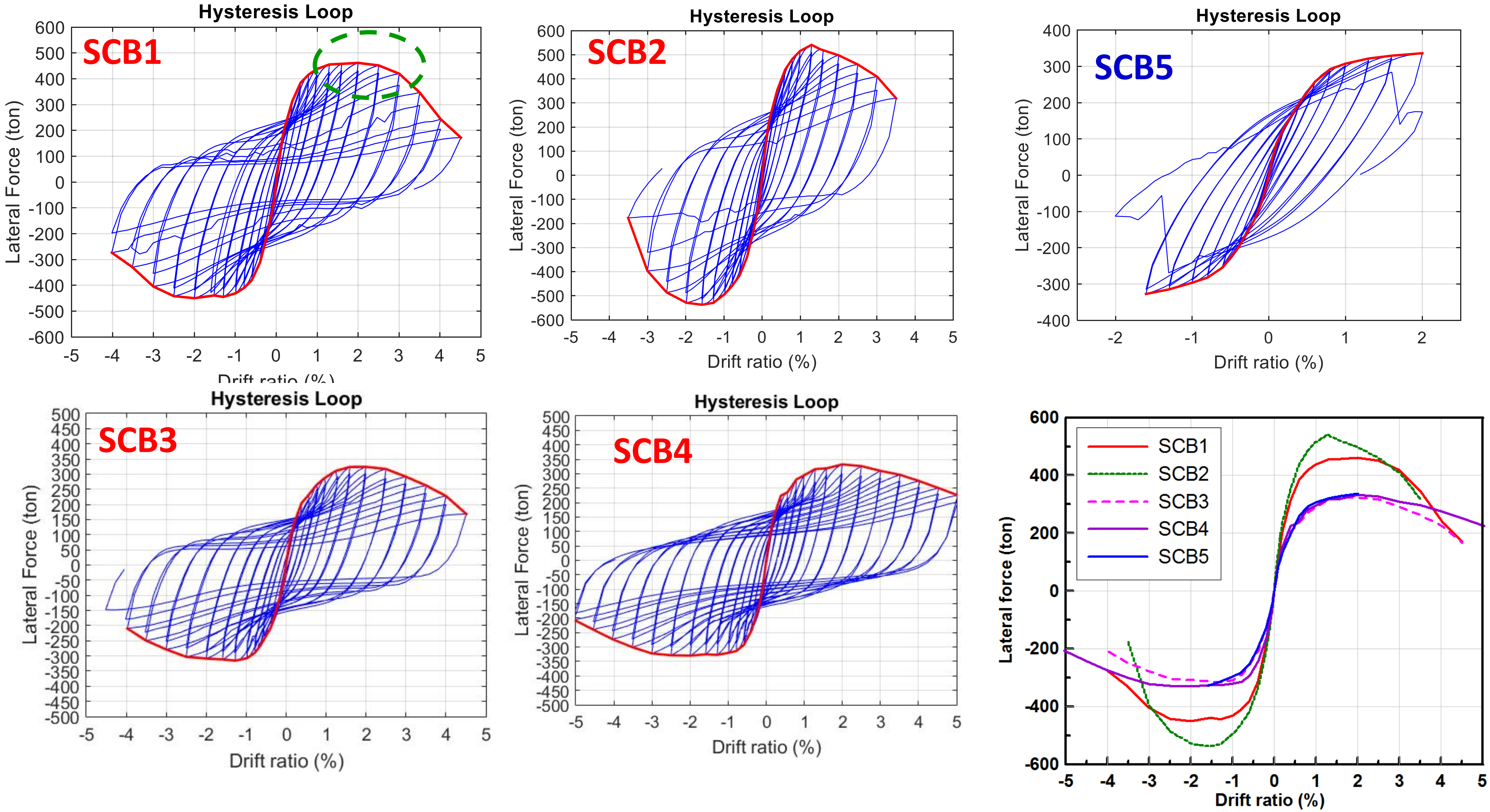
SCB3

SCB4

Damage to Faceplates (End of Test)
(Flexural critical)

SCB5

Force-Displacement Cyclic Response



Conclusion

- The shear-critical specimens of this study demonstrated very ductile behavior. Both specimens reached a drift ratio of 3~5% without losing 80% of their peak capacity.
- The test of the flexural-critical specimen (SC5) stopped at a drift ratio of 2% after the brittle rupture of the welding between the endplate and baseplate. The connection design for such SC walls is challenging and needs to be conducted carefully.
- The lateral-load strength of SC walls can be predicted well using numerical analysis.

Thank you !!

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