

DISCUSSION

"IRA and the Flexural Bond Strength of Clay Brick Masonry"
W.M. McGinley

Comments (L.R. Lauersdorf, State of Wisconsin):

According to the ASTM C-270 Appendix, bond is the single most important physical property of hardened mortar, and mortar generally bonds best to masonry units having moderate initial rates of absorption (IRA). Test results from this paper as well as from other sources confirm this statement.

The data in the paper confirms that the IRA of clay brick masonry units can have a significant influence on bond, greater than is generally accepted by the masonry industry. There are actually three facets to bond; namely, strength, extent and durability.

In regard to bond strength, the paper well summarized conclusions on the effects of IRA on bond strength by Figure 3. This graph is similar to that contained in "Factors Affecting Bond Strength and Resistance to Moisture Penetration of Brick Masonry" by T. Ritchie and J.I. Davison, Research Paper No. 192, Division of Building Research, National Research Council, Ottawa Canada, July 1963. This latter paper confirmed a previous similar graph contained in "A Study of the Properties of Mortars and Bricks and Their Relation to Bond" by L.A. Palmer and D.A. Parsons, Research Paper RP683, Bureau of Standards, U.S. Department of Commerce, May 1934. Ritchie and Davison also reported on extent of bond affected by IRA, as measured by leakage rates.

The masonry industry highly recommends that low flow mortars be used with low IRA units in order to increase the bond strength. Even with the extraordinarily low flow mortar which was used as indicated in this paper, the bond strength with both mortar types used was still low with the low IRA masonry units. In fact, the configuration of the bond strength versus IRA plot seemed unchanged when compared with the curvature of the other two references, which utilized a higher, more conventional flow mortar.

In conclusion, the paper along with previous impartial data reported suggests that the existing note in ASTM C-216 relating to IRA should be updated to reflect that both laboratory and field investigations show that strong and watertight joints between mortar and masonry units are not usually achieved by ordinary construction methods when the units as laid have excessively low or high IRA's. Mortar generally bonds best to masonry units having IRA's from 5 to 25 g/min/30 sq. in. (194 sq. cm.) at the time of laying, although adequate bond can be obtained with some units having IRA's less than or greater than these values.

Comments (McGinley) I appreciate and support the comments put forth by Mr. Lauersdorf. It should be recognized by the masonry industry that a number of factors affect the bond developed between clay bricks and mortar. While workmanship and the constituents of the mortar mix have a long recognized and major effect on bond strengths, other factors such as brick IRA, mortar flow and brick surface texture can also have a significant effect on the bond developed between clay bricks and mortar.

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Question (J. H. Matthys, University of Texas at Arlington):

Table 2 on Mortar Properties lists COV on mortar compressive strengths that appear to be excessively high particularly for moist cured specimens. To what factors do you attribute this high COV?

Table 2 also gives average air entrained air of 7.2% and 7.9% for Type S and Type N prepackaged Masonry Cement. These values do not seem to be typical levels of air found in prepackaged masonry cements, i.e., these values are too low. I wonder if these products by ASTM C-91 actually qualify as a masonry cement. Do you know? What method was used to determine the air content?

For Prism 1, Mortar Type S, the COV on bond strength is 95.6, not 69.6. The range of COV on bond strength in Table 3 is from 28.5 to 156.8 with an average COV of 82%. Do you attribute the high degree of variability to the test procedure, assemblage, mortar, etc.??

Table 1 on Brick Properties indicates a range of brick IRA from 2.7 gms./min./30in.² to 38.6 gms./min./30in.²; yet the flow of the mortar used was low (100.7 and 111.3) for field mortars. Do you feel that these flows are typical of mortars in the field for laying brick? Do you feel that some of your conclusions might be significantly altered using a flow of mortar more closely associated with the IRA demand of the brick?

At the age of seven days you state specimens were sprayed with water to simulate a rain shower in the field. I would suspect that there is a significant amount of masonry built that is not subjected to applied moisture at seven days. There is also a large amount of masonry built that is never subjected to applied moisture (interior masonry). In your opinion would your bond results in both magnitude and spread in terms of brick IRA be significantly different if you had not sprayed the specimens with water? Would the bond values be significantly lower without spraying?

Table 3 gives for Type S masonry cement mortar a range of bond strength from 1.89 psi to 55.40 psi with an average of 27.98 psi. Fifty percent of the Type S group specimens exhibited average bond strengths less than the allowable flexural tension found in the ACI/ASCE 530 Code. Type N masonry cement mortar exhibited a range of

bond strength from 5.34 to 47.5 psi with the average of 21.89 psi. Thirty percent of the type N group exhibited average bond strengths less than the allowable flexural tension found in ACI/ASCE 530 code. Do you think this should be a cause of concern or not? If so, what suggestions would you give.

Answer (W. M. McGinley) Your questions are addressed in the following point form:

1. Since this investigation attempted to evaluate the flexural bond strengths obtained using standard field practices, the mason mixed the mortar batches. The relatively high variation in the cube compressive strengths may have been due to inadequate mixing of the mortar resulting in larger variation in the properties of the cubes than is normally observed for laboratory mixed mortar batches.
2. The values of air entrainment measured for these masonry cement mortar mixes were low. They were, in fact, below the minimum allowed in ASTM C-91 (min 8 %). The air entrainment of each batch was obtained using the procedures in ASTM Standard C 780 and a roller pressure meter. However, retesting of nominally identical mortar batches with the same procedures and a pump pressure meter gave air entrainment values of approximately 17 %. These results suggest that the roller meter may have given inaccurate readings of air entrainment.
3. As mentioned previously, this investigation was intended as an evaluation of normal field practice. The high variation in flexural bond strengths can be attributed primarily to a relatively high variation in the mortar properties (see 1) and, at best, average workmanship on the part of the mason.
4. The flow of the mortar used was low. Surprisingly, the mason preferred this low mortar flow for laying the stack bonded prism specimens. Higher flow mortars do produce better bond strengths [1] and it is expected that higher flow mortars will be less sensitive to brick IRA. However, I have observed many masons vigorously tapping brick units into place, especially the last few units laid into a long bed joint of mortar. It is likely that these units are laid into

low flow mortar and will result in a poor bond if the IRA of the brick is high.

5. Since the primary mechanism of mortar to brick bond appears to be the mechanical interlocking of cement hydration products at the interface of the mortar and brick, the additional water present at the interface after spray the specimens with water should affect the bond strength developed. However, subsequent testing of similar specimens that were not subjected to this spraying resulted in higher bond strength values. It appears that the amount of water that was available at the interface was not greatly affected by the light spraying.
6. Overall, the bond strengths measured for the prism specimens tested in this investigation were low, especially when compared with applicable allowable values in the ACI/ASCE 530 Code. If the measured values reflect the bond strengths present in a wall, there is indeed a cause for concern. It has been my opinion, and that of many others, that there must be a performance specification for unreinforced masonry that defines a minimum flexural bond strength for the brick and mortar assembly. Flexural bond is probably the most important property of the assembly when used in a non-load bearing application.