DOI: http://dx.doi.org/10.12989/sem.2009.33.5.649
Structural Engineering and Mechanics, Vol. 33, No. 5 (2009) 649-652

Technical Note

Experimental investigation of performance in L-shaped wall to wall corner connections of 3D Panels subjected to lateral cyclic loading

M.Z. Kabir† and R. Vasheghani-Farahani

Department of Civil and Environmental Engineering, Amirkabir University of Technology, Iran

(Received October 11, 2007, Accepted August 31, 2009)

1. Introduction

This paper measures experimentally the ductility of L-shaped wall connections of 3-D sandwich panels subjected to lateral cyclic loading. The main objective of current study is to examine the effect of vertical boundary element at the conjunction of L-shaped wall connections of 3-D sandwich panels against seismic-type loading.

2. Experimental program

Two different types of L-shaped wall connection, with and without vertical small column at the conjunction are cast, Fig. 1.

Types (a) and (b) include three and two identical specimens respectively. Both types of connection, with and without boundary element at the conjunction are shown in Fig. 1. The

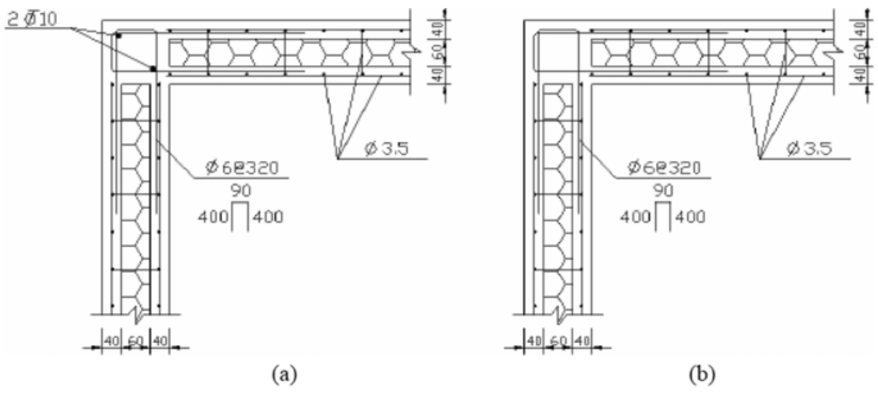
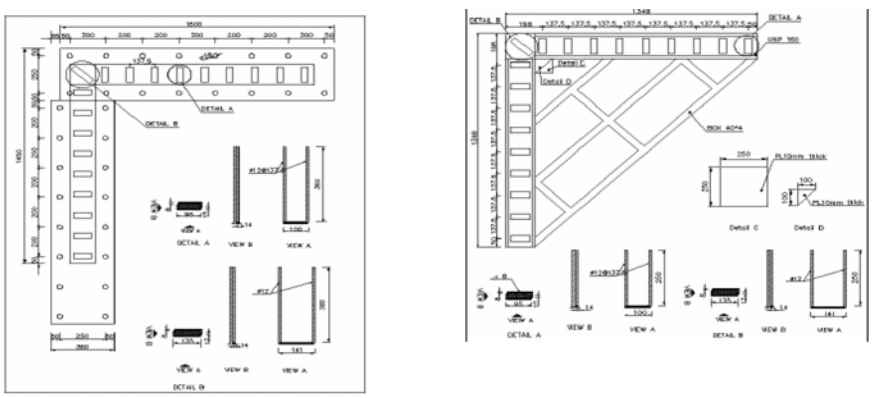


Fig. 1 Two different types of L-shaped wall connections, (a) with and (b) without vertical boundary element at the conjunction

† Corresponding author, E-mail: mzkabir@aut.ac.ir

specimens selected for testing purposes have two 3-D walls with 1350 mm height, 140 mm constant thickness including 40 mm shotcrete wythes in each side and 60 mm of expanded polystyrene core. The welded wire fabric is consisted of a cold rolling of steel bar with final outside diameter of 3.5 mm in accordance with ASTM A82 and automatic welding process with accordance of ASTM A185. The yield and ultimate strength of drawn and annealed wires are 380 and 450 MPa respectively. The shotcrete used for all specimens is used from Portland cement (II), river sand with maximum 8 mm diameter, drinkable water. The (W/C) is about 0.50 and the mix is made of 400 kg cement, 1700 kg sand and 200 kg water for a unit cubic meter shotcrete. Compression tests are carried out on (150×150×150 mm) standard cubes and provided cores from shotcrete panel.

In Specimens without vertical boundary element ten strain gauges are installed at critical locations in the height of 380 mm above the base plate determined through numerical analysis. In specimens with vertical boundary element two other strain gauges are installed on vertical boundary element in the height of 380 mm above the base plate at the conjunction. In all cases, the specimens are monolithically connected to a foundation which is utilized to fix down the wall to laboratory's strong floor, simulating a fully fixed footing. Fig. 2-shows the base plate and anchor bars used for specimens. Detail B exists only in specimens with vertical boundary element at the conjunction. The specimens are incrementally loaded with a hydraulic actuator. For transferring the applied force to the specimens, a transferring load system as shown in Fig. 3 is used.



(a) (b)

Fig. 2 Base plate used for all specimens (a) and Transferring load system, (b) -Detail B only exists in specimens with vertical boundary element

(a) (b)

Fig. 3 System setup (a) overall view, (b) details of system setup

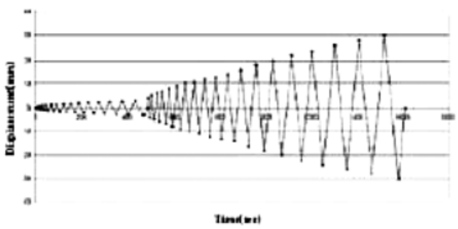


Fig. 4 Applied successive cyclic displacement

3. Loading history and test procedure

To simulate loading sequences that might be expected to occur during earthquake, simplified types of horizontal cyclic loading history are adopted. Since no standard cyclic test procedures has been introduced for testing reinforced shotcrete panels, the horizontal load is applied at a quasi-static rate in displacement controlled cycles with different patterns which corresponded to three major states, namely cracking state, yielding state and ultimate state. Fig. 4 represents the successive cyclic displacements to the specimens. Linear transducers of type LVDT are used to measure and monitor the horizontal displacements at top and bottom of specimens. The measured values of applied load and 6 displacements are recorded by a computer data logger capable of measurement to sensitivity ranges of 0.1 N, 0.001 mm, respectively.

4. Experimental results

Fig. 5 shows the lateral load versus top displacement curve established from the tests for all specimens. Based on ASTM standard method, the applied displacement and their corresponding reaction forces are plotted in load deflection hysteretic curves. The envelope curves for all specimens in forth moving and back moving are plotted in Fig. 6 for the purpose of ductility calculations.

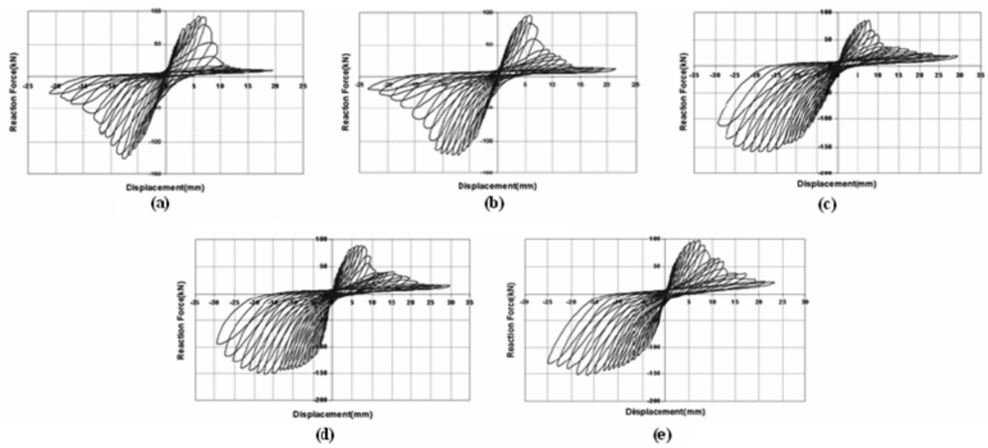


Fig. 5 Reaction force versus top horizontal displacement relationships (a) Specimen No.026, (b) Specimen No.027, (c) Specimen No.028, (d) Specimen No.029, (e) Specimen No.030

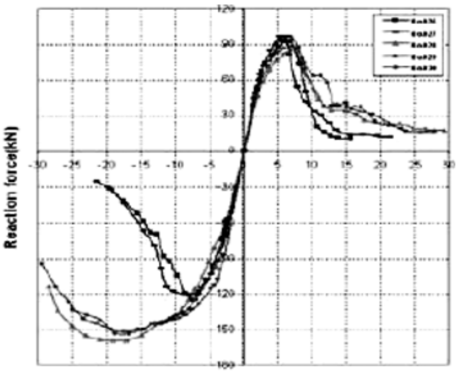


Fig. 6 Envelope of hystertic curves for forth moving and back moving for all specimens

5. Discussion

For all specimens, the cracks are initially formed near the bottom part of the tensile zone of the right wall when only about 12% of the final horizontal deformation capacity is applied. The significant cracks initiated at the tensile zone of the right wall during compressive reversal displacements. These cracks continue to penetrate deeply into the conjunction of the walls towards the left wall. In specimens without vertical columns these cracks are horizontal but in specimens including vertical column at the junction of two walls the first cracks are horizontal which obliged 45^o towards the conjunction. Since the strength of the concrete used for all specimens differs slightly, the variation in wall specimens is considered predominantly to reflect the effect of vertical column at the conjunction. It is seen that the horizontal load-carrying capacity of all of the specimens, with and without vertical boundary element are almost identical when they are subjected to forth moving while in back moving, specimens with vertical boundary element exhibit more capacity about 26 per cent, see Fig. 6. In forth moving the conjunction region is under compression so vertical boundary element has almost no effect while in back moving, vertical boundary element is under tension and improves load-carrying capacity of the structure so ultimate strength of specimens increases about 26 per cent.

References

Einea, A., Todros, M.K., Salmon, D.C., Culp, T.D. and Culp, T.D. (1994), "A new structurally and thermally efficient sandwich panel system", *PCI J.*, **39**(4), 90-101.

Kabir, M.Z., Jahanpour, A.R. and Rahbar, M.R. (2004), *An estimation of ductility and the behavior factor of 3D sandwich shotcreted panels subjected to monotonic shear loads*, High Performance Structures and Materials II.

Kabir, M.Z., Rezaifar, O. and Rahbar, M.R. (2007), "Upgrading flexural performance of prefabricated sandwich panels under vertical loading", *Struct. Eng. Mech.*, **26**(3), 277-296.

Kim, T.H., Lee, K.M., Yoon, C. and Shin, H.M. (2003), "Inelastic behavior and ductility capacity of reinforced concrete bridge piers under earthquake II: Numerical validation", *J. Struct. Eng.*, ASCE, **129**(9), 1208-1219.

Nijhawan, J.C. (1998), "Insulated wall panels interface shear transfer", *PCI J.*, **43**(6), 98-101.

Park, R. (1988), "Ductility evaluation from laboratory and analytical testing", *Proceeding of Ninth World Conference on Earthquake Engineering*, Tokyo, Japan, August 2-9.

Salmon, D.C. and Einea, A. (1995), "Partially composite sandwich panel deflections", *J. Struct. Eng.*, **121**(4), 778-783.