Utilization of Some Annual Fiber (Corn and Cotton Stalks) As a Possible Raw Material Environmental Friendly Panel Production

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Abstract—**The aim of this study is to investigate the potential utilization of corn and cotton stalks in composite panel environmental friendly production. In this study, water absorption, thickness swelling, bending strength internal bond properties of composite panel produced with corn and cotton stalks at various resin addition levels and density ranges were studied. It was found that the some composites produced showed technological properties acceptable to the TS-EN standards. But lower density panels may be used as insulation boards.**

Keywords— **Annual fiber, corn stalk, cotton stalk, composite panel.**

I. Introduction

One of the important reasons for environmental pollution is fast depletion of forest resource as a raw material. While many industries utilize forest products as a raw material and uneconomical use of these resources cause extinction of forest. For assurance of continuous supply for lignocelluloses, fast growing trees should be planted and whole trees and residues should be utilized. In addition, the utilization of annual plants and agricultural wastes would reduce the depletion of forest resources. It is really necessary to find alternative raw material source in order to reduce forest consumption. For this reason it is important to study suitability of annual plants fibres for composite panel production. Therefore the maximum utilization of present resources are extremely important. This will aid protection of environment and as well as development of environmental friendly technologies.

Utilization of annual fibers as a raw material does not only bring solution for raw material deficit in the composite panel industry, also brings some reduction in consumption of forest.

Annual plants as a secondary raw material for the particleboard are not utilized in a greater amount in the countries where the forests are abundant. However, as a result of decreasing wood resources, the annual plants as an alternatives material are gathering considerably attraction. The improvements in the production technology also eliminate the some previous problems in utilization of annual plants for the composite panel production.

Manuscript received May. 23, 2016. This work was supported in part by the Duzce University, BAP (Directory of Scientific Research Projects) 2012.02.03.127

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TABLE 1. WORLD ANNUAL FIBER POTENTIAL [1].

NON-WOOD RESOURCHERS	Million ton/y
Wheat stalk	600
Price stalk	360
Barley stalk	195
Oats straw	55
Rye	40
Grass seed straw	3
Seed flax straw	2
Sub-total straw	1,255
Sugar cane bagasse	102.2
Reed	30
Bamboo	30
Cotton staple fiber	18.3
Cotton linters (1st and 2nd cut)	2.7
Cotton stalks	68
Other stem fiber (eg: hemp, jute, kenaf), as whole stalk	13.7
Leaf fiber (eg: sisal, henequen, maguey)	0.5
Abaca (ie: manila hemp; also a leaf fiber)).	0.08
Hemp fiber	0.2
Corn stalks	750
Grain and sweet sorghum stalks	252
Papyrus	5
Sabai grass	0.2
Total	2,527.88

Cotton is a polyannual temperate zone plant. However it can be grown as an annual plant. Annual species have a height of 60-100 cm, whereas polyannual species may grow to as high as 5-6 m in height. Species cultivated for cotton production are annuals [2].

Cotton has been widely used in textile industry. Cotton linters are used in the pulp and paper industry, medicine and textile industry. On the other hand, cotton oil obtained from cotton seeds is used as liquid edible oil. In addition it is used in the soap and dye industries. Oiloake remained from oil production is also animal fodder [3].

Maize or corn is a cereal crop that is grown widely throughout the world in a range of agroecological environments. More maize is produced annually than any other grain. About 50 species exist and consist of different colors, textures and grain shapes and sizes. White, yellow and red are the most common types.

Search has gone on to the possible use of annual plants such as bagasse, bamboo, sunflower stalks, rice husks, banana and oil-palm [4].

In recent studies; cotton stalks [5], cotton carpel [6], hazelnut husk [7], oil palm [8], bamboo chips [9], kenaf core and kenaf stalks [10]-[11], date palm branches [12], corn and cotton stalks [13], wheat straw and corn pich [14], peanut hull [15], sunflower stalks [16]-[17] have been investigated.

II. Material and Method

Corn and cotton stalks gathered were cleaned from husks and other impurities, and then chipped and screened. After these processes, the chips were dried at 110 ^{0}C until they had a moisture content of 3 %. In the production of panel urea formaldehyde (UF) resin was used as an adhesive (for middle layers 8 %, for the outer layers 10 % based on the oven dry weight of the chips). As a hardener, 33 % of ammonium chloride solution was used for all of the UF resin boards. Properties of UF and the panel production parameters were also displayed in Table 2 and 3.

Table 2. Properties of The Urea Formaldehyde.

Properties	UF
Solidity (%)	55±1
Density (g/cm^3)	1.20
pH	8.5
Viscosity (cps)	160
Ratio of water tolerance	10/27
Reactivity	35
Free formaldehyde (%)	0.15
33% NH_4Cl content (max, %)	1
Gel point (100°C, sec.)	25-30
Storage time (25°C, max. day)	90
Flowing point (25°C, sn.)	20-40

Table 3.Experimental Design Composite Panels.

Panel types	Raw materials	Density (kg/m^3)	Resin ratio (%)		Pressure (N/mm^2)	Pressing time (min.)
			Outer layer	Core layer		
A	Cotton stalk	500	10	8	2.4-2.6	6
B	Cotton stalk	600	10	8	2.4-2.6	6
C	Cotton stalk	700	10	8	2.4-2.6	6
D	Corn stalk	500	10	8	2.4-2.6	6
E	Corn Stalk	600	10	8	2.4-2.6	6
F	Corn stalk	700	10	8	2.4-2.6	6

The sampling performed from panels according to TS-EN 326-1 [18]. The water absorption and swelling in thickness of materials were determined according to TS-EN 317 [19]. The boards are also tested for bending strength in accordance to TS-EN 310 [20] and internal bond strength in accordance to TS-EN 319 [21].

III. Result and Discussion

Water Absorption and Thickness Swelling; results are shown in Table 4. It was found that the panel type A was the weakest against the water penetration. It showed the highest water absorption. It was believed to be due to the lowest amount of resin present in board and the lowest density of the board compared with others.

Table 4. Results of Water Absorption and Thickness Swelling of The Panels.[A]

Board types	Water Absorption (%)		Thickness swelling (%)	
	2-hr.	24-hr.	2-hr.	24-hr.
A	83.8 (6.00)	105.4 (4.64)	20.09 (2.78)	24.76 (3.09)
B	76.87 (6.76)	97.3 (5.53)	21.55 (1.62)	31.72 (2.85)
C	56.51 (6.65)	75.18 (8.01)	15.34 (1.14)	26.72 (1.51)
D	61.74 (4.84)	75.77 (4.58)	25.95 (2.40)	27.49 (3.12)
E	55.42 (5.65)	66.24 (5.52)	25.10 (3.03)	26.41 (4.08)
F	54.30 (6.52)	63.39 (7.02)	24.61 (3.03)	25.55 (3.08)

[A]Values in parentheses are the standard deviations of the means ; *n* denotes sample size: 30.

In general it was found that the extent of water absorption and level of thickness swelling of the boards made of cotton stalks are higher than that of made from woody materials. It is thought to be mainly due to the cell properties of the annual fiber. The cells of corn and cotton stalks a porous structure hence shows lower density.

Bending strength and internal bond strength; results are illustrated in Table 5. It was found that bending strength of boards tested are in the range of 4.32 N/mm^2 being lowest for sample D and 16.79 N/mm^2 being the highest for sample C. It is seen that samples B and C (cotton stalks panels) meet the requirements set by TS-EN 312 [22]. While the rest of samples are found to having the bending strength lower than others.

Table 5. Results of The Mechanical Properties of The Panel.[A]

Boards types	Bending strength (N/mm^2)	Internal bond strength (N/mm^2)
A	7.32 (1.13)	0.245 (0.037)
B	11.49 (1.46)	0.352 (0.055)
C	16.79 (2.43)	0.563 (0.137)
D	4.32 (2.11)	0.11 (0.05)
E	7.23 (1.87)	0.16 (0.06)
F	9.13(1.28)	0.20 (0.05)

[A]Values in parentheses are the standard deviations of the means ; *n* denotes sample size: 20; average MC at test was 10.5 percent.

B and C panels type are also found to be goal in terms of internal bond requirements. Due to the low bulk density of corn and cotton stalks compared to woody materials. The press can be operated in higher pressure and temperature in the production of corn and cotton stalks board. This can significantly increase the internal bond strength of the board. There are similar results in the literature [5]-[13]-[15].

IV. Conclusion

Manufacturing of panel from cotton or corn stalks appears to be technically feasible. Because of increased consumption of wooden materials due to increase in population. Using corn and cotton stalks for manufacturing of panels would be a new solution to the raw material shortage in the industry.

It is shown that annual fibers can be used as an alternative and valuable raw material for the production of environmental friendly panel. Because these wastes are disposed of pollute the environment and are often burned by farmers.

The boards having the lower mechanical properties tested in this study can be used as insulation materials in the buildings from the fact that such materials would not be subjected to any mechanical stress.

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