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BRIEF EVALUATION OF MASS LOSS INDEX, WATER ABSORPTION AND COMPRESSIVE STRENGTH REVERTIBILITY COEFFICIENTS OF PAPERBRICKS IMMERSED IN WATER

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Abstract

With the need to develop alternative, lightweight cheaper bricks for masonry which will be durable, paperbrick produced with varying cement content of 3 – 18 wt. % and fixed sand content of 20 wt. % were immersed in water for seven days, it was observed that with increasing cement content and curing ages, compressive strength revertibility increased. Weight loss index also reduced with higher cement content and longer curing days and concluded that higher cement content and longer duration periods produce more water durable paperbricks.

Keywords: Mass loss index, paperbricks, revertibility coefficient, water absorption.

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1. INTRODUCTION

Concrete bricks are common bricks used in masonry, characterized with high strength and density. Due to their high cost of production, research is been carried out towards developing cheaper alternative building bricks. Paperbricks made by the blending of waste paper, cement and other forms of additive can be alternative building material [1] [2] due to cheaper cost of production [3] [4] and less energy consumption in the course of production. Since paper is hygroscopic and hydrophilic, there is need to examine the durability of this paperbricks to be able to ascertain their usage in masonry and be able to determine areas of usage. To this effect, mass loss index, water absorption and compressive strength revertibility coefficient was examined on paperbricks made from the mixture of waste office paper, cement and sand.

2. MATERIALS AND METHOD

Paperbricks produced from the blend of waste office paper, cement and sand as highlighted in Table 1 were utilized in this study. After production, the samples were cured for 14, 21 and 28daysafter which they were placed in an adjustable autoclave; maintaining temperature for 60 ^{O}C for 36 hours until mass was attained. Cube samples of length 100 mm were subjected to compressive strength after curing test using universal testing machine (TBTUTM-600) in accordance to stipulated procedure (ASTM 39/C39M-20). The results obtained wererecorded. Weight of each sample after drying was also noted. The samples were immersed in water for 7 days and water absorption for a period of 7 days were noted. In assessing compressive strength revertibility coefficient (CS_R) after 7 days immersion, the samples were dried in the author clave for another 36 hours, after which they were reweight and re-tested for compressive strength. Weight loss and CS_R was evaluated using equations 1 and 2 respectively.

$$WI = \frac{M_{2-M_1}}{M_1} \quad (1)$$

$$(CS_R) = 1 - \frac{Compressive\ \ strengt\ h\ before\ \ 7\ days\ \ immersion}{Compressive\ \ streng\ th\ after\ \ 7\ days\ \ immersion} \quad (2)$$

Where WI is weight loss index, M_1 weight before 7 days immersion, $M_2$is weight after 7 days immersion and CS_R is compressive strength revertibility coefficient.

Table 1: Mix proportion of samples

Sample Designation	Cement (%)	Sand (%)	Waste paper (WP) %
A	3	20	77
B	6	20	74
C	9	20	71
D	12	20	68
E	15	20	65
F	18	20	62

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3. RESULTS AND DISCUSSION

3.1 Property evaluation

Water absorption by immersion observed for 1 day and 7 days are as illustrated in Fig. 1(a) and (b). The results obtained show that water absorption reduced with increasing cement content and this ensued based on reduced pores within the matrix. This occurrence is traceable to stronger bonds hydrants formed filling up and covering up pores. Curing duration also played a role in reducing water absorption. Fig. 1 (a) revealed lesser values of porosity with curing duration. It can be inferred that curing for longer days promote lower water absorption capacity.

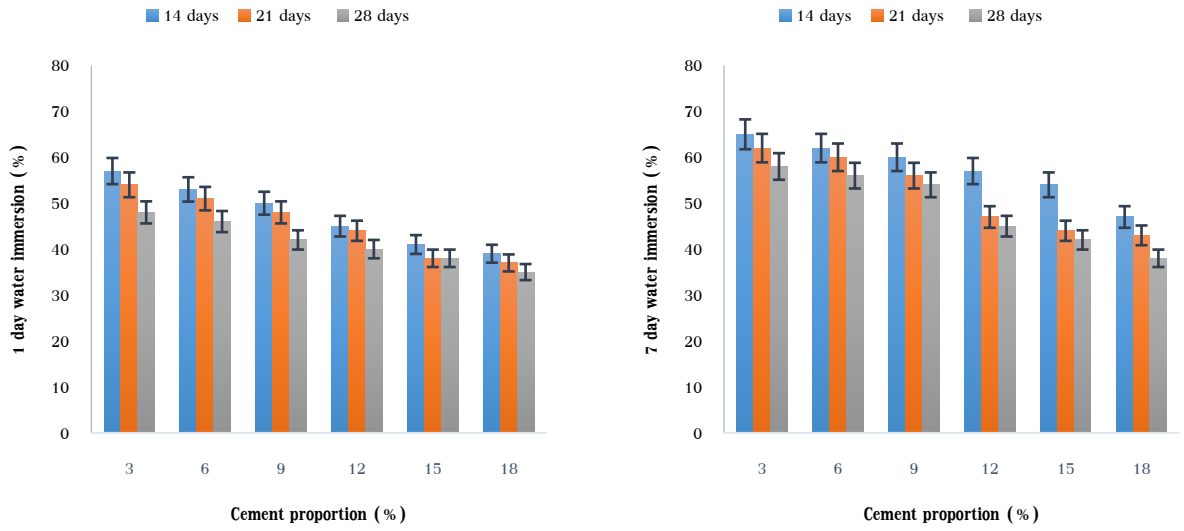

Fig. 1: Variation in water absorption with cement proportion at immersion days of (a) 1 day and (b) 7 days.

At 7 days, water absorption increased gradually which may be caused by the gradual weakening of the bond within the matrix. This weakening led to gradual loosening of sand particles which resulted in enhanced more water absorption. Just as in the case of 24 hours, increased cement content presents lowering of the water absorption capacity. Also, samples cured for more days exhibit lower water absorption capacity than the ones cured for lesser days. As curing ages are lengthened in samples more and stronger hydrants, filling up more pores, hence water absorption reduces.

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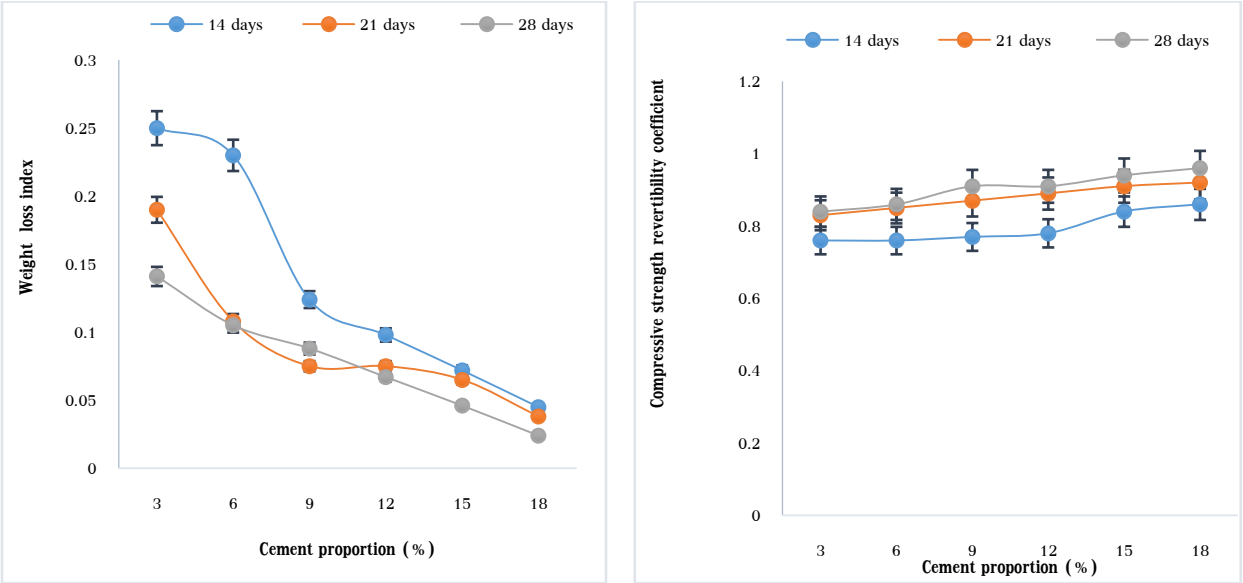

Fig 2: Effect of cement proportion and 7 day water immersion on (a) weight loss index and (b) compressive strength revertibility coefficient.

Fig. 2(a) indicates the varied value of weight loss obtained for samples immersed in water for 7 days at varying cement proportion. As cement content and curing ages content increased, lesser weight are lost in water for the duration of 7 days, hence, weight loss index reduced with increasing cement content as well as curing ages.

Fig. 2(b) revealed compressive strength revertibility coefficient for samples immersed in water for 7 days and Table 2 shows percentage loss in compressive strength over a period of 7 days.

Table 2: Percentage loss in compressive strength.

Cement proportion (%)	Percentage loss in compressive strength (%)		
	7 days	21 days	28 days
3	24.0	17.1	16.2
6	24.0	15.2	14.1
9	23.0	13.0	9.3
12	22.0	11.0	9.0
15	16.0	9.4	6.1
18	14.0	8.0	4.4

From the results obtained as depicted in Fig. 2(b), revertibility coefficient for samples cured for 7 days varied between 0.76 and 0.96 indicating loss in compressive strength between 24.0 % and 4.4 %. As cement content increased revertibility coefficient increased (higher value indicates higher strength recovery and lower strength loss. Value of 1.0 shows 100 % revertibility and 0 %

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loss in strength. The highest which was 0.96 was achieved at cement content of 18 % for sample cured for 28 days. With higher cement proportion, internal bond strength and compaction are improved, eventuating uptrend in compressive strength.

Considering curing ages, it was noted that revertibility coefficient appreciated with duration of curing and this has linkage with the presence of stronger hydrants products which prevents perviation of water which could weaken bond.

At 24 hours, samples attain at least an initial saturation point owing to filling of pores within matrix. In the presence of strong bond, hydrants formed prevent further absorption of water. It should however be noted that with increasing days, there will be further interaction between the water content and the hydrants, which may eventually degrade gradually. Also, the paper matrix which has low resistance to water degrades slowly in the presence of water. The consequence of this is the further weakening of the bond strength. This necessitates need to study internal bonding strength of paperbricks in water. These gradual weakening depends on the internal bonding strength, sizes of pores, period of immersion and chemical content in water. The decrease in bond strength eventually lowers resistance to water absorption and in the long run, depreciation in compressive strength. Going by the results (Fig 2(b) and Table 2), higher compressive revertibility was achieved at 3-18 wt. % of cement and curing age of 28 days as compared to other curing ages.

3.3 Relationship between water absorption (7 days) and compressive strength revertibility coefficient and weight loss using 28 days as case study.

The linear relationship between compressive strength revertibility coefficient (CR_R) and water absorption (7 days)(WA) is inversely linear with model expression of CR_R = -0.0051 WA + 1.1536, indicating that at increasing water absorption, revertibility coefficient reduces; Coefficient of determination been R^2 = 0.8498. The model representation for the inter-relationship between weight loss index (WI) and water absorption (WA) is expressed as WI = 0.0049 WA – 0.1606. The relation is linear with positive gradient showing that with increasing water absorption, weight loss index appreciates. The lower value of slope (less than 1) depicts a slower change.

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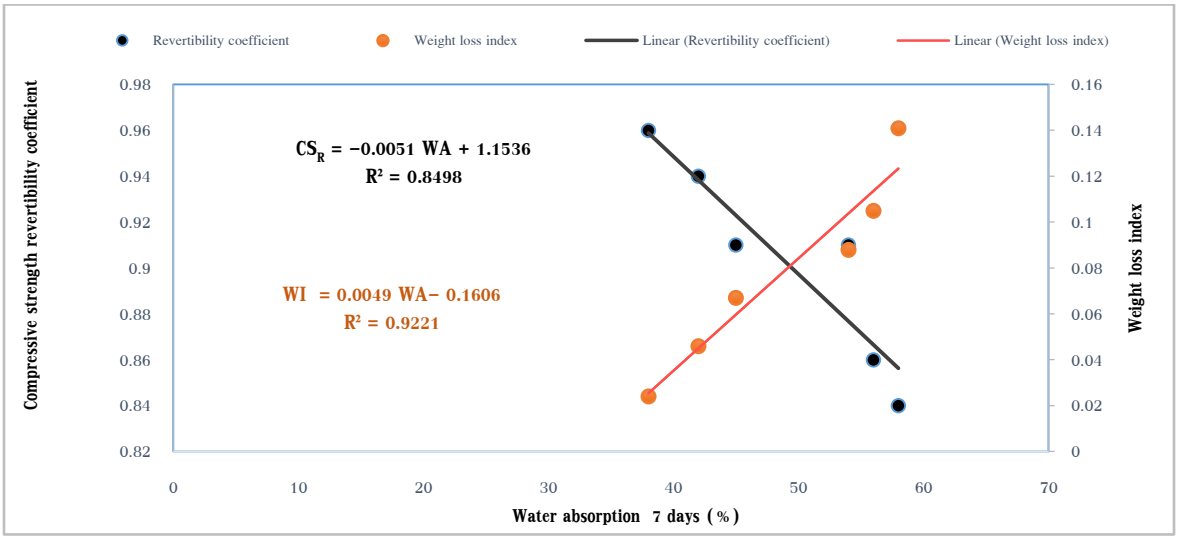

Fig. 3. Relationship between revertibility coefficient, weight loss index and water absorption (7 days)

Conclusion

With the need to develop alternative, lightweight cheaper bricks for masonry which will be durable, paperbrick produced with varying cement content were immersed in water for seven days, it was observed that;

i. With increasing cement content and curing ages, compressive strength revertibility increased.
ii. Weight loss index also reduced with higher cement content and longer curing days.

It is finally concluded that higher cement content and longer duration periods produce more water durable paperbricks.

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