The Influence of Time of Docking and Draining on the Properties of Bricks and Brickwork Specimens

by

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1. INTRODUCTION

Haller[1] first showed that the strength of full sized walls loaded eccentrically decreases with increasing suction rate of bricks and hence recommended that the permissible stress in the brickwork should be reduced if the suction rate exceeded 3 $kg/m^2/min$.

Following this, the first recommendations in the Model Specification of Load-bearing Clay Brickwork[2] were that the suction rate should not exceed 2 $kg/m^2/min$ and that bricks of high suction rate should be "docked", that is briefly immersed in water, to reduce them below this value. Since then it has been recognized[3] that there is an optimum value rather than a maximum and that in Palmer and Parsons[4] original work it was 1 $kg/m^2/min$. SP 56 has accordingly been amended[5] so that the recommendation is now 1.5 $kg/m^2/min$.

All this seems to suggest some very high precision both in measurement and in determining the effects of modified suction rate when in fact what is of interest is the development of bond between the bricks and mortar and in particular the effect of that bond in providing the brickwork with sufficient flexural strength to resist the stresses developed under lateral loading by wind forces.

Bond might be said to be a very evocative word in some quarters at the moment. Of course it is true, as many ancient buildings testify, that the force of gravity reinforces a lot of inadequate design and when that force is reduced to the self weight of a single-storey, single skin, as it is in boundary walls, then of course the quality of the bond becomes important.

Similarly it is not difficult to understand the caution expressed by some legislators over workmanship. But is the quality of the average workmanship really any worse than it was? It may well be difficult to find craftsmen capable of building perfect decorative brick arches - though it is certainly not impossible - but as any amateur bricklayer knows it is not difficult to build stretcher bond walls, which most brickwork now is, and the difficult thing is laying to line, level and plumb. In other words if it looks right it probably is right and when architects talk about bad brickwork they mean it looks awful - in fact this may not affect its engineering properties at all.

This present small investigation is an attempt to look at variable effects due to docking and to consider one other aspect of workmanship, deep furrowing of the mortar bed.

2. EXPERIMENTAL

Only two bricks have been used, a low water absorption wirecut and a high water absorption semi dry pressed brick. The suction rates are such that the latter would be docked and the former not; their water absorptions bring them into the highest and lowest categories of characteristic flexural strength given in BS 5628: Part 1[6]. They are the bricks on which the very considerable programme of lateral load testing carried out by B.C.R.A. has been done. Brick A has 16 holes giving a perforation volume of 24.6%. Brick B has a deep frog the volume of which is 16.1% of the brick. Their properties are recorded in Table 1.

Table 1

Mean Properties of Bricks Used

Bricks	Compressive Strength N/mm^2	Water Absorption 5h boil %	Suction Rate $kg/m^2/min$	fkx[6] 1:1:6 mortar N/mm^2	After Normal Docking	
					Water Absorption %	Suction Rate $kg/m^2/min$
A	63.1	6.4	0.84	0.5	-	-
B	27.9	22.2	2.5	0.3	8.4	0.7

One mortar was used, 1:1:6, cement:lime:sand. Some of the earlier results quoted relate to flexural tests carried out on wallettes tested in the standard way[6] but in the present tests the flexural strengths were obtained by 4 point loading in the vertical attitude on 7-high prisms.

3. RESULTS AND DISCUSSION

In the suction rate test the bed face of the brick is immersed in water to a depth of 3mm and this thus attempts to simulate the effect of a brick removing water from the mortar bed. Of course the test is only concerned with the initial effect, that is the amount of water removed in the first minute though the rate is in fact proportional to $t^{\frac{1}{2}}$ and Gummerson, Hall and Hoff[7] have shown that water continues to be absorbed at a decreasing rate for about two years, in the case of the brick they tested, when it reached a water content approaching that determined by the vacuum test[8]. Typical short term results for bricks A & B are shown in Figure 1.

It is immediately apparent that there is a wide variation in the suction rates for individual bricks. The solid lines are the means of 5 and the dotted lines are the bricks giving the highest and lowest

results in that 5. At 10 min. there is a range from 3.9 to 7.2 $kg/m^2/min$ for Brick B and even Brick A ranges from 1.4 to 2.2 $kg/m^2/min$. Disparities of this magnitude, which must effect the brick/ mortar bond, clearly make nonsense of theories of brickwork behaviour which are based on the performance of an individual brick mortar joint.

Gummerson et al[7] did some simple tests designed to show how the removal of water from fresh mortar depends on the water content and hydraulic properties of the units. They tested a common brick and an autoclaved aerated concrete (AAC) block by immersing the whole of the former and the bed face of the latter in water for varying times and then measuring the weight loss after 30 min. from a pat of mortar placed on the unit. The results are shown in Table 2.

Table 2

Water Absorbed from Mortar by Masonry Units

Material	Immersion/ Absorption time Min.	Loss in Weight of Mortar in 30 min. %
Brick	0	13.6
	1	13.6
	4	13.8
	15	10.3
	30	8.1
	40	4.4
	60	1.0
AAC Block	0	10.2
	0.5	7.3
	1	6.5
	2	5.9
	10	3.5

The authors point out that a long time of docking is needed to have much effect with bricks but not with AAC blocks. The brick has a high sorptivity and will therefore absorb more water during the wetting process but it also has a much higher diffusivity than the block so the water is rapidly distributed to the drier parts of the brick. In the block the water effectively remains on the surface. Not dissimilar from the effect that occurs with a low water absorption brick as will be seen.

The authors also note that while short term docking of these clay bricks does not affect the amount of water removed from the mortar over the 30 min. period it may well help the laying process because the initial suction of the brick is reduced until the water in the surface

has been redistributed and of course this is shown by the reduced values of apparent water absorption and suction rate for Brick B in Table 1. Extending this argument, the time between the end of docking and laying the bricks should therefore also be important.

Initially Brick B was soaked for 16h and allowed to drain for varying times before laying. For drainage of up to one hour the prisms were very difficult to build and in the case of those built immediately the mortar squeezed out of the joint. This long soaking time was therefore abandoned and a standard immersion of 1h adopted with the bricks then laid immediately or allowed to drain first in air in the laboratory for periods up to 24h.

The results given in Table 3 are means of 10 bricks for water content and the flexural strengths are means of 4. In the first set the bed was deeply furrowed to simulate bad workmanship and when the prisms were broken a gap was still clearly seen in the centre of the bed so that the contact area of the brick with the mortar was reduced. This was worst with Brick B but could be seen to a lesser extent in Brick A. In the second set the prisms were built normally with bricks laid on a reasonably flat bed of mortar.

Table 3

Relation Between Period of Draining and Flexural Strength of Prisms

Brick	Draining Period h	Mean Water Content of Brick at Laying		Mean Flexural Strength of Prisms			
				Furrowed		Good Workmanship	
		%	% of total water absorption	N/mm^2	C of V %	N/mm^2	C of V %
A	0	2.7	42.2	0.38	9.3		
	1	2.5	39.1	0.36	9.8		
	6	2.2	34.4	0.41	11.7		
	24	1.5	23.4	0.38	12.5		
B	0	16.5	74.3	0.78	21.1	0.55	16.7
	1	16.3	73.4	0.56	14.1	0.53	10.5
	6	15.9	71.6	0.55	22.2	0.57	19.5
	24	14.6	65.8	0.66	26.0	0.51	27.2

Taking first the hydraulic properties of the bricks, there is a clear distinction between them. Brick A is a low water absorption brick (6.4%) and in 1h. absorbs only 42% of this. Brick B has high water absorption (22.2%) and in the same time absorbs 74% of this. Brick A drains proportionately faster, in 24h. it has lost almost half the water absorbed, while Brick B has lost only about one tenth. In part this is no doubt a pure drainage phenomenon, but in part of course it is just the simple arithmetic effect that roughly comparable drying areas lose roughly the same amount of water by evaporation in a given time and this quantity is a larger proportion of the total in Brick A than Brick B.

However, what should be noted is that there is no significant difference in the flexural strengths. The coefficients of variation increase with time of draining and this may be an indication of the importance of the surface condition but the most important point is that the strengths are only some two thirds those normally expected with this brick and mortar (0.57 N/mm^2). They are indeed below the characteristic flexural strength required by the Code[6] although that has to be determined on wallettes. Of course these bricks would not normally be immersed in water before laying and although bricks get wet by brickwork being wrongly left uncovered in wet weather this occurs only in one course and bricks as wet as these were would not normally be laid because of difficulties experienced with "floating".

It must also be noted that only results for prisms built with a degree of furrowing are available for these bricks and such deliberate bad workmanship may also be expected to have an effect, perhaps a decisive one, in reducing the flexural strength. Indeed in wallette tests on these bricks undocked the mean flexural strength was reduced by almost exactly this amount (0.57 N/mm^2 reduced to 0.36 N/mm^2) by bad workmanship which included not only over-furrowing but also just tipping the perpend joints instead of filling them.

Taking the results for both good and bad workmanship for Brick B, there is no difference between 6 of the sets although in the other two sets the furrowed results are higher. The six similar sets have an overall mean strength only some 80% of that usually expected from wallette tests with conventionally docked bricks and in those wallette tests deep furrowing and tipping perpends can reduce the strength by a third (from 0.67 N/mm^2 to 0.44 N/mm^2). In general it must be said that the results of furrowing are not conclusive in the prism tests though in all the sets of Brick B the variability is perhaps higher than usual. What must also be said is that these results even with bad workmanship are well above the characteristic strength levels of the Code[6].

ACKNOWLEDGEMENTS

The author thanks Dr. D.W.F. James, Director of Research, British Ceramic Research Association for permission to publish this paper. He also thanks his colleague Mr. J.F. Goodwin who carried out the experimental work.

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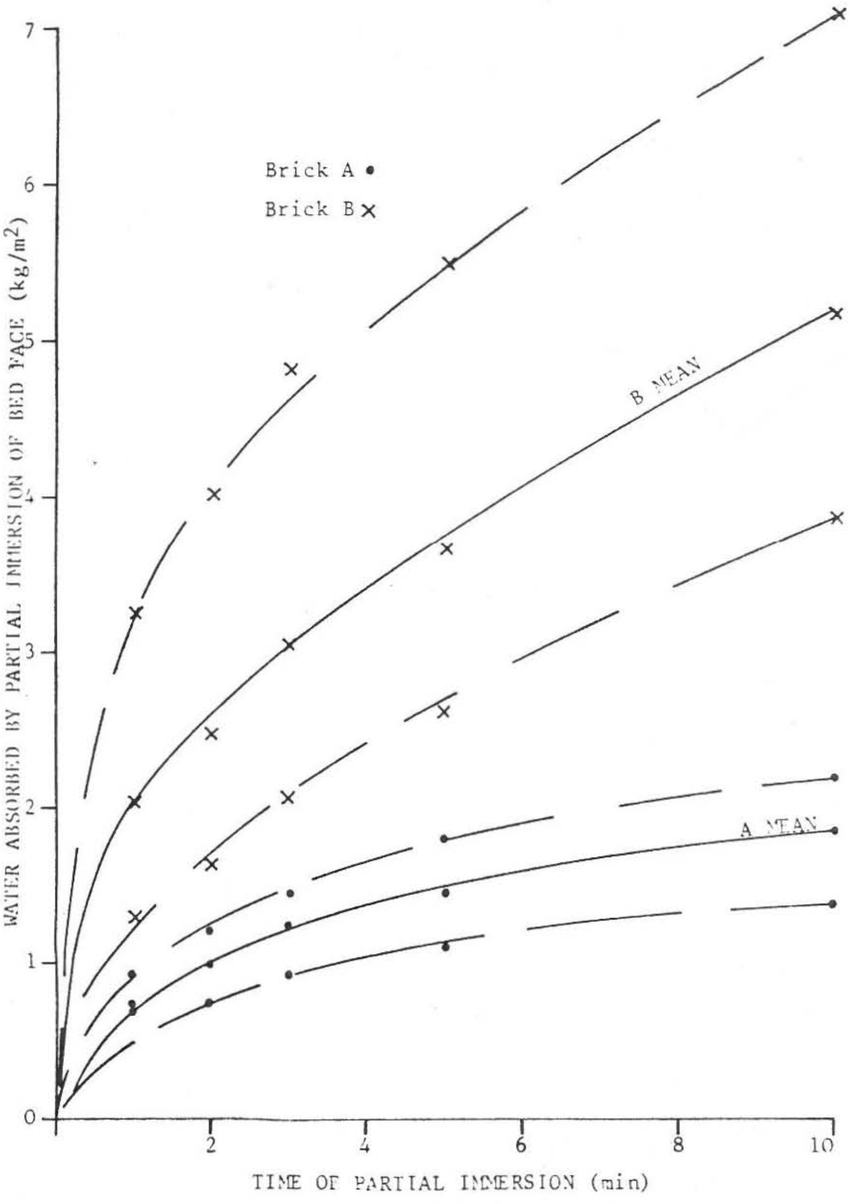

FIGURE 1: EFFECT OF TIME OF PARTIAL IMMERSION ON INITIAL ABSORPTION