ABSTRACT

Unreinforced block masonry walls are commonly used in non-seismic areas. The out-of-plane capacity of these walls is controlled by the flexural tensile strength which is limited by the low adhesion bond at the block-mortar interfaces. This paper presents the results of the first phase of an experimental investigation to develop the material and methodology for strengthening block walls using highly workable strong grout which can be easily pumped into an existing wall. Different mixes of fine grout were tried using different admixtures. Hollow block prisms, 1 1/2 blocks wide by 4 courses high, were grouted from the sides using hand pump. The increase in flexural strength of the mortar joints due to grouting was determined using the bond wrench. The quality of the pumped grout was examined by saw-cutting at different locations. The results show a high quality grout with no voids or flaws. A significant increase in flexural strength due grouting was achieved. It is concluded that The proposed technique is a viable approach in strengthening existing hollow block masonry walls.
1. INTRODUCTION

A very common design condition for concrete block masonry walls is wind and earth pressure loading normal to the wall’s surface. The out-of-plane capacity of these walls is controlled by the flexural tensile strength which is limited by the low adhesion bond of the mortar face shell bedded area (1). Grouting the hollow cores (about 40-50 percent of the gross area significantly increases the flexural tensile capacity due to continuity across the weak mortar joints (2,3).

This paper presents the results of the second phase of an experimental program conducted at Drexel University to develop the material and methodology for strengthening existing block masonry walls using highly workable grout which can be easily pumped into the existing walls.

2. EXPERIMENTAL PROGRAM

2.1 Grout Mix

In phase one of the program, different grout mixes were examined using different admixtures in an attempt to reach to an optimum grout mix that satisfies both high strength and workability. Admixtures such as Grout Aid, Super plastisizers, polymers and combinations thereof were used with fine grout (3). Two successful mixes were chosen based on the results of phase one: 1) base mix of Portland Cement and sand with Grout Aid (4) and 2) base mix of Portland Cement and Sand with Superplastizer. These two types of grout satisfy the two acceptance criteria of high strength and workability. The strength of grout was determined by splitting tests of 1.7 x 3.4 in. cylinders which were core drilled from grouted cells of the prism.

2.2 Test Specimens

Two types of specimens, shown in Fig. 1, were used. The four course stack bonded masonry prism was used first to check the vertical flow of the pumped grout. The other type of specimen, which is a running bond assembly representing part of a full scale wall, was selected to check, in addition to the vertical flow, the horizontal flow in adjacent cells. The latter specimen was saw cut, after 14 days from grouting, along the head joints to produce one block wide specimen for bond wrench testing.

2.3 Pumping Procedure

Pumping was conducted from the bottom through a1-in. diameter hole that was drilled in the faceshell of the block in the first course, see Fig.1.
Pumping using type 1 grout mix (with Grout Aid) was successful. The second type of grout mix using superplastizer as an admixture showed segregation during pumping. Therefore, it was decided to adopt the first type of grout mix for the project.

2.4 Bond Wrench Test
A bond wrench test set-up, shown in Fig. 2, was designed and fabricated to measure the flexural tensile strength of each joint in the prism. The apparatus consists of a wrench which is clamped to the top of the prism, and a support which clamps to the block immediately below. An eccentric axial load is applied via a hydraulic jack which produces a small axial stress and a large bending stress. The resulting flexural tensile stress at the extreme fibers can be easily calculated using linear elastic theory. After the top joint is tested, the prism support system moves up, and the next joint is tested. This procedure results in testing every joint, thus, a more representative average strength can be determined the variation in joint strength can also be determined.

3. TEST RESULTS
3.1 Joint Strength
The joint strength using the selected type of grout was determined using the bond wrench apparatus. The two types of prisms were grouted and tested after 14 days. The results are presented in Table 1. As can be seen, the 14-days joint strength ranges from 174 psi to 188 psi. This level of strength is considered satisfactory in light of the fact that joint strength of hollow masonry is in the range of 20-30 psi (1). This means that strength was increased by about 8 folds due to grouting. The 180 psi average strength is comparable with strength of grouted masonry in new construction reported in the literature (1). The UBC-85 code (4) specifies a modulus of rupture of block masonry equals to 2.5/ f’<sub>m</sub>. This means that for typical compressive strength , f’<sub>m</sub>, ranging between 2000-3000 psi, the flexural tensile strength (modules of rupture) of grouted masonry in new construction will range between 112 psi and 137 psi. This range is well below the strength obtained in this program by pumping grout into existing hollow block masonry assemblages.

3.2 Quality Of Pumped Grout
In addition to the satisfactory joint strength achieved, the quality of the in-plane grout was examined. The fracture surface at the mortar joints shown in Fig. 3, clearly indicates the ability of the grout to fill all the spaces which provides full continuity across the mortar joints. It also shows no shrinkage cracks between the two materials. The prisms were saw cut vertically across the webs of the blocks to further examine the quality of the grout. As can be seen in Fig. 3, a superior quality grout free from voids or flaws was achieved. It is interesting to observe that the grout filled all spaces even the very small gap that exists at the head joints due to
Table 1 - Test Results

<table>
<thead>
<tr>
<th>Specimen</th>
<th>Grout Strength (psi)</th>
<th>Flexural Strength (psi)</th>
<th>C.O.V. (%)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Indiv.</td>
<td>Mean</td>
</tr>
<tr>
<td>440</td>
<td>164</td>
<td>164</td>
<td>174</td>
</tr>
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<tr>
<td></td>
<td>230</td>
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</tbody>
</table>

Fig.1- Test Specimens
Fig. 2- Bond Wrench Test
Fig. 3 - Quality of Pumped Grout
common face shell bedding.

4. CONCLUSIONS

Based on the limited test results reported herein, it is concluded that a successful pumping of quality grout into existing hollow block masonry is achievable. The developed technique for strengthening existing block masonry walls has potential. Further study is currently conducted at Drexel University.

5. REFERENCES


