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Bagasse Fiber Reinforced PVC Composites for Building Applications

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Abstract

Wood, reconstituted wood, fiber reinforced composites (with inorganic & organic matrices both), polymer sheets etc. are used for doors, windows, cladding, partitioning, false ceiling etc. in buildings. Cellulosic fibers are gaining great potential applications for improving mechanical properties of composites with both inorganic and organic binders. Some inherent properties of the binders also play both positive and negative roles in managing the end product properties. In this work two composites using sugar cane bagasse fiber as the reinforcing material and PVC (polymeric) and Ordinary Portland Cement (inorganic) as binders were made and compared together for their different physico-mechanical behavior. This study was aimed to identify the extent of use of polymers in composites in building in place of cement.

INTRODUCTION

Variety of components are used in buildings, which include bricks, cement, aggregates, steel, aluminum, wood, cladding and partitioning materials, electrical and sanitary items, coatings etc. Large alternative materials are available for replacing the conventional materials to lessen the dependency on them. Reconstituted wood, fiber composites in inorganic and polymer matrices, MDF boards, polymer sheets etc. are finding increasing uses in buildings. Cement bonded fibre reinforced boards are gaining momentum in this area of doors, windows, cladding, partitioning, false ceiling applications in buildings. It's a few inherent properties, such as higher moisture content, higher water absorption and its lower mechanical properties under moist condition, limits its applications. These properties can be improved by using polymeric materials as matrix material in place of cement. This study, therefore, is carried out to evaluate and compare the improvements in both the composites.

Lignocellulosic fibers found increasingly applications in polymer reinforcement because of desirable characteristics. In comparison with mineral and synthetic fibers (Agrawal et. al, 2002), lignocellulosic fibers are inexpensive, renewable and biodegradable and have low density and a desirable fiber aspect ratio. In addition, lignocellulosic fibers exhibit several attractive mechanical properties when used as reinforcements inthermoplastics. These include high specific strength, high stiffness to weight ratio, and low hardness that minimizes abrasion of equipment during processing.

The matrix materials used with sugar cane bagasse elsewhere(Monteiro et. al, 1998; Chiellini et. al, 2004; Mothe et. al, 2002; Poompuang et. al) include polyester, Polyvinyl Alcohol (PVA), Polyurethane, High density polyethylene with blending of coir fiber etc. The studies using polyvinyl Chloride (PVC), a resin widely used in building products and components, were seldomly reported. Polyvinyl chloride (PVC) is one of the most widely used polymers in the world and its properties can be tuned from rigid to soft and flexible by varying the plasticizer content. The largest uses include rigid pipe, window frames, flooring, cable insulation and other household and construction applications. PVC waste can also be used for making Bagasse-PVC composites. Other additives such as calcium carbonate, carbon black, China clay etc. effect also the physico-mechanical behavior of bagasse-PVC composites (Agrawal et. al, 2003).

The composite made under this study uses 50 grams of sugar cane bagasse with 200 grams of PVC by weight. The physico-mechanical behavior is compared with the composites using 50 grams of sugar cane bagasse with 200 grams of ordinary Portland cement.

RAW MATERIALS

Raw materials used for fabrication of composites were sugar cane bagasse, polyvinyl chloride and commercial OPC of 54 Mpa strength. The sugar cane bagasse was supplied by M/s Uttam Sugar Mill Pvt. Ltd., Libberheri, Haridwar, India. The de-pithed bagasse was characterized for physical and chemical compositions. The physical composition of depithed bagasse contains useful fibers 77%, pith 16.5 %, water solubles 6.5% while fibre pith ratio was 4.6. The chemical composition of bagasse contains ash 2.8%, silica 1.8%, has solubility in hot water 10.6 %, solubility in 1.0% hot NaOH solution 32.4%, Pentosans 26.5%, alpha cellulose 32.3% , and lignin 20.4%.

Commercial suspension grade PVC is used for fabrication of composites supplied by M/s Indian Petro-chemicals Ltd., India. The glass transition temperature was 85°C, melting temperature 240°C, crystalline density at 25°C was 1.52 gms/cm^3.

EXPERIMENTAL WORK

Preparation of Bagasse

Sugar cane bagasse was first passed through two-roll mill (SS) under pressure in order to disintegrate it into smaller size and simultaneously to separate soft and hard portion. This mechanical separation prevented the excessive fiber damage. The fiber (hard portion) of the bagasse and pith were manually separated. The de-pithed bagasse was then soaked in water for 24 hours and thoroughly washed with fresh water. Depithed bagasse is shown in Fig. 1.

Fabrication of Composites

Two different composites of bagasse fibre with PVC and OPC were made. 5 % $CaCO_3$ and 7% TiO_2 of PVC powder (both LR grade), by weight, were mixed with PVC in a Ball Mill using steel balls for 8 hours at 15 RPM. Then the dried 50 grams of bagasse fibres were mixed manually with 200 grams of prepared PVC admixture.

The mixture of bagasse fiber and PVC was poured into the pre-lubricated mild steel mould. The mould was put into a hot press and pressed hydraulically for 60 minutes. The temperature of press was maintained at 200^0C. Pressure was kept at 0.3 kg/cm^2. On achieving the set temperature, the heating of the press was switched off keeping the board under pressure in the press for further 60 minutes. After that board was taken out of the press. The fabricated sheet of Bagasse-PVC Composite is shown in Fig. 2.

The bagasse cement composite was made following the similar method. 50 grams of prepared bagasse was taken and soaked in water for 24 hours and washed with fresh water twice. The excess water was allowed to drain and 200 grams of OPC was mixed with this soaked and washed bagasse manually. The mixture was poured into a pre-lubricated MS mould. The mould was put into a hydraulic press and pressed at room temperature for 24 hours keeping the pressure constant at .34 kg/cm^2, the de-molded sheet is cured for 7 days in moist condition and for 21 days in open air. The bagasse cement composite is shown in Fig. 3.

RESULTS AND DISCUSSIONS

The FTIR spectra of mixture of PVC, $CaCO_3$, and TiO_2 and Bagasse-PVC composite (Figs 4 and 5) shows that all the constituents used in admixture of PVC used for making composite are present as such. There is no reactive consumption of different constituents.

The results of the physico-mechanical behavior of bagasse-PVC and Bagasse-Cement composites, determined as per IS:3087-1985, are given in Table 1

CONCLUSIONS

The results show that composite using polymeric matrix (PVC) has better performance in moisture content, water absorption while tensile strength in comparison to bagasse-cement composite is marginally lower. However, lower range of working temperature of bagasse-PVC composite, restricts its application in limited areas only. The enhanced property of lower water absorption of bagasse-PVC composite shows its better application in higher humid built environments. Thus bagasse-PVC composites are suitable for doors/ windows panels, cladding, partitioning, false ceiling etc. in buildings for interior applications.

Thus it can be concluded here that both the composites have their own areas of application for building applications. Their own properties of both the composites will identify their specific areas of applications in buildings for themselves.

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Table 1 Physico-Mechanical Behavior of Bagasse-PVC and Bagasse-Cement Composites

S. No.	Characteristic	Unit	PVC	OPC
1.	Density	Kg/m^3	1212.60	1143.30
2.	Moisture content	Wt. %	1.710	4.91
3.	Water Absorption	Wt. %		
	- 02 hrs soaking		2.062	9.900
	- 24 hrs soaking		5.952	30.659
4.	Change in Length	%		
	- 02 hrs soaking		0.210	0.094
	- 24 hrs soaking		0.302	0.120
5.	Tensile Strength Parallel to surface	N/mm^2	52.37	57.43
6.	Tensile strength perpendicular to surface	N/mm^2	31.81	44.05
7.	Screw Holding Strength	N	2752	3432
8.	Nail Holding Strength	N	907	1460
9.	Working Temperature	°C	73	-
10.	Coefficient of Linear Thermal Expansion (–30 to +30°C)	Per °C.	6.63×10^{-7}	-

Fig. 1 De-pithed and Washed Bagasse

Fig. 2 Bagasse-PVC Composite

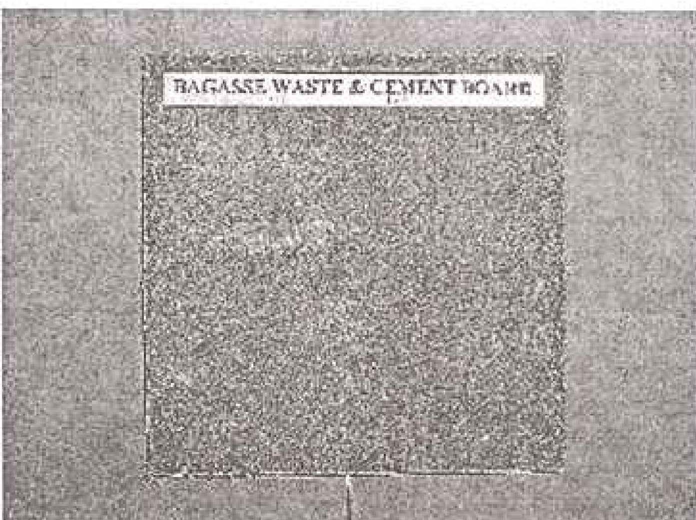

Fig. 3 Bagasse-Cement Composite

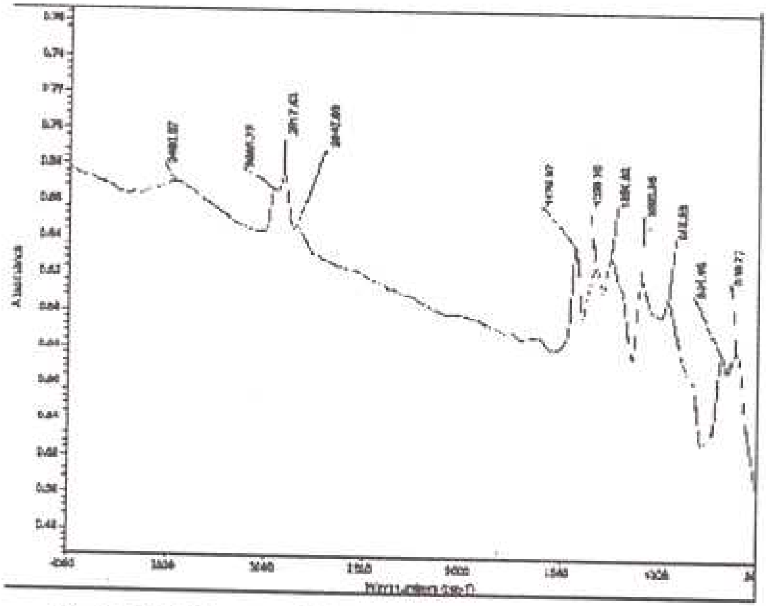

Fig. 4 FTIR Spectra of Mixture of $CaCO_3$, TiO_2, and PVC

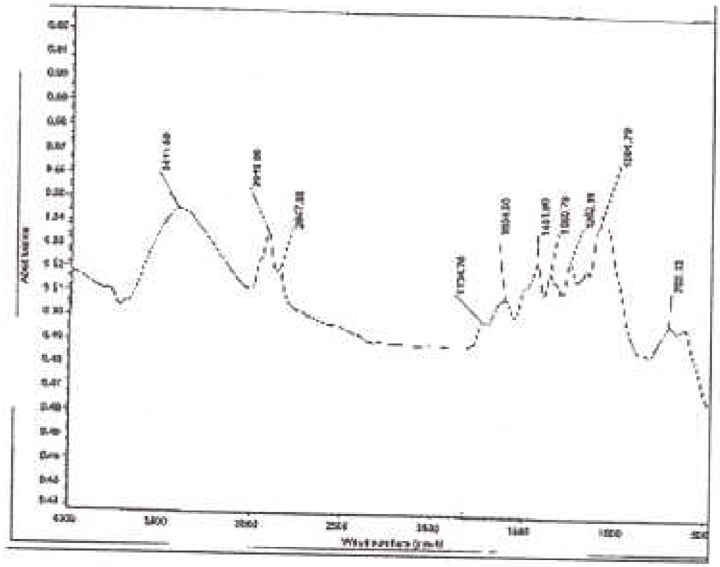

Fig. 5 FTIR Spectra of Bagasse-PVC Composite