# COMPOSITE BOARDS FROM COTTON STALKS

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## Introduction

India is the only country, which has the highest area under cotton cultivation and has the distinction of being the seat of all the four cultivated species of cotton in addition to hybrids. India can also take pride in being the only country growing cottons that meet the quality requirements for spinning a wide spectrum of yarn counts ranging from 6s to 120s.

To make cotton farming an economically viable proposition, three alternatives seem to be plausible. Encouraging cultivation of "Desi Cottons" that have the inherent resistance to pest and diseases possessing excellent tolerance to both biotic and abiotic stresses. The average cost of cultivation of such varieties also seem to be much less of the order of Rs. 8000/- per hectare. Organic farming seems to be another way of reducing the cost of cultivation. As 42% of the input cost goes towards plant protection chemicals, adoption of biocontrol agents and other farm products would definitely help in bringing down the cost.

## How to Improve Farm Income?

Another way of improving farm income is to utilise the byproducts of cotton cultivation beneficially. Cotton stalks is one of the important byproducts of cotton crop. About 23 million tonnes of cotton plant stalks are generated in India annually. On an average about 2 to 3 tonnes of stalk is generated in one hectare of land. Most of the stalk is treated as waste, though a small part of it (15%) is used as fuel. The bulk of the stalk is burnt in the fields after the harvest of the cotton crop although it is not desirable since it causes high pollution. At the same time cotton stalks piled up in the field harbour pests and disease causing organisms. Cotton stalk is comparable to most of the common species of hard wood with regard to fibrous structure and hence can be used for manufacture of particle boards preparation of pulp and paper, hard boards, corrugated boards and boxes, micro-crystalline cellulose and for growing edible mushroom.

Over the years, CIRCOT has been engaged in the development of cost effective technologies for production of value added products like particle boards and hard boards from cotton stalks with a view to provide supplementary income from cotton farming to cultivators and also to help entrepreneurship creation in rural areas. A brief summary of the economic potential of one of the by-products of cotton crop viz., cotton plant stalks is given below.

In India cotton is cultivated during the period July to December and the crop is harvested from January to March. Following table gives information about the area and production of cotton and availability of stalks in various parts of the country.

**Table 1: Area Under Cultivation, Production of Indian Cotton & Availability of Cotton Stalks (State-wise) 2005-2006***

| States | Area (M. ha) | Cotton production (Lakh bales of 170 kg) | Availability of Stalks (M. tonnes) |
|---|---|---|---|
| Andhra Pradesh | 0.972 | 30.0 | 1.94 |
| Gujarat | 2.077 | 80.0 | 4.15 |
| Haryana | 0.597 | 14.0 | 1.19 |
| Karnataka | 0.363 | 7.0 | 0.73 |
| Madhya Pradesh | 0.635 | 15.0 | 1.27 |
| Maharashtra | 2.889 | 46.0 | 1.78 |
| Punjab | 0.580 | 21.0 | 1.16 |
| Rajasthan | 0.454 | 11.0 | 0.92 |
| Tamil Nadu | 0.150 | 5.5 | 0.30 |
| Others | 0.100 | 13.0 | 0.20 |
| Total | 8.817 | 242.5 | 13.54 |

- CAB estimate

The yield of biomass varies from species to species, it is highest in the case of hybrids and lowest in the case of G. arboreum species. However, on an average about 3 tonnes of cotton plant stalks are available in one hectare of land. Depending upon the variety and the crop condition the sticks are 1 to 1.75 meter long and their diameter just above the ground may vary from 1 to 2.5 cm. The specific weight of short chopped stick is about 160 kg/$m^3$. The calorific value of cotton stalks is equivalent to poor quality wood and is about 17.40 (MJ/kg). About 23 millions tones of cotton stalks are generated in India with an average production of 3 tonnes per hectare of land.

Most of the stalk produced is treated as waste though a small part of it is used as domestic fuel. The bulk of the stalk is burnt off in the fields after the harvest of cotton crop. The following table gives the chemical composition of cotton plant stalks from different species of cotton. On an average cotton plant stalk contains about 68 % holocellulose, 26% lignin and 7% ash.

It is interesting to note that in contrast to other agricultural crop residues, cotton stalks possess fibre dimension comparable to most commonly available species of hardwood. It can therefore be used for the manufacture of particle boards, preparation of pulp and paper, hard board, corrugated boards and boxes and as a source of cellulose for the manufacture of micro-crystalline cellulose. Cotton stalks can also be used to grow edible oyster mushrooms.

**Table 2: Constituents of Cotton Plant Stalk of Different Species**

| Species | Holo-Cellulose | Lignin | Ash |
|---|---|---|---|
| 1. G. arboreum | 67.3 | 25.8 | 7.0 |
| 2. G. herbaceum | 69.1 | 28.1 | 8.3 |
| 3. G. hirsutum | 70.0 | 27.1 | 6.7 |
| 4. G. barbadense | 69.2 | 28.2 | 8.1 |
| 5. Desi Hybrids | 67.3 | 27.6 | 6.8 |
| 6. Hirsutum hybrid | 68.6 | 24.3 | 5.9 |
| Mean Value | 69.1 | 27.0 | 7.1 |
| Range of values | 67.3 to 70.0 | 24.3 to 28.2 | 5.9 to 8.3 |

**Particle Board**

Particle board is manufactured out of dry wood particles (chips) or fibres, which are coated with a synthetic resin binder and wax and formed into flat sheets under pressure. Heat is applied with the pressure, to cure the resin binder. The resin binders used are urea formaldehyde (UF) for interior applications and phenol formaldehyde for exterior products. Bitumen is also used for certain specific end use. Particle board may have a uniform structure throughout its thickness or it could be a sandwiched matrix with coarser grains at the centre and finer ones on both sides. It is manufactured in different thicknesses and forms, such as plain, single or both sides veneered, single or both sides laminated, single or both sides covered with plywood lamination.

**CIRCOT Process**

CIRCOT has standardised the process of preparation of particle boards from cotton plant stalks which involves chipping of stalk to 1.5 – 2.0 cm size, rechipping to particles of 20 mesh size to 8 mesh size. Mixing of chips with synthetic binders such as urea formaldehyde and phenol formaldehyde and preparation of a three layered mat comprising coarser particles at core layer and finer at top and bottom respectively are next steps in the process. Finally, between heated platens of a hydraulic press for specific time and pressure the mat is pressed to form boards that are cooled to attain dimensional stability and then cut to the desired size. By using different chemicals and additives, these boards can be made water proof, fire proof, termite resistant, etc. These boards have been found to meet BIS specifications and can be used for interior decoration, false ceiling, partitioning, panelling etc. Due to the lower cost of raw material and lesser power requirements for its conversion into the finished product, the cost of particle board made from cotton stalk will be much lower than that made from wood.

As can be seen from Table 4, the particle boards from cotton plant stalks possess all the desirable properties sought for internal as well as external applications such as false ceiling, partitioning, paneling, etc. However, it may be mentioned that boards made from cotton plant stalks using urea formaldehyde as binder lack in water resistance properties as compared to boards made from other raw materials, which is mainly, due to higher percentage of bark having more fibres resulting in increased absorption of water. This problem is not observed in phenol-bonded boards. However,

by use of different chemical additives, the water resistance property can be improved with minimal increase in the cost. These boards can also be made fire resistant, termite resistant, etc. by use of chemical additives.

The applications of particle boards are many. Areas identified include door panel inserts, partitions, wall panels, pelmets, furniture items, floor and ceiling tiles, etc. for residential houses, commercial buildings, schools, hotels, theatres, etc. In recent years, particle board is being used increasingly in place of commercial plywood, in the preparation of printer blocks.

In all the above applications, substitute materials for particle boards are, timber, commercial plywood, marine plywood and block board in general and for false ceiling the plaster of Paris. Advantages of particle board are many.

i) It is free from natural defects of wood, like warping.

ii) It is easier to fix. For instance, the factory made panel doors with particle board are available in ready-to-fix form. Similarly, for wall panelling, false ceilings, table tops, etc., pre-laminated or pre-veneered particle boards can be used with advantage.

iii) It is cheaper than substitute materials.

iv) With proper protective surface coating and edge covering, particle board can be made termite proof and fire resistant. It can take a variety of surface finishes, like laminations, veneers, paint, varnish polish, etc. Attractive wall paper can also be used as surface finish.

**Hard Boards (Binderless Boards)**

The hard board is a general term used to cover boards or sheet materials having density greater than 0.4 g/cm$^3$. It can also be defined as a sheet of material manufactured from wood or other lignocellulosic materials with the primary bond strength derived from the inherent adhesive property of the fibres and the hydrogen bonding of the cellulose molecules. Further additives may be included during manufacture to increase strength, resistance to moisture, fire resistance and other properties of the product. Presently, fibre bards are manufactured from hard wood.

**Table 3: Properties of Three Layered Particle Boards from Cotton Plant Stalks**

| Properties | Unit | Flat pressed Three layer/ multi layer particle board (IS 3087-1985*) | CIRCOT Board | |
|---|---|---|---|---|
| | | Type I | Type II | |
| Density | $Kg/m^3$ | 500-900 | --- | 750 |
| Moisture | % | 5-15 | --- | 11 |
| Water Absorption<br>i) 2 h. soaking<br>ii) 24 h. soaking | % | <br>10<br>20 | <br>40<br>80 | <br>20<br>40 |
| Swelling Thickness | % | 8 | 12 | 9 |
| Swelling due to surface absorption | % | 6 | 9 | 6 |
| Modulus of Rupture<br>i) Up to 20 mm<br>ii) Above 20 mm | $N/mm^2$ | <br>15.0<br>12.5 | <br>11.0<br>11.0 | <br>17.6<br>- |
| Internal bond strength<br>i) Upto 20 mm<br>ii) Above 20 mm | $N/mm^2$ | <br>0.45<br>0.40 | <br>0.30<br>0.30 | <br>0.51<br>- |
| Screw withdrawal strength<br>Face<br>Edge | N | <br>1250<br>850 | <br>1250<br>700 | <br>1400<br>860 |
| Nail withdrawal strength | N | 1250 | --- | 1300 |

* Bureau of Indian Standard

**CIRCOT Process**

A method has been standardised at CIRCOT to prepare hard boards from cotton plant stalks. The process comprises chipping of cotton plant stalks, conversion of chips into thermo-mechanical pulp under high temperature and pressure in a thermo-mechanical pulper, mat formation and then pressing of mat in a hydraulic press by a three step pressure cycle to get hard boards.

These boards possess all the desirable properties specified by the Bureau of Indian Standards. The process is eco-friendly as no chemicals are used either during pulping or pressing. It is the lignin present in the raw material that acts as the binder.

The boards could be subjected to oil tempering using cashewnut shell liquid or linseed oil to improve their properties. The process involves dipping of hard boards in oil for a specific period and then drying in an oven at $150^0C$ for different periods depending upon the end use. On evaluation, It was found that the boards possess better strength and water resistant properties and are useful in specialised industrial applications.

**Table 4: Properties of Hard boards**

| Properties | Cotton Stalk | BIS Specification |
|---|---|---|
| Thickness (mm) | 6.0 | 3-8 |
| Density (gm/cc) | 1.0 | 0.8-1.2 |
| Bursting Strength (kg/cm$^2$) | 340 | 300 |
| Water Absorption (%) | 50 | 40 |
| Tensile Strength (kg/cm$^2$) | 68.0 | ----- |

The following are the advantages if cotton stalks are used for the purpose of preparing composite boards

- Additional income to farmers
- A new material for composite board industry
- Avenues for setting up rural industry
- Employment opportunities for rural youth
- Conservation of forest resources

The following are the risk factors

- Availability of cotton stalks
- Availability of stalks at sustainable price round the year
- Transportation of stalks at affordable price
- Problems of cleaning cotton stalks from boll rinds, lint etc.
- Incidence of pests and diseases during storage
- Presence of pesticide residues in stalks