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Performance of Cement Boards in Presence of Waste Paper

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Abstract

The possibility of using waste paper in manufacturing of cement board has been investigated in this paper. Cement fiber ratio and pressure is the two variables in this experimental work. Samples were prepared with fiber/cement ratios of 5:95, 15:85 and 25:75 by weight. Every mixing ratio was divided in seven sub categories depending on the pressure of 0, 1.4, 2.4, 4.2, 5.5 6.9 and 8.3 MPa. Three boards were prepared for each category to evaluate the mechanical and physical properties of the boards according to ASTM standard. It is observed that the mechanical and physical properties of the board are directly influenced with pressure. However, the flexural strength and modulus of rupture were decreased with an increase of the amount of waste paper in the board. Five percent addition of waste paper exhibits the best performance of cement board in all aspect. The optimum production condition was obtained when the fiber content and pressure were 5% and 6.9 MPa respectively. At this optimum condition the prepared cement board satisfies the flexural strength requirement for Grade 2 type cement board according to ASTM C 1186.

Keywords: Waste Paper; Flexural Strength; Modulus of Rupture; Water Content.

1. Introduction

Innovative and environment friendly construction material is a key matter in developing and sustainable issues. Presently a burning issue is the environmental awareness, which involves to the construction industries to produce environment friendly materials. Material from available resources along with waste has environmental benefits, if this is being considered for applications in the building components.

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Generally waste gives some problems to nature rather than any other utilities. Now a day the waste materials are used to produce the same or another product after following some recycling process. This has the advantage of not only reducing the volume of waste but can also bring cost reduction of the new materials [1-4]. Recycling is a good way to clean the environment by reducing the waste dumping problem. Paper is a valuable waste material to recycle, which mainly comes from the houses, industries, stationaries and many other sources. Different paper exhibits different quality of fiber, which may show different effects on the properties of cement board. Therefore only waste newspaper is considered as a source of waste paper in this work. To prepare a construction material asbestos, synthetic and natural cellulas fiber are used by different researchers [5,6]. However, researcher's draw their attention to find out a new alternative of asbestos fibers after outlawing it due to its negative effects on human body. Among the other two, naturals cellulus fiber is widely available in different form in nature as waste material and have cost effective, ecofriendly and no negative effect on human body [7-10]. There is an increasing trend is found to incorporate natural materials to produce cementitious building components in construction industry. Bamboo, Hemp Shives and coconut fiber are being considered as a suitable materilas in cement based building component production and many researchers are focused on this two in different manner [11-13]. Cellulous extract from natural plants and crops are widely discussed in different literature to produce cement based building materials, however, cellulose from waste paper is not sufficiently investigated, and however, waste news-paper and packaging paper is a good source of cellulose [14]. Cement board with callouses extract from waste paper exhibits low tension softening properties [15]. Plaster board, insulation materials for wall, floors and roofs including bricks are already manufactured by cement incorporating waste paper, which increased its mechanical properties as well as the capillary absorption properties [16]. This work opens a new idea for environmental friendly construction materials to the researchers and will contribute to reducing the amount of waste paper in nature. However, durability of this type of cement-waste paper composites is the main drawback. This was analyzed by Wei et, al. in 2016 [17] and concluded that it showed a good mechanical property with low density. However, the composites having paper callouses exhibits poor durability in cement matrix. On the other hand it was found that the resistance to crack propagation, increasing acoustic performance by increasing sound absorption is improved due to the uses of waste paper in cement board [18,19]. The aim of this work is to investigate the performance of newsprint paper waste incorporating cement to produce a cement board in order to use it as replacement of wood. The mechanical properties and its suitability to use it as a replacement of wooden plank is confirmed by ASTM standard.

2. Material and Methods

The materials used for the experiment were waste newspaper, cement and water. Portland composite cement and waste newspapers (newsprints) were collected from nearby markets and offices. These papers were with organic composition greater than 99% and inorganic composition of less than 1% and this inorganic part was removed before use it. Then it was soaked in water about 24 hours for softening and was ground thoroughly by power agitating tools to form paper slurry shown in Figure 1. Paper slurry was collected and was kept in a bawl for 6 hours to drain the amount of water present in it.

Figure 1: Blending of old newspaper to produce paper pulp

2.1. Casting of Board

Rectangular mold of 300 × 150 × 18.5 mm was used to production of cement board. Paper pulp was mixed with cement and agitates for 5 minutes to mix uniformly with a constant water-cement ratio of 0.6. Samples were made keeping cement: paper ratio 100:0, 95:5, 85:15 and 75:25 by weight. Immediately after casting samples were faced a pressure by Universal Testing Machine for two times at an interval of 5 minutes. Different samples were faced different pressures as 1.7MPa, 4.8MPa, 6.9MPa. After applied the pressure, samples were removed from mold and kept it for curing. No pressure is applied on sample prepared from only cement, which is named as controlled sample. Detailed process of casting is shown in Figure 2 (a) and (b). Samples were cured at 100°C temperature in oven for 24 hours after that, it was kept at room environment for 90 days shown in Figure 2 (c) and (d). Sample with 0% paper was immersed in water at ambient temperature for 28 days after 24 hours of casting. Then it is cured at room temperature for 62 days.

Figure 2: Applying pressure (a) on cement board; (b) after removal; (c) Curing in Oven and (d) at room environment

2.2. Test Procedure

Abrasion Test For the purpose of this test, a dried sample of the board was weighed (W1). A hard shoe brush was used to rub against the two surfaces of the board. 50 strokes of forward and backward movements each were made against the surfaces. The flaked particles from the surfaces were collected and weighed. The flaked board was also weighed (W2). This procedure was repeated for nine more samples. Flaking concentration (Fc) was determined using the expression in (1):

$$Fc = \frac{(w1-w2)}{w1} \quad \text{-----[1]}$$

Flexural strength test

This is a routine test for cement board to measure the product characteristic and grading. Samples were tested in equilibrium and wet condition. Before testing in equilibrium condition the samples were kept in a space having 28^0C temperature and 32% relative humidity for seven days. Testing for wet condition, samples are immersed in water for four days prior testing. Flexural strength in both conditions of each sample is measured by placing the sample on two 16 mm diameter plain bars maintaining a span 254 mm constraints keeping equal free space in both side longitudinally using the standard load frame of compression testing machine. Load is applied at uniform rate. When the first crack is observed, the maximum load and deflection are measured and recorded. Using this maximum load samples were graded according to the ASTM C1186-02 [20]. The slandered value of Modules of Rupture (MOR) is given in Table 1.

Table 1: Standard value of MOR for non-asbestos fiber-cement board

Grade	Minimum Wet Strength, psi (MPa)	Minimum Equilibrium Strength, psi (MPa)
I	580 (4)	580 (4)
II	1015 (7)	1450 (10)
III	1885 (13)	2320 (16)
IV	2610 (18)	3190 (22)

Moisture content & water absorption

The sample is placed at 28°C temperature for seven days in such a manner that all faces are adequately ventilated. After this the sample is weighted which is treated as its initial mass. Sample is dried in oven at 100°C for 24 hours and weighted. The mass of the sample is taken as final mass. Moisture content and water absorption of the cement board has been done according to ASTM C 1185-08 [21].

3. Results and Discussions

The result of modulus of rupture Paper Cement Bonded board for mixing ratios 100:0, 95:5, 85:15 and 75:25 cement/paper with 1.7, 4.8 and 6.9MPa pressure shown in Table 2. The mean equilibrium and wet strength of the board for controlled sample exhibits same values and confirming ASTM grade I. on the other hand, samples

having 4.8 and 6.9 MPa pressure with five percent waste paper showed better result when compared with the controlled and other samples. Initial pressure showed evidence of control to the MOR values. In this investigation, MOR values increased by 18 and 25 percent for equilibrium and dry condition respectively when pressure increased from 4.8 to 6.9 MPa. Paper content in the cement board had a great influence on the Modulus of rupture values. However, paper content is not only one parameter is shown in following figure. Pressure is also play a vital role on the MOR values. At 1.7 MPa pressure samples with 25 percent paper content exhibits lowest result and this is true in every pressure cases.

Table 2: Modulus of Rupture with pressure and mixing proportion

Mixing Proportion (Cement: Paper)	Pressure (MPa)	MOR Dry (MPa)	MOR Wet (MPa)	Grade
100:0	--	6.9	6.9	I
95:5	1.4	7.6	6.6	I
	2.8	9.6	8	II
	4.2	11.4	9.7	II
	5.5	13.1	11.2	II
	6.9	13.7	12.1	II
	8.3	13.4	11.3	II
85:15	1.4	6.6	5.5	I
	2.8	7.6	6	I
	4.2	8.6	6.9	I
	5.5	9	7.1	II
	6.9	9.1	7.3	II
	8.3	8.8	7	II
75:25	1.4	4.8	3.1	--
	2.8	5.5	3.5	--
	4.2	5.9	3.8	--
	5.5	6.1	4.3	I
	6.9	6.2	4.5	I
	8.3	6	4	I

The slope of the line is near about flat for fifteen and twenty-five percent paper content shown in Figure 3, however, a sharp increasing trend is observed in case of five percent paper content cement board for both in dry and wet MOR values. It also observed that the external pressure application at the innitial phase of the manufacturing process has very little effect after 6.9 MPa pressure.

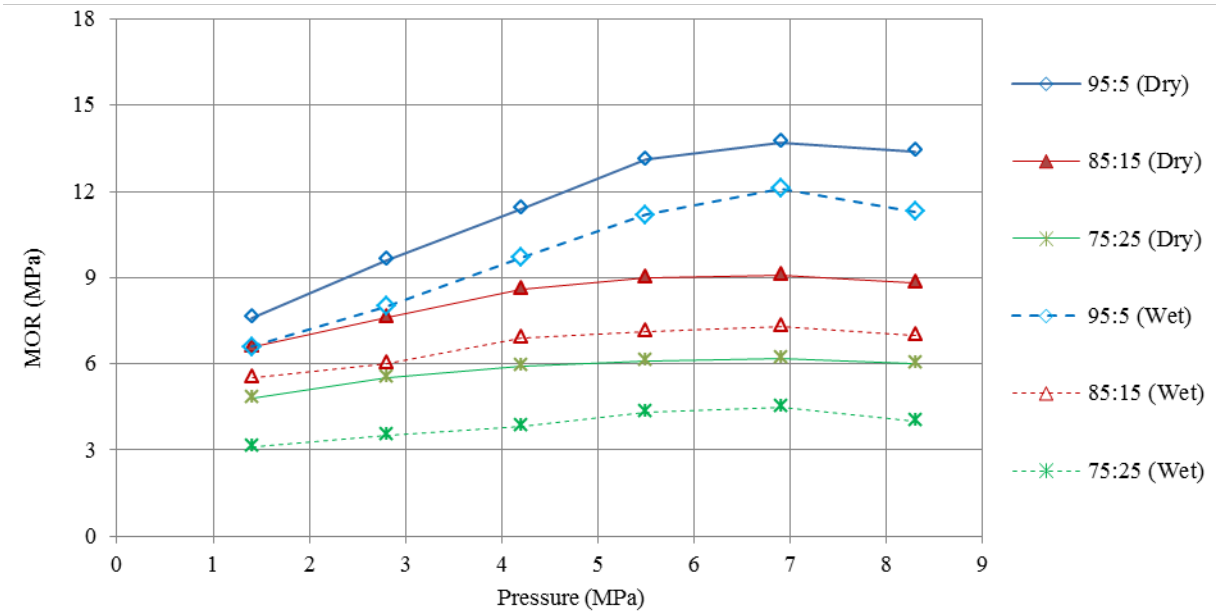
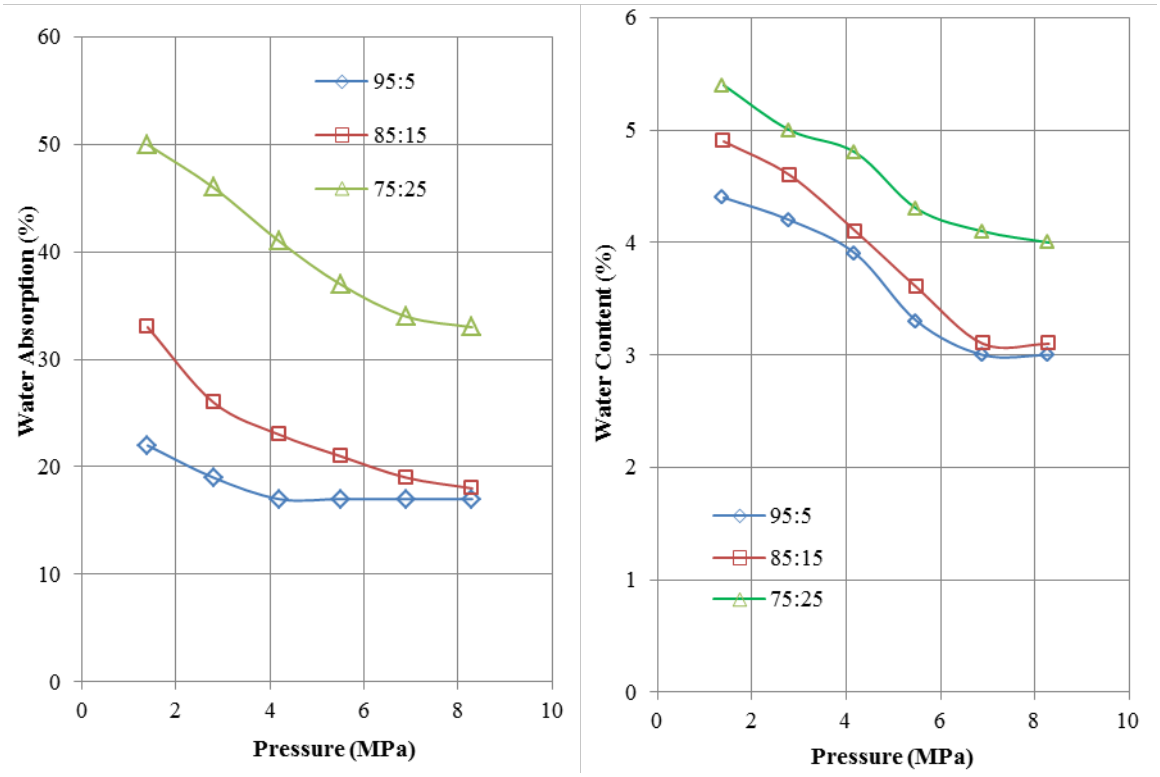


Figure 3: Relation between Paper content, Pressure and Modulus of Rupture (MOR)



(a) (b)

Figure 4: Effect of innitial pressure on (a) water content and (b) moisture content in the cement boards

Moisture content and water absorption of cement board incorporating waste newspaper exhibits that both values are decreased due to increases the initial pressure. However, amount of paper content plays an imperative role. Water absorption is increased with increasing the amount of newspaper in the mixture. This statement is similar

for moisture content also. However for 15 and 5 precents mixing of newspaper exhibits quit similar in nature for moisture content of the cement board shown in Figure 4.

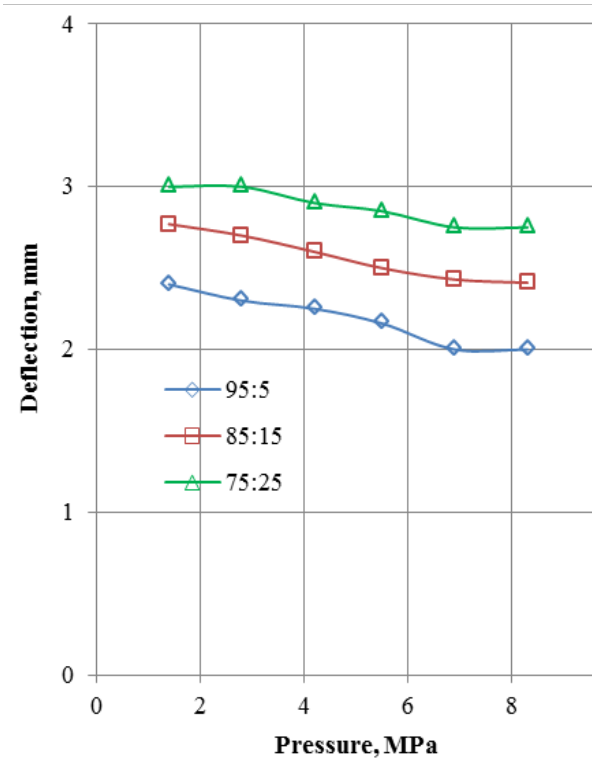


Figure 5: Relation between mix proportion, Pressure and Deflection

Figure 5 represents the deflection of different types of sample with changeable pressure and paper content of cement board. It is observed that defection increases with the increase of paper content. Same figure demonstrated that the deflection decreases while the initial pressure is increased. However, the sample made from only cement without pressure (Control) has very low deflection (1/3rd of the samples with paper, on an average), which makes it in brittle nature. Higher amount of paper mixes exhibits higher abrasion value and reverse result was found in case of initial pressure on the sample.

4. Conclusions and Recommendations

Cement board produced from waste newspaper comply the flexural requirement of grade I and II type cement board according to ASTM C 1186-08. The paper cement board may be cheaper in terms of cost, performance and environmental aspect when compared with wood and other available board. Cement board with paper exhibits less brittle behavior than board with no paper. The modulus of rupture of this board is higher with 5 percent paper by weight. In every cases of pressure this result is spot on. However, deflection of the board is reduced with lower amount of paper in the board. Higher initial pressure exhibits lower deflection of the board. Pressure makes the sample dense and enhances its compactness. Modulus of Rupture improves with pressure and it has been found maximum at 6.9 MPa

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