Manufacturing of Decorative Material by Using Locally Available Waste Wood and Plastic Composite

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Abstract: Plastic and wood fibre or wood powder are combined to create the composite material known as wood-plastic composite (WPC). It has been studied and utilized more frequently in building materials because, among other benefits, it is plastic, mothproof, and resistant to corrosion. When analyzing WPC's mechanical qualities, its flexural property is a crucial area to consider. In this paper, wood-plastic raw materials and processing technology are introduced; internal and external WPC factors that affect the flexural properties are analyzed; various methods of increasing the bending capacity, such as surface pretreatment and the addition of various modifiers (compatibility agent and coupling agent), etc., are summarized; and the mechanisms of operation and strengthening effect are analyzed. Reference material for additional research is provided by this work.

Keywords— composite made of wood and plastic(WPC)

1. Introduction

The plastic and wood wastes have become a major environmental concern as regards degradability and pollution. WPC with its wide range of application helps to put these wastes into meaningful and commercially viable use thereby, reducing pollution considerably. It is a fast-growing research area. It has found uses in fences, sidings, decking's, park benches, landscaping timbers, windows and door frames, ponds, indoor furniture, pellets and many others.

Term "wood-plastic composites" WPC widely refers to Many numbers of composition will contain wood, plastic, thermoset-or thermoplastic polymers. More specifically, the term refers to thermo-plastically processible composites that consist of varying contents of wood, plastic and additives, and are processed by thermoplastic shape forming techniques such as extrusion, injection moldings, pressing. The birth of the WPC industry involved the interfacing of two industries that have historically known little about each other and have very different knowledge bases, expertise, and perspectives. The products of industry has greater experience and resources in the building products market and its production methods center around the typical wood processes; sawing, veneering, chipping, flaking and gluing. The plastics industry has knowledge of plastics processing that centers around extrusion, compression molding and injection-molding technologies.

In the earlier stages the wood plastic composite almost century years in the past where in wooden floor was mixed with phenol formaldehyde resin to produce the wood plastic composite substances, used as an motor vechile gear shift knob. The extremely good review of composites made with wood flour mixing with polymer is provided by Rowell and Konkol. An earlier stage connection to the manufacturing WPC like blending elements like wpc with thermo plastic resin through the extrusion process which is appeared more than 60 years in the past. Most current issues with references on materials from thermoplastic polymer only.

The equations are an exception to the prescribed specifications of this template. You will need to determine materials of WPC are still now new material for the researchers which relating to the long history of natural lumbers of building materials substance. The maximum application of WPCs in USA is in the outdoor deck floor, but it's also used for indoor furniture, fence, railings, outdoor frames, park benches, siding and cladding and frames of doors and window. WPC are extra eco pleasant, most effectiveness, and require much less maintenance than the options of solid wood treated with preservative or solid wood of rot resistance species. This WPC material which had plastic which having extra elastic modulus. Surface hardness is excessive, commonly 2 - 5 times the timber.

2. OBJECTIVE

- Effective utilization of renewable sources like wash WPC composite.
- Identifying best composite combination in WPC
- Identifying the test properties of wood and plastic composite

3. MATERIALS AND METHODOLOGY

A) MATERIALS

a) POLYMERS: Polyvinyl chloride (PVC) is the widely used polymer because it will be making products with multiplicity propertied from smooth and flexible to light and inflexible or rigid form. The outcome is regularly decided with the aid of additives. Other substances should typically be added to convert those resin right into a finished product. These can consist of lubricants, heat stabilizers, foaming agents, impact modifiers and coupling agents. Usually, 50% PVC is added in production of WPC.

b) CALCIUM CARBONATE(CaCO3): Making advantage of Calcium Carbonate is mainly for increasing the

Toughening has an impact on polymers and effectively fill in WPC for the best impact, flexural, and tensile characteristics of WPC and also reduces the energy consumption for processing. CaCo3 that's utilized in manufacturing of WPC is as shown in fig 2 The appropriate calcium carbonate in excess amounts added is 40%.

c) WOOD POWDER: The colour of the WPC produced in particular depending on the sort of wood powder used. The appropriate amount of wood powder added is3%- 5%. The wood powder used in production of WPC.

d) LUBRICANTS: Lubricants are essential because it increases throughput and improve WPC surface appearance

and it also prevents the edge tearing of WPC boards. The different lubricants used are wax, glycerol, fatty acids Etc. Approximately 1-2% of lubricants utilized in production of WPC.

e) FOAMING AGENTS: Foaming agents utilized to reduce density and improving machinability. Approximately 1-2% of foaming agents are used in production of WPC.

f) STABILIZERS: Stabilizers utilized to slowdown the reaction process, maintain chemical stability, prevent light and also thermal decomposition, reduce the surface tension, approximately 1-2% of stabilizers are used in production of WPC The stabilizer calcium zinc and lead salt used in production of WPC.

g) IMPACT MODIFIERS: Impact modifiers are used to improve strength and toughness and increase the screw holding strength of WPC. It added depends upon the level of impact resistance needed for the application. Approximately 1-2% of impact modifiers are used in production of WPC. The impact modifiers Propylene and Ethylene used in production of WPC.

h) COUPLING AGENT: Coupling agents bond the wood or timber powder to the resin matrix. they enhance the structural power and stiffness. In additionally increases the dimensional stability, fiber dispersions and impact force resistance. Approximately 1-2% of coupling agents are used in production of WPC. The coupling agent's Maleic anhydride and silane used in production of WPC.

B) METHODOLOGY

Material properties and composition levels

Sl No	1	2	3	4	5	6	7	8
Materials/ chemicals	Polymer (pvc)	$CaCo_3$	Wood powder	Lubricant (wax)	Foaming agents	Stabilizers (CaZn)	Impact modifiers (propylene)	Coupling agents (maleic anhydride)
Size/grade No	212µm	300µm	50µm	LP0020P	AC series SA3000	HS944	100µm	150µm
Composition 1	50%	40%	3%	1%	2%	1%	2%	1%
Composition 2	50%	40%	5%	1%	1%	1%	1%	1%
Compositon 3	40%	50%	4%	1%	1%	2%	1%	1%

Development of WPC

a) Pulverization of PVC

It is the process called for crushing solid particles into fine particles of required size mayin micron size also, it is the process of combination of crushing, impacting and also grinding. The tools utilized in this technique are called a Pulverizer. It is a mechanical device for crushing of many various forms of materials like metals, rock, glass Etc.

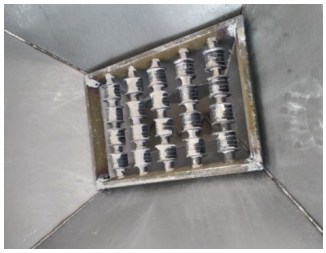
Pulverize

b) Mixing and Feeding of Raw materials

Mixing or Blending is the oldest operation used in the solid based industries to make heterogeneous mixture to homogenous mixture in which before feeding the raw materials like Polyvinyl chloride, Calcium carbonate, Wood powder, Lubricant like Wax, Foaming agent, Stabilizers like Ca-Zn, Impact modifiers like propylene and Coupling agent like Maleic anhydride to the feeding chamber it should be mix manually because to get the uniformity of Raw materials in the hot mixing chamber.

Feeding is the process uses thee feeding mechanism to fed the required raw materials for the production of WPC to the hot mixing chamber followed by cold mixing chamber finally, to the hopper of the Extrusion equipment here, 110 kg/hr is the maximum capacity of feeding mechanism is used for the process is mainly based on the capacity of Extrusion machine used for the Extrusion of WPC.

Feeding system



Feeding mechanism

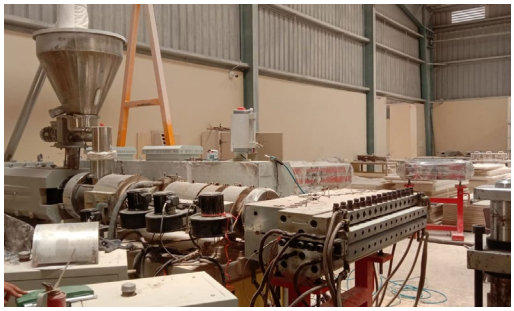
c) Hot mixing and Cold mixing

d) extrusion of WPC

In this process, the raw material required for the preparation of WPC is fed to the hopper of the Extrusion equipment through the feeding mechanism as shown in fig 4.3 from the cold mixing unit after the getting the homogeneity mixture.

Extrusion equipment

Mould



Sheet foramtion

e) Cooling (Curing)

After the extrusion process, the primary goal of this process lane is cooling, because extruded part of WPC had approx 170^0C so that cooling is crucial. In which WPC is passed through the cooling track for the cooling purpose here water acts as a cooling media.

Indirect cooling

Direct cooling

f) Cutting and Dust collection

Cutting is the final objective of process lane here after the completion of the extrusion of WPC cutting action takes place to a desired length depending on the need for the end user. This cutting action taken place by the pneumatic operating cutter as seen in the fig. 4.10. After the completion of cutting action dust/ powder which is around the cutter so this dust is collected by the dust collector.

Dust collector

4. EXPRIMENTATION, RESULTS AND DISCUSSION

A) Tension test

Tension test is to know the tensile behavior of the wood plastic composites (WPC) as per the ASTM D7031 standards using electronic Universal testing device of having maximum capacity to apply the load of 400KN and finally determine the maximum/ Ultimate Tensile capacity by applying the constant load on only one axis.

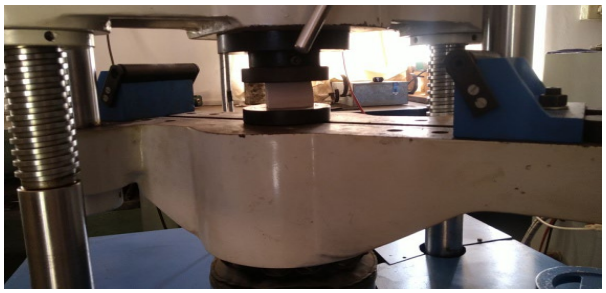
Tension test of WPC

Table 1. Tension Test

compression	Comp- 1	Comp-2	Comp-3
Ultimate tensile strength in N/mm^2	7.69 N/m^2	9.61 N/mm^2	12.82 N/mm^2

B) Compression test

Compression test is to know the Compressive the behaviour of wood plastic composites (WPC) as per the ASTM D7031 computerized universal testing machine standards of having maximum capacity to apply the load of 400KN. This test is exactly opposite in nature to tensile test. Nature of fracture and deformation is pretty unique from nature of the tensile test this sort of applied load squeeze the specimen.



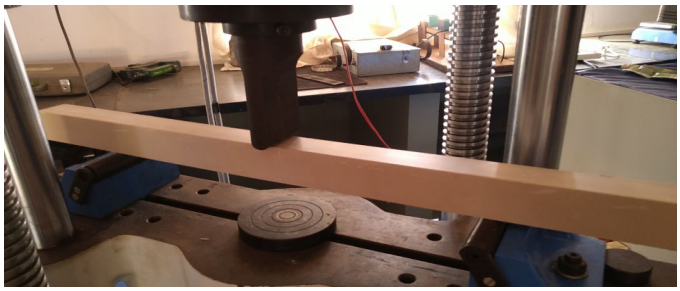
Compression test of WPC

Table 2 Compression test

Composition	Comp- 1	Comp-2	Comp-3
Maximum Compression Strength in N/mm^2	11.24 N/mm^2	12.14 N/mm^2	15 N/mm^2

C) Bending test

Bending test is performed to know the bending nature of the developed specimens of different composition using the universal computerized testing machine standards of maximum capacity of 400KN can be applied. The main goal of this test to determine modulus of rupture of the developed specimen, because a beam is a long structural member which is generally subjected to bending due to transverse forces which are applied on the WPC beam, the main application of this beam the fact that they are accustomed support floors and ceilings of the buildings shafts supported on bearings Etc.



Bending test of WPC

Table 3 Bending test

Composition	Comp- 1	Comp-2	Comp-3
Modulus of Rupture in N/mm^2	15.26 N/mm^2	15.98 N/mm^2	21.024 N/mm^2

D) Impact test

An impact test a type of test to check the materials durability which means that capability of the content to absorb the energy after the elastic limit or during the deformation in the plastic region when subjected to suddenly applied loads. Impact strength of material is the resistance of material to shock or suddenly applied load. It is equal to the work performed in breaking a specimen in a testing machine. Brittle materials have small toughness value because it has small plastic deformation before failure but in ductile material it has ability to sustain these types of loads hence it is good at or greater resistance to shocking loading. The test is performed out at room temperature.

1) IZOD test

IZOD test is carried out according to the ASTM standards, in this test specimen is held firmly in vice as cantilever as seen in the fig 5.4.2 and the load is applied at the free end and the specimen having a V-Notch of upto 1/8 of total depth the specimen depicted in fig. 5.4.1 in which arm or lever strike the specimen from 90^0 specimen dimension (Breadth (b) 10mm, Depth(d) 10mm, Length(L) 75mm, Depth below the notch(y) 8.75mm).

Izod test of WPC

Table 4 Izod test

Composition	Comp- 1	Comp-2	Comp-3
Impact strength in N/mm^2	0.27 N/mm^2	0.297 N/mm^2	0.308 N/mm^2

2) Charpy test

Charpy test is carried out according to the ASTM standards, in this test specimen is supported as simply supported beam and impact load is applied at the Centre as seen in the fig 5.4.2 and the specimen having a U-Notch of upto 1/8 of total depth the specimen depicted in fig. 5.4.1 in which arm or lever strike the specimen from 145^0 specimen dimensions (Breadth (b) 10mm, Depth(d) 10mm, Length(L) 55mm, Depth below the notch(y) 8.75mm).

Charpy test of WPC

Table 5 Charpy test

Composition	Comp- 1	Comp-2	Comp-3
Impact strength in N/mm²	**o.274 N/mm²**	**0.285 N/mm²**	**0.320 N/mm²**

E) Moisture absorption test

Absorbing moisture is the test to conducted to evaluate the moisture/ water absorption level of the developed different compositions of WPC's by checking the weight of the specimens before test and weight check after the test will give water/ Moisture absorption percentage of the different compositions of WPC's. and this test is carried out for 2hrs and 7hrs in which specimens are completely dipped in water for 2hrs and 7hrs.

Specimens in Water

Table 6 Moisture absorption test after 7 hours

Composition	Weight before test	Weight after test	% of Moisture absorption
Composition 1	**114.5**	**116.3**	**1.572**
Composition 2	**119.8**	**121.8**	**1.660**
Composition 3	**125.6**	**126.5**	**0.716**

F) Hardness Test

Hardness test is the test which provides an accurate, rapid and economical way of determining the resistance of the content (WPC) to the deformation. Hardness is by calculating resistance of a content to indentation. The used indenter like a ball, cone or pyramid made of material, which is much harder than that is being utilized for tested. Brinell hardness test utilized to determine the hardness of WPC, this test uses a permanent indentation is made on the material using a hardened steel ball of 10mmdiameter, under standard loading condition of 250 Kg. for 20sec on the WPC surface, the hardness number expressed as a number (Brinell hardness number BHN).

Comparison of characteristics of wood and WPC

Sl. no	Tests carried out		wood	Composition 1	Composition 2	Composition 3
1	Tensile test		4.10 Mpa	7.69Mpa	9.61Mpa	12.82Mpa
2	Compression test		40.7 Mpa	11.42 Mpa	12.14Mpa	15Mpa
3	Bending test		67.1 N/mm²	15.264 N/mm²	15.984 N/mm²	21.024 N/mm²
4	Impact test	Izod	0.59N-m/mm²	0.274N-m/mm²	0..297 N-m/mm²	0.308N-m/mm²
		Charpy	0.59N-m/mm²	0.274N-m/mm²	0.285N-m/mm²	0.320N-m/mm²
5	Moisture Absorption test	2 hrs	2.2%	0.524%	0.759%	0.398%
		7 hrs	12.95 %	1.572%	1.660%	0.716%
6	Hardness		4.5 BHN	7.255 BHN	7.255 BHN	7.255 BHN
7	Density		630 kg/m³	699.2 kg/m³	715.2 kg/m³	1004.8 kg/m³

5. CONCLUSION

- The process used for the production of WPC is extrusion process which is very easy and very convenient for the production of WPC.
- Produced WPC is very cost effective than teak wood, which used as furniture product like beams, cladding and decking applications and which will replace the

teak wood products in future and it will avoid the deforestation.

- Moisture absorption which is more in the composition 2 and composition 1 of about 0.756% and 0.524% for 2hrs of complete soaking in water and 1.660% and 1.572% for 7hrs complete soaking in water but in composition 3 which is less when compare to others two composition which is about 0.398% for 2hrs and 0.716% for 7hrs of complete soaking in water. (Compositions as visible in 4.1)
- Comparing the overall strength of the developed composites. The composition 3 is more effective and is very cost-effective compare to others two composites due to reduce in the PVC weight percentage and increase in the $CaCo_3$ weight percentage.

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