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Investigating Cement-Bagasse Fiber Composite Properties

[1]Ali Varshoee, [1]Hamed Nasiri, [2]Abolfazl Kargarfard, [1]Abdollah Hoseinzadeh, [3]Ebrahim Ezati

[1]ANatural Resources faculty, Islamic Azad University, Chalous, Iran
[2]Research Institute of Forests & Rangeland, Tehran, Iran
[3]Lecturer, Payamnoor University, Guilan, Iran

Abstract: The aim of this study was to investigate the feasibility of bagasse fiber usage in Fiber-Cement Composite (FCC) manufacturing. Due to this purpose, the effect of two bagasse fiber loads (%4, 10), three levels of calcium chloride as facilitator (5, 7.5 and 10 percent per dry weight of cement) and two different types of Portland cement (type II and V) on physical and mechanical properties of experimental specimens were investigated. The given results were analyzed with three variables by a fully randomized process as factorial experiments as well as Dankan Test (DMRT) and Variance Analysis Technique. The results demonstrated that the best conditions reported for flexural strength, modulus of elasticity, Internal Bond and minimum thickness swelling were %4 fibers, %7.5 calcium chloride and type II cement.

Key word: Composite · Bagasse · Fiber · Portland cement · Calcium Chloride · Physical properties · Mechanical strength

INTRODUCTION

Wood composite materials are some types of wooden material consisted of fiberboard, chipboard, mineral connected wooden panels and the molded chip products. One of these multi-structure construction materials, is wood-cement board which made of wood chips and cement. The background of producing wood-cement sheets dates back to 1914 in Austria. Despite of such long history, there were some critical difficulties in adapting different lingo-cellulosic materials with cement matrix. There were many studies which illustrate the various characteristics of fiber-cement boards' properties with different fiber origin. Regarding the mechanical properties of the hemp fibers reinforced cement, Sedan [1] stated that bending strength was increased to a certain extent by an increasing in fibers' load. On the other hand, alkaline treatment of fibers improved strength of about 94% in contrast with the fiber-matrix adhesion [1, 2]. The utilization of waste agro materials such as bagasse and its ash as pozzolanic materials was successful in initial compressive strength improving, as well as in water permeability reduction. The utilization of such substances also leads to appreciable resistance to chloride permeation and diffusion [3]. According to results of an study which performed by Bilba; the heat treatment of wood improves the dimensional stability and hydration of cement at its early age but it reduces the hygroscopicity of the wood fiber, conversely [4]. In view of that, Rappoprt [5] found many types of fibers enhancing the mechanical properties such as tensile strength, flexural strength and flexural toughness in concrete and cementations materials. Unfortunately, the bagasse fibers usage without proper treatment caused a reduction in hydration temperature but it increased the setting time of the cement. Likewise, due to degradation of some water soluble sugars during the heat treatment the setting time of concrete samples will be diminished [2].

MATERIALS AND METHODS

Materials: In this research, the variables were different types of cement (Portland type II and V), bagasse fibers of sugar cane in two levels of 4% and 10%, as well as chloride calcium as an additive material in three levels of 5%, 7.5% and 10% (based on cement's weight). Other factors such as the thickness of fiber-cement board (15 mm), press pressure (550 Psi), time of pressing (12 hours) and finally cold pressing time were fixed for all treatments.

Corresponding Author: Hamed Nasiri, Former MSc. Student, Natural Resources Faculty, Islamic Azad University, Chalous Branch, P. O. Box: 41939-65746, Iran. Tel: +98 131 6666325, Mob: +98 911 134 3763.

Table 1: The effect of the amount of bagasse fibers on Elasticity modulus, flexural strength and internal bond of boards

Levels of fibers (%)	MOE (Mpa)	MOR (Mpa)	IB (MPa)
4	5137.444	6.623	0.482
10	3359.583	5.632	0.302

Sample Preparation: As for molding bagasse fibers-cement boards, the aluminum sheets with dimensions of 40×40 cm and a wooden mold with dimensions of 35×35×7 cm were used. In order to prepare bagasse fiber-cement mat, at first, calcium chloride and water were mixed together then fibers were added to them. In the next stage, the cement was added to this combination and mixed together completely. After fully mixing the materials and being sure about no accumulation of fibers is formed, this mixture was strewn in a wooden mold and pre-compressed evenly by a wooden sheet then an aluminum sheet was placed on it to be exposed to cold pressing. It is worth mentioning that for controlling the thickness of boards, pressing stops were also used. After 12 hours pressing, the produced boards were taken out of cold press and then they were watered for 28 days to get their final strength. Finally, the boards were stored for post-curing in an air-conditioned room.

Preparation of Experimental Samples: Physical and mechanical characteristics of board were investigated under DIN standard No.68763 after 28 days of their production. The size of bending strength samples was 28×5×1.5cm, internal bond (IB) 5×5×1.5 cm and thickness swelling was 5×5×1.5 cm.

Statistical Analysis: The results were examined with three variables by a fully randomized process in which factorial experiments, Dankan Test (DMRT) and Variance Analysis Technique were employed. Through these statistical methods, the mutual and independent effect of each variable factors on the functional characteristics, was analyzed at the trust levels of 99% and 95%.

RESULT AND DISCUSSITION

Table1 illustrate the elasticity modulus (MOE), flexural strength (MOR) and internal bond (IB) amounts of experimental boards which have been produced at two levels of bagasse fibers loads (4% and 10%). As these results are indicted, all tested mechanical strengths were dramatically decreased by improving of fiber load from 4% to 10%, especially for internal bond that caused a reduction by 60%. Fig. 1 presents the independent effect of the calcium chloride consumption's amount on flexural strength. There is an steady downward trend in flexural strength by increasing of calcium chloride level from 5 to 10% and reach to a minimum of 5.7MPa. Although there is no significant difference between flexural strength of boards which composed of 7.5 and 10% calcium chloride. In Fig. 2, the mutual effect of fibers amount and calcium chloride on flexural strength is presented. Although there is a significant difference between flexural strength of boards which produced at 5% calcium chloride with 4 or 10% fiber load, but that variation comes to a similarity in boards which produced at calcium chloride consumption of 10%.

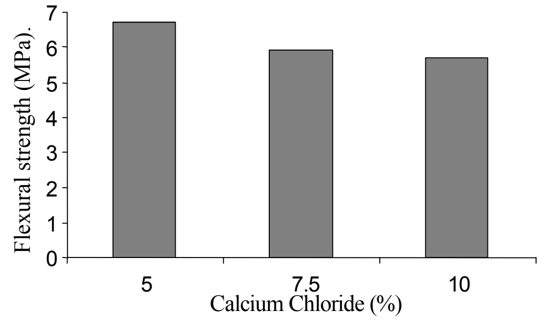

Fig. 1: Independent effect of the amount of calcium chloride consumption on flexural strength

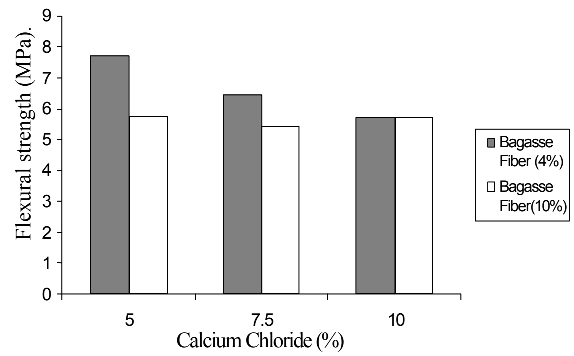

Fig. 2: Mutual effect of amount fibers and calcium chloride on flexural strength

The results are shown in Fig. 3 indicated that the mutual effect of cement types and calcium chloride on the internal bond. The internal bond strengths (IB) were risen and reach a peak at 7.5% calcium chloride consumption in boards which produced by each type of cement. After this turning point, for those boards which produced with type II cement, the IB was fallen sharply as the calcium chloride amounts were increased to 10%, but it was remain level out in boards which manufactured with cement type V.

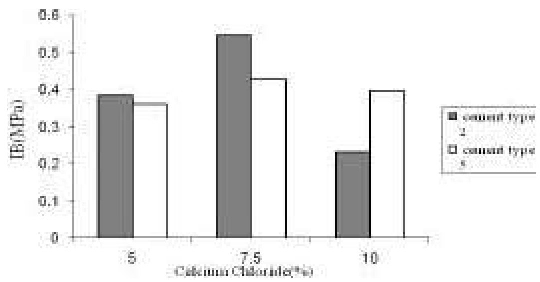

Fig. 3: Mutual effect of the type of cement and calcium chloride on internal bond

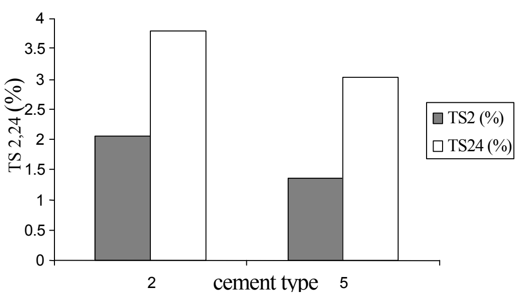

Fig. 4: Independent effect of the type of cement on 2 and 24

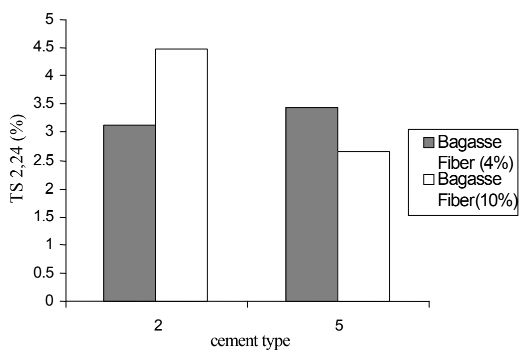

Fig. 5: Mutual effect of the type of cement and amount of fiber on 24 hours thickness swelling

Fig. 4 and 5 shows the effects of cement types and fiber loads on 2 and 24-hour-thickness swelling, respectively. It is clear that applying type V cement had a negative effect on both 2 and 24-hour-thickness swelling (Fig 4). But as baggase fiber load was reduced to 4%, the boards which produced by type V cement, had greater amount of thickness swelling.

CONCLUSION

The characteristics of experimental bagasse fiber-cement composite boards showed that those which composed of pretreated fiber by steaming at 170°C, have better adhesion characteristics among bagasse fiber and cement matrix to raw bagasse. It is due to lesser soluble sugars, hemicelluloses and lignin. Since these compounds have negative effect on adhesion of cement and fibers, so through decreasing these compounds by heat treatment the boards' strengths were improved. The researches which conducted by Bilba *et al*. showed that the mechanical properties of bagasse-cement boards which treated by heat treatment, have developed and so these boards needs a less hydration temperature to create an strong connection with cement..

Use of bagasse fibers leads to an increase in mechanical properties of composites, thanks to strong networks between cement particles and fiber surfaces which result in an improvement in bending features of composites. Moreover, the results of present study were confirmed by the findings of Cao *et al* and also Ganesan *et al*. which stated that applying fibers, at adjacent amounts, for producing the bagasse fibers-cement composites leads to improvement in mechanical characteristics of concrete especially its bending strength. This phenomena is actually because of high contact surface of fibers and creating a more network, not due to increasing in adhesion of fibers and cement articles. As the investigation conducted by Ganesan *et al* proved, the use of certain amount of cellulose fibers, as reinforcing material, led to strength increase but through raising the amount of fibers the strengths were decreased. Additionally, the use of certain amount of cellulose fiber led to a strong fiber-cement network and reduced drying shrinkage crack width (Rappoport *et al*). It is suggested that at high level of fiber load, water absorption sites will be increased, so the porosity of boards will be augmented what is more it widens water absorption to the inner spaces, Consequently (Ganesan *et al*, Semple *et al*).

Furthermore, using calcium chloride as an accelerator and neutralizing the limitative factors, (Bilba *et al.*) give rise to the speed of hydration so there will be an incomplete hydration process of cement that contributes to stress, a negative effect on the strength.

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