Study on the Practical Characteristics of Bagasse-Poplar Composite Board

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Abstract: As to the necessity and need to optimize utilization of non-forest lignocellulosic materials in Iran, the present study was fulfilled to evaluate the possibility of producing composite boards comprised of the mixture of poplar and bagasse particles in Khoozestan. In order to find out practical characteristics of the boards, several experiments were conducted to measure water absorption and thickness swelling after 2 and 24 hours immersion in water, modulus of rupture, and internal bond, all tests in compliance with ASTM-D1034 as well as DIN 68763 standards. Results showed that the optimum mixture of bagasse/poplar composite board is 60/40 respectively having %12 of resin.
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Introduction

As to the definition by FAO, composite boards may be produced with wood particles or other lignocellulosic materials, using synthetic resins, and under adjustable temperature, pressure, moisture content, as well as some catalysts.

Iran has always been facing the problem of shortage of wood as the raw material needed for wood and composite industries. Due to the vast and fierce utilization of woody resources of Iran and its decreasing trend, plantation of fast-growing species such as *Populus spp.,* having suitable technological characteristics, may certainly be useful. Some of poplar species have also cultivation capabilities such as insemination and selection of fast-growing stands in order to shorten rotation period as well as to increase productivity.

In the meantime, bagasse, with yearly production capacity of more than 1,170 million cubic meters in the world in the year 2005 (FAO, 2006), is one of the important lignocellulosic materials to be used in composite boards. Traditionally, bagasse is used as fuel in sugarcane factories, also in a lower scale in paper-making plants. Some small portion of it is also used in composite board plants in China and Pakistan (Berns & Caesar, 2000), as well as Cuba, Argentina, and Venezuela (Fernandez, 2000). Bagasse is one of the lignocellulosic resources that have chemical composition similar to hardwoods. Bagasse is mainly comprised of fibers, vessels, and parenchyma cells. The amount of holocellulose in its structure is around %74.5, lignin %18.9, proteins %0.8, extractives %5-6, and its pH is 5.6 (Hesch, 1993).

Based on the above mentioned facts, it can be concluded that the main cellulosic resources in Iran in the future would be fast-growing species like poplar and eucalyptus, as well as agricultural residues like bagasse (Doosthosseini & Khademieslam, 1993; Noorbakhsh & Kargarfard, 1995). Several researches on the consumption of lignocellulosic items as raw materials indicate that using bagasse along with woody particles can improve practical characteristics of the boards (Hosseinkhani *et al*., 2000; Karimi *et al*., 2003). Turreda (1983) studied the bonding potentiality of bagasse particles with wood particles using isocyanat, urea-formaldehyde, and poly-vinyl acetate resins. The results of his study showed that urea-formaldehyde resin had the most bonding potentiality for bagasse particles. Boards made of only bagasse particles were in compliance with Japanese standards while boards made of the mixture of wood and bagasse particles had a higher MOR and IB.

Doosthosseini and Paydar (1998) studies on the practical characteristics of composite boards made of eucalyptus and bagasse particles. They reported the optimum mixing ratio would be similar amount of each, and optimum conditions would be 160° centigrade and 6 minutes pressing time.

Hesch (1973) studied the relationship between density and resin content on the quality of the homogenous boards made of bagasse particles. The boards were in compliance with the DIN standards. Khademieslam (1989) studied the possibility to use pruned branches of fruit-trees mixed with poplar particles in composite boards. The results showed that optimum boards may be produced under moisture content of %14, press closing-time of 10 mm/s, and resin content of %11.

Stael *et al.* (2001) made composite boards with bagasse particles and poly ethylene vinyl acetate (EVA) and compared their impact strength with boards made of bagasse and PE, bagasse and PP, and commercial composite boards. Results showed that powerful bonds between bagasse particles and EVA decrease the deformation capability of this polymer to a large extent; meanwhile, its impact strength was comparable to the usual heavy particle-boards. The results of their study prove the possibility to produce optimum composite boards made of bagasse residues.

Talavera *et al.* (2007) studied on the effect of production variables on MOR, WA, and TS of composite boards made of bagasse and recycled PE. Results indicated positive impact of the increase in bagasse content over PE (60 to 40) on MOE.

In the present study, we aim at optimum utilization of the mixture of poplar and bagasse particles grown in Shooshtar[1] to produce composite boards.

Materials and methods

In the present study, bagasse particles and poplar particles (as lignocellulosic materials), as well as urea-formaldehyde resin (as bonding material), were used in production of homogenous (one-layer) composite board. Bagasse particles were procured from Karoon particleboard manufacturing company in Shooshtar; poplar particles were procured from Alborz Research Institute, located in Karaj city, on a dried and ready-to-use condition.

Variables in the present study were mixing ratio of bagasse particles and poplar particles, as well as resin content. Different mixing ratio and resin content are shown in table 1.

Table 1- Different levels of variables.

Mixing Ratio		Resin Content (%) (Based on Dried Weight of the wood particles)
Bagasse (%)	Poplar (%)	
40	60	10 & 12
60	40	10 & 12
80	20	10 & 12
100	-	10 & 12

Dry specific gravity of poplar and bagasse particles was 0.395 gr/cm^3. Other production factors were considered to be constant in the present study; these constant factors include: shape and dimensions of the wood particles and bagasse particles; moisture content of the mat as well as its distribution in the mat; temperature; time; pressure; and closing speed.

In order to measure the dimensions of wood particles and bagasse particles, some were chosen on a random basis and measured using a digital caliper with a precision of 0.01 mm. Then, slender as well as flatness ratios were calculated. The mean values for the above mentioned two ratios are shown in table 2.

As may be seen from table 2, bagasse particles have higher length and lower thickness averages comparing poplar particles; this will cause the slenderness ratio of bagasse particles to be higher, and consequently improves the quality of the composite boards. Moisture content of bagasse particles was %3, while the MC for poplar particles was %6. Urea formaldehyde was used as the resin in the present study adding %1 clorur ammonium (based on the dry weight of the resin) as catalyst. Pressure was set at 150 bars, and temperature at 180° C. The nominal thickness of the boards was set at 16 mm.

Modulus of Rupture as well as internal bonding was measured in compliance with ASTM-D1034 standard; and water absorption as well as thickness swelling was measured according to specifications stipulated in DIN 68763.

Statistical analysis was done on a complete random block basis using two-variable factorial design at significance level of $\alpha = 0.01$ as well as 0.05; then Duncan's multiple range test (DMRT) was fulfilled for different levels of each variable.

[1] Shooshtar is one of the cities located in Khoozestan province, in the southern part of Iran.

Table 2- Specifications of wood and bagasse particles.

Kind of Raw Material	Length (mm)	Width (mm)	Thickness (mm)	Slenderness Ratio	Flatness Ratio
Bagasse	36.85	7.14	0.56	64.03	12.75
Poplar	22.94	5.40	2.56	8.96	2.10

Results and Discussion

Tables 3 and 4 show respectively the effect of the kind of material (bagasse and poplar in different proportions) as well as resin content on mechanical and physical properties of the composite boards.

Table 3- The effect of the kind and proportion of raw material on mechanical and physical properties of the composite boards.

Kind of Raw Materials		Modulus of Rupture (M.Pas)	Internal Bonding (M.Pas)	Water Absorption		Thickness Swelling	
Bagasse	Poplar			2 hours	24 hours	2 hours	24 hours
40	60	17.14	1.30	42.77	49.26	16.97	26.36
60	40	19.39	1.33	41.57	48.52	16.55	24.61
80	20	16.60	0.55	40.45	54.93	14.65	21.93
100	__	14.78	0.46	43.87	59.61	16.90	24.01

Table 4- The effect of resin content on mechanical and physical properties of the composite boards.

Resin Content	Modulus of Rupture (M.Pas)	Internal Bonding (M.Pas)	Water Absorption		Thickness Swelling	
			2 hours	24 hours	2 hours	24 hours
10	16.75	0.88	47.45	48.68	20.28	28.58
12	17.19	0.93	87.36	46.03	17.25	22.87

Statistical analysis showed significant different at α level of %1 for the kind of raw materials on the modulus of rupture. Maximum MOR was obtained having mixing ratio of %60 bagasse particles and %40 poplar particles; while minimum MOR was obtained with %100 bagasse particles (see table 3). Figure 1 shows the effect of the kind of raw materials on MOR.

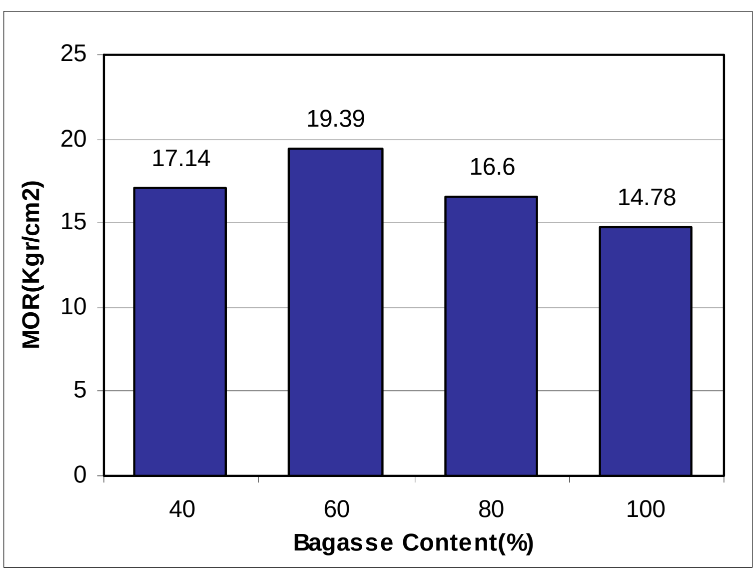

Figure 1- Modulus of rupture versus bagasse content.

Increasing resin content from %10 to %12 improved MOR (table 4). Alteration in bagasse/poplar mixing ratio had significant difference effect at α level of %1 on the internal bonding. Maximum IB was obtained having %60 bagasse and %40 poplar particles. Next in rank for IB specifications is for mixing ratio of %40 bagasse and %60 poplar particles (figure 2). It is to be noted that there is no significant difference between these two treatments; therefore they have the same Duncan grouping.

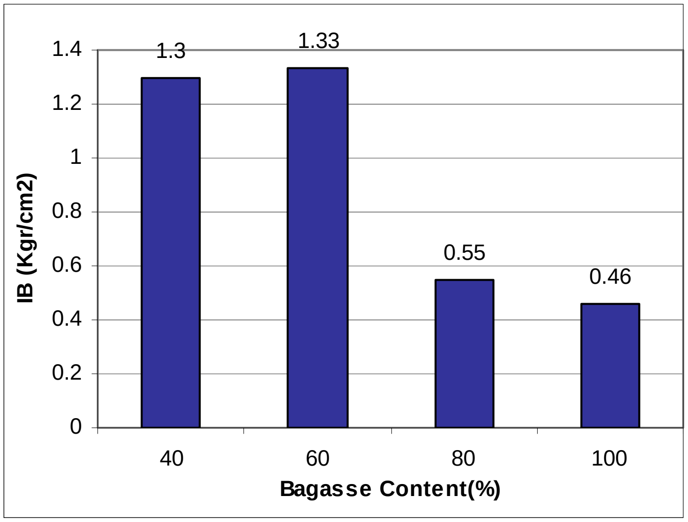

Figure 2- Internal bond versus bagasse content.

The effect of the kind of raw material on water absorption showed significant difference at α level of %1. As may be perceived from figure 3, mixing ratio of %80 bagasse and %20 poplar particles shows the lowest water absorption both for 2 as well as 24 hours of immersion. This can be caused by better bonding between bagasse/poplar particles in the boards. The highest water absorption was obtained for boards having %100 bagasse particles. Adding %20 poplar particles made water absorption decrease; but increasing poplar particles ended in more water absorption which was due to the increasing porosity in the boards (tables 3 and 4).

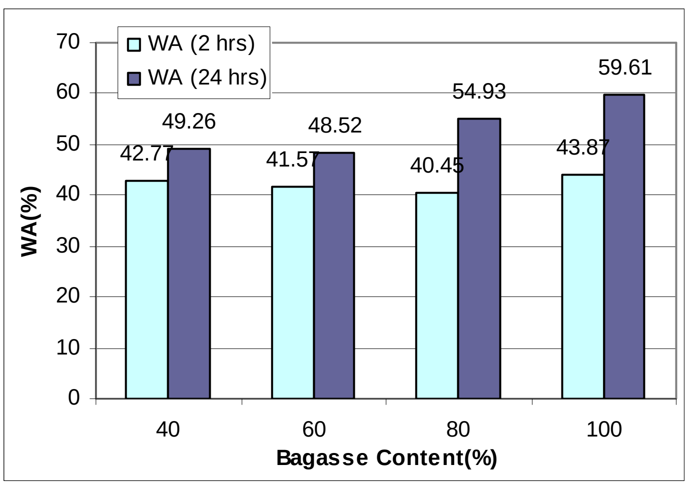

Figure 3- Water absorption versus bagasse content.

There was significant different at %1 level in different resin contents on water absorption for 2 and 24 hours immersion; resin content of %12 decreased water absorption.

The effect of the kind of raw materials on dimensional stability of the boards was statistically significant at %1 level. The lowest thickness swelling after 2 and 24 hour immersion was obtained in boards having mixing ratio of %80 bagasse and %20 poplar particles (figure 4). Resin content showed similar effect as previously was observed in thickness swelling; that is, resin content of %12 decreased thickness swelling (tables 3 and 4).

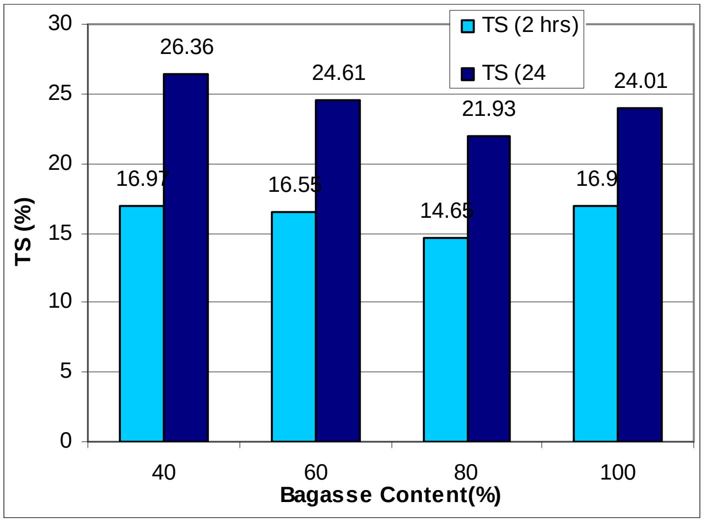

Figure 4- Thickness swelling versus bagasse content.

Conclusion

Based on the results obtained through the present study we may conclude that mixing ratio of %60 bagasse and %40 poplar particles show the best mechanical properties of MOR as well as IB. Reasons to this may be rooted in smoother distribution of bagasse particles and poplar particles, as well as better bonding between raw materials and resin.

As to the physical properties of the boards including water absorption and thickness swelling, mixing ratio of %80 bagasse and %20 poplar particles showed better results in comparison with other mixing ratios. The reason is that the boards were homogeneous and therefore compression of small and big particles located in the midst of the boards was higher.

Increasing resin content from %10 to %12 improved the physical and mechanical properties of the boards. Therefore, optimum conditions may be defined as mixing ratio of %60 bagasse and %40 poplar particles, adding %12 resin to the final mat.

Comparison between the properties of the composite boards made in the present study with those stipulated in international standards shows that generally the MOR values obtained here are lower than standards. Reasons may be rooted in not removing dirt and Pith from bagasse particles, as well as big dimensions of poplar particles. Dirt may absorb part of the resin and cause uneven distribution of resin on the surface of bagasse particles and wood particles; consequently, contact area would decrease substantially. Big dimensions of poplar particles causes less compactness and naturally mechanical properties would decrease.

As to the physical properties, the mean values for water absorption and thickness swelling after 2 and 24 hour immersion were higher than those stipulated in the standards. Reasons may be rooted in not using paraffin in the boards, as well as high cellulose content in bagasse and big wood particles.

We may conclude that physical and mechanical properties of bagasse/poplar composite boards can be improved through better dimensionally control of wood particles, removing dirt from bagasse particles, and using suitable additives such as paraffin emulsions.

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