23468

日本建築学会大会学術講演梗概集
（関東） 2011年 8 月

BENDING TESTS ON PINNING-RETROFITTED MASONRY BEAMS WITH USE OF POLYMER CEMENT PASTES AS BONDING AGENTS

正会員 ○Shrestha Kshitij C.* 同 Pareek Sanjay*2 同 Araki Yoshikazu*

masonry pinning retrofitting bonding agent
polymer-cement paste impregnant one-point bending

1. Introduction

Pinning-retrofit procedure involves the use of epoxy resin for bonding between masonry and reinforcing bar (Takiyama et al.[1] and Shrestha et al.[2]). Epoxy resin, being an organic adhesive, has got its limitations such as, low fire resistance, higher cost and poor bond to wet surfaces. The use of ordinary mortar or paste as bonding agent in place of epoxy resin largely affects the workability environment since it is very difficult to insert reinforcing bar. As an alternative, use of polymer-cement paste (PCP) as bonding agent has been proposed in this study with investigation on performances of masonry beam specimens in one-point bending.

2. Specimen and test set-up

Fig. 1 shows the masonry beam specimen with dimensions 1040×320×320mm. All the specimens were subjected to one-point bending. Two sets of each PCP bonded specimens were prepared. Three different types of commercially available polymer admixtures were used in this study -- SBR, ACL and PAE. Here, SBR represents Styrene-butadiene rubber polymer, ACL stands for Acrylic resin and PAE for Polyacrylic ester-methacrylate ester copolymer emulsion. PCPs for the above listed polymers were prepared using ordinary Portland-cement with polymer-cement ratio (P/C) of 20% and water-cement ratio (W/C) at 40% for all the mixes. Unreinforced masonry (URM) and epoxy bonded (ER) specimens were also prepared for comparison with PCP bonded specimens. For the reinforced specimens, fully threaded SS400 reinforcing bars of 5mm diameter were used.

Application of PCP in masonry requires another important consideration regarding check in workability. If applied to masonry in its normal state, water from PCP gets absorbed by masonry making the paste poor in workability. For this purpose, there is need for pretreatment of masonry to create a water penetration barrier film so that there is minimum effect on workability of PCP after insertion. The present study involves use of BPA (Barrier Penetrant) as impregnant for all the PCP bonded specimens. The choice of BPA as impregnant for the purpose of water penetration barrier came from workability tests and bond strength tests performed with different types of impregnants available.

3. Results and discussions

Fig. 2 shows the results for one-point bending test performed on each specimen. Cracks observed for the specimens as shown in Figs. 3 and 4 varied with the type of specimen. ER and SBR-2 specimens showed mode 1 kind of failure shown in Fig. 3. For URM, SBR-1 and ACL-1 specimens, mode 2 failure as shown in Fig. 4 was observed. The prediction of crack in masonry is highly unpredictable mainly attributed by the fact that there exists large deviation in strength of mortar joints from specimen to specimen. Resisting force corresponding to the particular failure mode has been predicted assuming a free-body as shown in Figs. 3(b) and 4(b) neglecting the bed-joint tensile strength. Equilibrium condition for the given free bodies gives following expression:

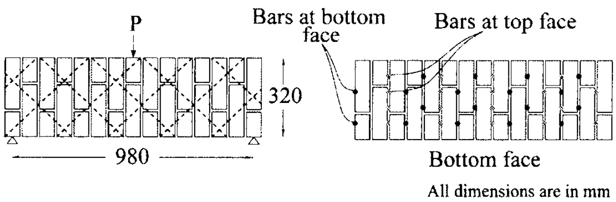


Figure 1 Specimen and test set-up

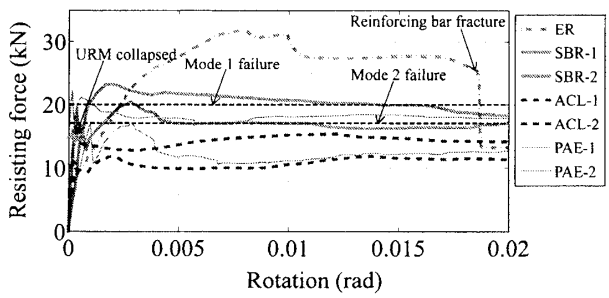


Figure 2 Comparison of results for all the specimens

Bending tests on pinning-retrofitted masonry beams with use of polymer cement pastes as bonding agents

Kshitij C. Shrestha, Sanjay Pareek, Yoshikazu Araki

$$\text{Moment about A, } P_1 \times L_1 = \frac{2F_{\text{pin}}}{\sqrt{2}} \sum_{i=1}^{n} L^i_{\text{pin}}$$
$$\text{Moment about B, } P_2 \times L_2 = \frac{2F_{\text{pin}}}{\sqrt{2}} \sum_{i=1}^{n} L^i_{\text{pin}} \qquad (1)$$
$$F_{\text{R}} = P_1 + P_2$$

where L_1, L_2 is the distance of reaction force from the point of rotation, F_{pin} is the reinforcing bar tensile strength assuming f_y=400MPa and L^i_{pin} is the distance of ith reinforcing bar from the point of rotation in the free body. The value of predicted resisting force F_{R} for mode 1 failure is 20.5kN and mode 2 failure is 17.3kN as shown in Fig. 2.

In Fig. 2, resisting force versus rotation angle plot has been made for each specimen. For URM specimen, after the initiation of first crack at around 15kN of resisting force and very small deformation angle, the specimen collapsed with no resistance shown afterwards. For ER specimen, maximum resisting force of around 32kN was observed larger than for any of other specimens and even higher than the theoretically predicted resisting force for both failure modes. This large resisting force was contributed by strength of epoxy resin itself whose bond strength is higher than the reinforcing bar's tensile strength. For the same reason fracture of reinforcing bar was observed for ER specimen at 0.018 radian rotation angle.

For PCP bonded specimens, SBR specimens showed comparatively better response. The maximum resisting force for SBR specimens showed resistance close to the theoretically predicted strength representing yielding of reinforcing bars used. No fracture of reinforcing bar was observed for SBR specimens. ACL and PAE specimens on the other hand showed relatively lower value of resisting force significantly lower than the theoretically predicted value which clearly signified bond slip of the reinforcing bars.

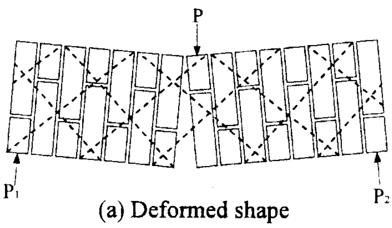
4. Conclusions

The following conclusions can be drawn within the scope of study:

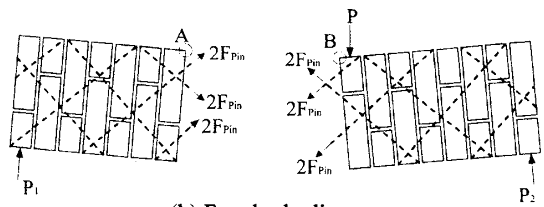
a) URM specimen showed brittle collapse post attainment of maximum resisting force.
b) The failure pattern observed for PCP bonded specimens was predominantly bond slip failure. For SBR bonded specimens, relatively higher load resistance was seen very close to theoretically predicted value for reinforcement yielding. ACL and PAE bonded specimens showed comparatively lower resisting force with excessive bond slip failure observed not allowing the reinforcing bars to yield.
c) Epoxy bonded ER specimens showed resisting force higher than SBR specimens due to higher bond strength. However the ER specimen showed unstable behavior with fracture of reinforcing bars at rotation angle of 0.018 radian. SBR specimens showed no fracture in reinforcing bars, hence showing more ductile behavior.

References

1. Takiyama N., Nagae T., Maeda H., Kitamura M., Yoshida N., Araki Y., Cyclic out-of-plane flexural behaviour of masonry walls rehabilitated by inserting steel pins, Proc. Of the 14th WCEE, Beijing, 2008. Available at http://www.iitk.ac.in/nicee/wcee/article/14_S11-015.PDF (Last accessed date: April 4, 2011)
2. Shrestha K.C., Nagae T., Araki Y., Finite element modeling of cyclic out-of-plane response of masonry walls retrofitted by inserting inclined stainless steel bars, Journal of Disaster Research, Vol.6 No. 1, pp. 36-43, 2011.

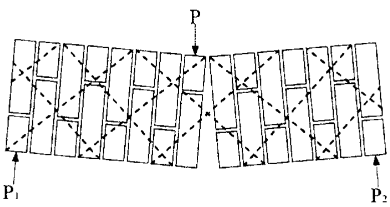


(a) Deformed shape

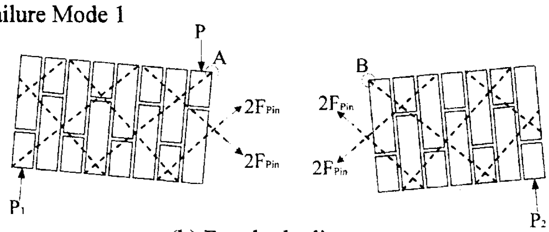


(b) Free body diagram

Figure 3 Failure Mode 1



(a) Deformed shape



(b) Free body diagram

Figure 4 Failure Mode 2

* 京都大学大学院工学研究科建築学専攻
*2 日本大学工学部建築学科
* Dept. of Architecture and Architectural Eng., Graduate School of Eng., Kyoto Univ.
*2 Dept. of Architecture, College of Eng., Nihon Univ.