

Techno Economic Feasibility Report for Manufacture of Coir Corrugated Roofing Sheet

Project Sponsored by



Coir Board
Bangalore

Project executed by



Indian Plywood Industries Research & Training Institute

(An autonomous Body of Min of Environment & Forests, Govt. of India)

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Introduction:

Roofing is the most important component or element in any type of construction. Particularly in housing, roofing is the costliest of all the components or elements and the type of roof determines the internal environment of the house. In low rise construction use of heavy roofing often leads to escalation of cost as heavy roof requires substantially strong walls and foundations.

In order to optimize the cost of construction engineers has always been on the look out for efficient and light roofing which requires minimum maintenance and labour to install. One of the conventional roofs cladding material popular with designers has been corrugated roofing sheets made of Cement or Galvanized Iron. The principle of corrugation allows use of minimum material by virtue of enhanced moment of inertia attained due to geometry of corrugation. A weaker material like cement in tension which has very low tensile strength requires deeper, wider and thicker configuration in addition requires a reinforcing material like asbestos fibres as compared to steel which has high tensile strength. Besides, corrugated roofing sheets allows mechanical and dry construction methods to cover large areas without the need for ceiling compounds to prevent leakage. It is no wonder that for these reasons ACCS & CGIS are the most popular and widely used roofing materials in the country. Unfortunately recent studies indicate that ACCS is a hazardous material from health point of view and has been banned from use in many developed countries. On the other hand, CGIS and Aluminium Corrugated Sheets require lot of energy for production. Other lesser known corrugated sheet material like plastics-PVC, Fibre reinforced plastics is still not widely used, relatively costly and has short life. In addition, all these roofing materials are not bio-degradable. Efforts to develop corrugated roofing sheets based on natural fibres as gained importance. Corrugated sheet has been successfully manufactured from woven bamboo mats. Coir, as already mentioned is a green building material and has potential as a raw material for the production of corrugated sheets. Experience gained in developing and standardizing Bamboo mat corrugated sheets and also coir moulded products suggested its suitability for the manufacture of corrugated roofing material.

The word 'coir' is derived from kayar which in Malayalam means a rope. The word seems to have been introduced into the European literature by Marcco polo, the Italian traveler, in thirteen century.

Coir is stiff coarse fibre and is being found between the husk and the outer shell of a coconut. The individual fibre cells are narrow and hollow, with thick wall made of cellulose. There are two varieties of coir; (i) brown coir extracted from a varieties ripe coconut which contains more lignin and less cellulose and are stronger but less flexible. (ii) White coir extracted from coconut before they are ripe, which are white or light brown in colour and are smoother and finer, but also weaker. The physical and chemical properties of coir are as follows:

1) Physical properties of coir fibre:

Coir length	:	10-30 cms
Fibre length	:	0.6 mm
Diameter	:	16 micron
Density	:	1.4 g/cc
Tenacity	:	10 g/tex
Breaking elongation	:	30%
Moisture content at 65% RH	:	10.5%
Swelling in water	:	5% in diameter

2) Chemical properties (composition)

Water soluble	:	5.25%
Pectin & related Compounds	:	3.3%
Hemi cellulose	:	0.25%
Cellulose	:	43.44%
Lignin	:	45.84%
Ash	:	2.22%

Although coconut palms grow throughout the world's tropical regions, the vast majority of the commercially produced coir comes from India and Sri Lanka. India produces about one-fourth of the world's 55 billion coconuts each year, out of which only 15% of the husk fibre are actually recovered for use. India annually produces about 2, 80,000 metric tons of coir fibre.

Brown coir is used in floor mats and door mats, brushes, mattresses, floor tiles and sacking. Pads of curled brown coir fibre, made by needling-felting are shaped and used to fill mattresses. A major portion is sprayed with rubber latex to be used as upholstery padding for the automobile industry in Europe. Major use of white coir is rope manufacture. Geo-textile from coir fibre such as meshes and netting, needled felt and pads, erosion control blankets and mulch blankets, geo-cushions and geo beds branded ropes anti weed blankets are effectively used in soil bio engineering applications.

For the manufacture of roofing sheet, coir in loose mass can not be used. It requires uniform layer of coir in the form of mat. Needled coir felt in suitable thickness was found to form required raw material for making corrugated sheet.

Production Cost of Non-woven Coir Felt

Sl. No.	Particulars	Amount (in Rupees)
I	Cost of the Project	
1.	Land 5000 sq. ft @ Rs 70.00 per sq. ft.	350,000.00
2.	Building 2500 sq. ft. @ Rs. 500.00 per sq. ft.	1250,000.00
3.	Machinery	2000,000.00
4.	Electrical installations	20,000.00

5.	Installation and other miscellaneous	15,000.00
6.	Working capital	444,650.00
	Total	4079,650.00
II	Operation cost (25 days)	25,000.00
1.	200 needles/day @Rs. 5.00 per needle	
2.	Fibre 1008 kgs @ Rs. 12.00/kg	302,400.00
3.	Wages -7 person @ Rs.5000.00 per month	35,000.00
4.	Labour benefit @35%	12,250.00
5.	Repairs & maintenance	35,000.00
6.	Electricity	25,000.00
7.	Admin expenses	10,000.00
	Total operation cost	444,650.00
III	Annual Expenses	
1.	Operation cost per month x 12	5,335,00.00
2.	Depreciation- building @ 5%	62,500.00
3.	Depreciation - machinery @10%	200,000.00
4.	Interest on bank loan @16%	522,195.00
	Total	6,120,495.00
IV	Sales proceeds	
1.	Annual production of coir felt 252000 sq mts	
2.	Annual expenses	6,120,495.00
3.	Cost of production per sq. mt.	24.29
4.	Sale value per sq. mt.	30.00

MATERIALS AND METHODS FOR THE MANUFACTURE OF COIR CORRUGATED SHEETS

1. Coconut coir non-woven felt
2. Bamboo mats
3. Phenol Cardanol Formaldehyde or Phenol Formaldehyde Resin Adhesive
4. BOPP film as releasing agent
5. Preservative Chemicals

Flow chart for the manufacture of Coir corrugated Sheets is given in **Fig .1**.

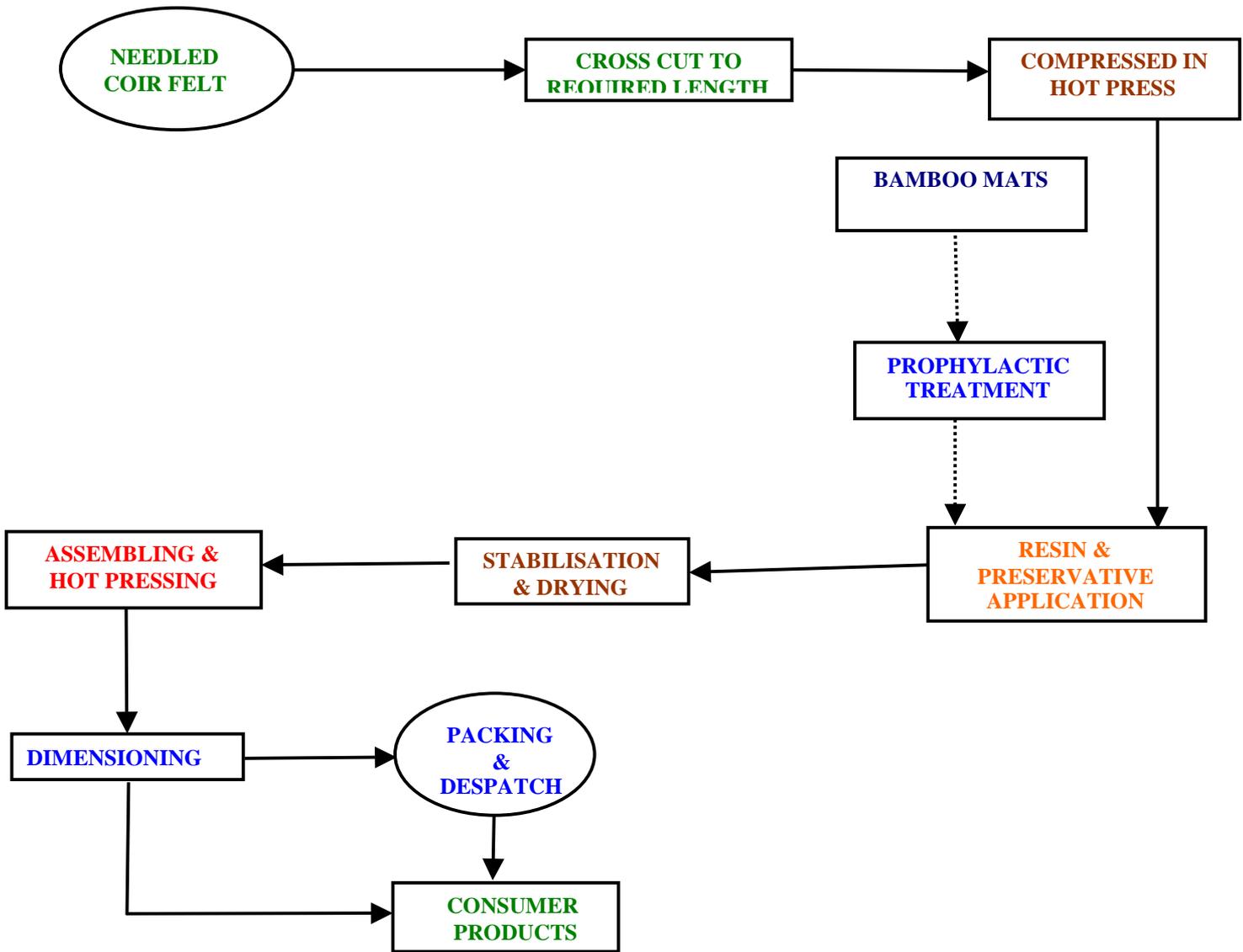


Fig. 1: Coir Corrugated Sheets - Process Flow Chart

1. Coconut coir non-woven felt:

Non-woven coir felt was supplied by the sponsor, M/s. Coir Board, Bangalore. Felts were obtained in rolls of about 4 feet width. The thickness of the non-woven felt varied from 4.25 cm to 4.78 cms with an average thickness of 4.5 cm. The felt is light weight porous material weighing about 1100 gm/m².



Roll of Coir Felt

2. Woven bamboo mat:

Woven bamboo mats were procured from M/s. Kerala Bamboo Corporation. Mats are tightly woven in herringbone type with bamboo sliver of thickness approximately 0.6 mm. The species of bamboo used *ochlandra travancoria*.

3. Resin:

Since corrugated roofing sheets are meant to use under exterior condition, the bonding material must be water and weather resistant. Two types of resin were attempted to make coir based corrugated sheets.

- i. Phenol Formaldehyde resin (conventional).
- ii. Phenol cardanol formaldehyde resin (PCF).

Although initial trials were carried out with both the resins, the final pilot scale trials were done with PCF resin keeping in view of the eco friendly nature of the final product.

The main constituents of PCF resin are phenol, cardanol, formaldehyde and a catalyst. Properties of resins depend upon the proportion of chemical ingredients used and method applied to synthesize the same

Raw materials for resin manufacture:

Phenol: is available either in crystal form or in liquid form. If crystalline phenol is used it has to be melted either by keeping the drum in a steam pit or by heating electrically to around 65°C and then loaded into kettle. Another way of melting phenol is to add water or formaldehyde (10%) on the wt. of phenol and allow for 3-4 days in the drum, slowly the phenol gets liquefied

Phenol is highly corrosive and will cause injury to the skin on contact. Handling of phenol must be done carefully.

Workers should be provided with rubber gloves, rubber shoes and goggles while handling phenol. In case if it comes in contact with skin, it should be thoroughly washed with water followed by washing with sodium bicarbonate.

Formaldehyde: Is a gas dissolved in water to form formaldehyde solution. Formaldehyde solution is commercially available as Formalin of 37% HCHO concentration (w/w). Percentage purity of formaldehyde is very important in order to use optimum proportion of formalin for resin manufacture. Formaldehyde is highly irritating to eyes and has pungent odour. If too much formaldehyde is inhaled, it affects the lungs and long contact with skin leads to dermatitis.

Workers should be provided with gloves, rubber shoes, goggles and nose guard. If formalin comes with contact with skin or any part of the body, it should be washed thoroughly in running water.

Cardanol: Cashewnut Shell Liquid (CNSL) is one of the few economic sources of naturally occurring phenols. The main constituents of CNSL are anacardic acid and cardol in the approximate ratio of 90:10. When commercial CNSL is distilled, the main decarboxylated product is cardanol which is a monohydroxy phenol with a linear side chain in the meta position. The side chain contains on an average two double bonds.

General properties of cardanol and the test methods to find out its suitability as a partial substitute for phenol in PF resin adhesives are given below.

TEST METHODS TO ASSESS THE QUALITY OF CARDANOL

SL NO.	PROPERTIES	REQUIREMENTS	METHODS OF TEST
1.	Specific gravity	0.9272 - 0.9335	IS: 840-1964, A-2
2	Volatile losses including moisture	Maximum 25	IS: 840-1964, A-3
3	Iodine value a) Wij's method b) Catalytic method	Minimum 220 Minimum 3301	IS: 840-1964, A-8.1 IS: 840-1964, A-8.2
4	Polymerisation time	Should not gel	IS: 840-1964, A-9
5	Viscosity by polymerisation	20-25 cp	IS: 840-1964, A-10
6	Viscosity	45-52 cp	ASTM-D1084-63 (76) Part-22
7	Acid value	Maximum 5	ASTM D 2849-69 (75) PART 36.
8	Hydroxyl value	180-200	ASTM D 2849-69 (75) PART 36.

ADDRESSES OF CARDANOL AVAILABILITY

1. KARNAS ENTERPRISES,
Bangalore.
2. Cardchem Industries,
Hyderabad.

Sodium hydroxide: is a strong alkali and generates lot of heat when dissolved in water. It is soapy to touch. Sodium hydroxide should not be touched directly with hands. Always it should be handled with gloves.

As far as possible care should be taken to avoid any spillages of phenol, formalin or sodium hydroxide near the kettle. If spillage occurs then the place should be thoroughly washed with running water. Working place should be clean and tidy.

Resin kettle or Batch resin reactor

Normally resin kettle is made up either of stainless steel or mild steel. It is advisable to use stainless steel kettle for longer life and to avoid iron contamination in the resin. It consists of a cylindrical vessel made up of stainless steel which is provided with a stirrer, jacket for steam heating and water cooling, an inlet for the reactants, a pressure relieving valve and a sight glass for visual observations. A condenser which may be operated either under vacuum or at atmospheric pressure is provided for refluxing the volatile constituents. The stirrer is coupled to a control speed regulator through a rectangular frame. The jacket is provided with an inlet and outlet together with a drain vent. The temperature of the reaction mixture is measured by probe and is connected to an electronic relay for semi automatic control. Outlet value is provided by emptying the kettle. Sampling of the contents of the kettle during reaction is carried out with the help of the sampling chamber. Photograph of the resin kettle is shown below.



Resin Kettle

1. Preparation of phenol formaldehyde resin:

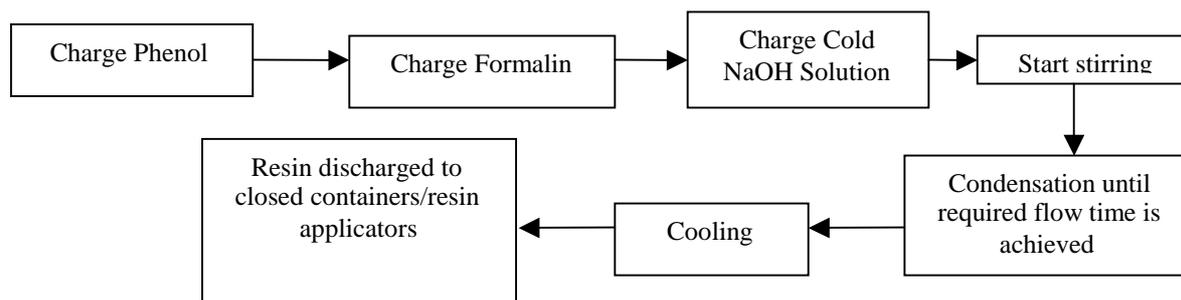
100 parts of molten/liquid phenol and 160 parts by weight of formalin (37% formaldehyde content) are charged into resin reactor and 6 parts of sodium hydroxide in 12 parts of water was added to the reactor. Stirring of the mixer was done throughout the reaction period until the final cooking of the resin is completed. Initially the mixture is heated to raise temperature 55^o-58^oC and then allowed for self heating. Heat is generated due to exothermicity of the reaction. The reaction mixture is kept at 82^o-85^oC for about 90 minutes till the flow time of the resin reaches 14 - 15 seconds (Depending on the cooling efficiency of the resin reactor) in hot condition when measured in B-4 flow cup of IS 3944 and water tolerance is 1:10-14. The flow time at ambient temperature is targeted to 27 ± 5 secs in B-4 flow cup (IS:3944). The product is cooled. Flow chart of resin preparation is given in **fig 2**

After complete cooling the resin will have following properties.

Viscosity:	Flow time of 27 ± 5 sec, at 25 ^o C when measured in B-4 flow cup of IS:3944
	80 ± 10m Pa.s at 25 ^o C
Solid content:	50% resin solids
Water tolerance:	1:12 ± 2.5 at 25 ^o C

The resin is thereafter discharged and stored in air tight container at room temperature. Shelf life of this resin when stored at 25 ± 2^oC is upto 2-3 weeks.

Fig 2: Flow Chart for preparation of PF Resin



2. Preparation of Phenol Cardanol Formaldehyde resin:

80 parts by weight of phenol (molten or liquid) and 20 parts by weight of cardanol are charged into the resin reactor followed by 60 parts by weight of formalin (37% formaldehyde content). To the reaction mixture 6 parts of sodium hydroxide in 35 parts of water is added and the mixture is heated to 90°C stirring is initiated at the beginning of the process and continued till the product is cooled. The reaction mixture is kept at 90±2°C for about 90 minutes. The product formed in the 1st stage is cooled to 55°C.

10 parts of sodium hydroxide in 45 parts of water is added next to the reaction mixture followed by 100 part of formalin (37% formaldehyde). The reaction is carried out in 2nd stage at 80° - 82°C. Maintain the temperature at 80° -82°C till the flow time when measured in B-4 cup of IS: 3944 gives 14-15 seconds in hot condition. Then start cooling to room temperature. Flow chart of resin preparation is given in **fig 3**. After complete cooling the resin will have following properties.

Viscosity: Flow time of 27 ± 5 sec, at 25°C when measured in B-4 flow cup of IS:3944

80 ± 10m Pa.s at 25°C

Solid content: 42% resin solids

The resin is thereafter discharged and stored in air tight container at room temperature. Shelf life of this resin when stored at 25 ± 2°C is upto 2-3 weeks.

The resin at this stage becomes completely water soluble when the flow time measured in B-4 flow cup is 22-24 secs (cold) the resin is cooled to room temperature and stored

If the resin becomes thick and loading of resin in the felt / bamboo mat is too high, then the resin can be diluted with water before dipping. In such event, care should be taken about the moisture content in the dried and glued felt/ mats.

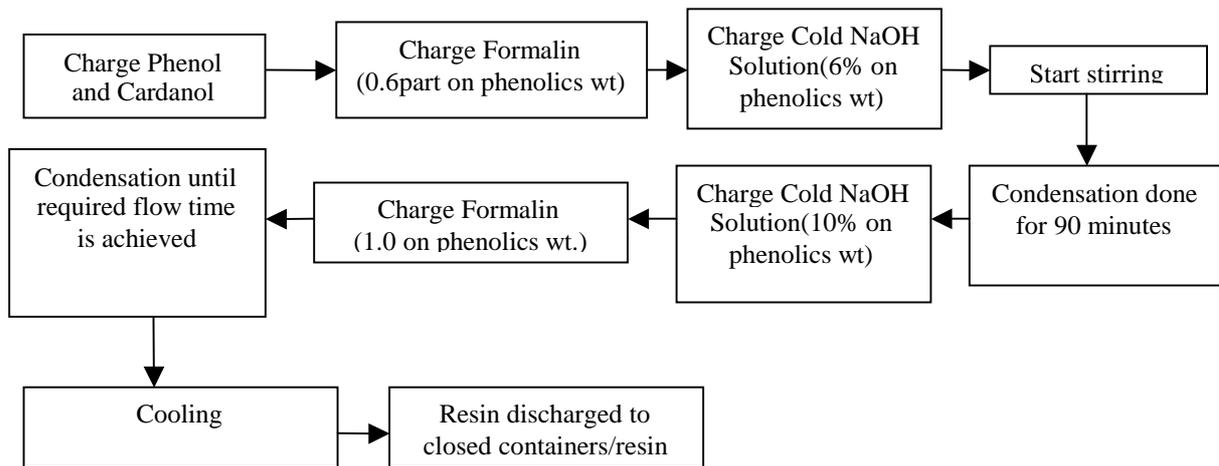


Fig 3: Flow Chart for preparation of PCF Resin

Consolidation of non-woven coir felt:

The non-woven coir felt, however compact it may be made; the individual coir will not come so close to each other that it would resist water penetration. Resin which is used as binder, not only hold the coir in place, but also fill up gaps between them to make the corrugated sheet unpenetratable. CPF resin which is being used as binder does not have highly gap filling properties. Hence, closeness of the individual coir will help the resin to bridge the gap between them. The distance between two coir fibre can be minimized by application of high pressure on the coir felt.

To overcome this problem the loose felt was pre pressed before glue application. Pre pressing of felt is done in platen press whereby the loose felt get compressed into compact sheet. A 75% compression in thickness has been found to work well during gluing of the felt. It has also been found that pressing under heated platen produces better felt for gluing compared to cold pressing of felt. Compact felt thus produced retains resin uniformly while resin applied by dipping the felt into resin contained in tray.

Construction of coir and bamboo mat for Corrugated Sheet:

Combination of coir felt and bamboo mat were made as follows:

- (i) 3 ply constructions : one coir felt : one bamboo mat : one coir felt
- (ii) 5 ply construction : 2 coir felts : one bamboo mat : 2 coir felts

Machinery/ equipment:

1. Guillotine Jointer: For cross cutting of coir felt to desired length
2. Flat platen hydraulic hot press: For consolidation of the coir felt into compact sheet
3. Resin treatment tank: Steel tank 2.75 m x 1.50m x 0.4m. should have draining outlet at the bottom
4. Perforated bed with resin collection tray at below : This should be fixed on a movable trolley

5. Resin squeezing machine: Similar to glue spreader for veneer but without doctors roll
6. Jet dryer with conveyor belt
7. Assembly Table
8. Hydraulic hot press with capacity to attain 50 kgs/cm² specific pressure and fitted with mould dies.
9. Trimming saws (DD saws)
10. Spraying booth

Salient feature in manufacture of coir felt corrugated sheet:

1. Coir felt: Uniformity in the coir felt is very important. It has been found that coir felt has non uniform distribution of coir and in place where density or total coir content in the felt is less, becomes a vulnerable point in the corrugated sheet for water leakage.

Non woven coir felt is loose mass of coir which can hold very little liquid resin. If non woven felt, as it is being received, is treated with resin, large quantity of resin remains in the gap in the felt and has to be squeezed out. Further, resin coated felts become so bulky that these are difficult to handle for further processing. It has been observed that if the felts are made into compact sheet by hot pressing under high pressure, all the above mentioned difficulties are overcome.

The colour of the coir determines the final colour of the corrugated sheets. It has been observed that white coir felt looks better than the brown coir felt.

Since coir felt is porous material, it holds enormous quantity of resin during resin application by dipping. Unless excess resin is not removed by squeezing this extra resin will be waste as, this resin would be squeezed during hot pressing. Resin content of 70-100 gm/ sq ft (42% liquid) is good enough for requisite bonding.

Moisture content of coir felt and mats:

Both the coir felt and bamboo mat are available in dried condition of equilibrium moisture content, further drying of the raw materials are not necessary. However, moisture content of glue coated felt and mats are more important. Higher moisture content will create blister during hot pressing and very low moisture content will result in inadequate bonding. Ideal moisture content for glued coir felt is 12-14% and that of glue bamboo mat is 10 ± 2%.



PCF Resin Adhesive Formulation [for bonding]

The economical feasibility of coir corrugated sheets manufacture depends to a large extent on the quantity of synthetic resin employed as resin cost is a major component in this products. The method of resin application is equally important to

ensure good bonding throughout as bamboo mat which is characterized by overlapped slivers inter spread with intersliver spaces resulting in rough and non-continuous layer of uneven surface.

About 200 kgs of PCF resin is poured into resin applicator. Two kgs sodium pentachlorophenate dissolved in 200 kg of water is added to the resin applicator.

The concentration of sodium pentachlorophenate is one per cent by weight of liquid PCF resin. This preservative compound incorporated in the adhesive penetrates into the felts along with resin and gets fixed during hot pressing and makes Coir corrugated sheets resistant to fungus and insect attack. About 10 coir felts are dipped into the resin solution at a time. For adequate soaking the felt/mats are given 3- 5 minutes of dipping time. After the stipulated time the resin soaked felts are passed through a glue spreader to squeeze out the excess resin from the felts and layed horizontally for open air drying.

Requirement of PCF resin

The quantity of PCF resin required per unit area of coir corrugated sheets depends on its viscosity. Average quantity of resin required will be around 700 - 1000 gms per sq.mt(42% resin solids) for a single layer of felt.

Glue Application on the Coir Felt and Bamboo Mat

Coir felt is first cut into desired length and checked for moisture content. If higher moisture is detected the felt is dried to required moisture level. Dried felts are consolidated as described above. Consolidated mats are dipped in CPF resin contained in a vat made of steel. It has be ensured that resin wets the felts thorough and thorough. The felts are removed from the vat and kept in slanting position for some time to drain out excess resin, Then these felts are passed through glue spreader to squeeze excess resin and to bring down the resin content to desired level. The resin coated felts are then allowed air drying till moisture content comes down to such level that on touching the felt, resin does not stick to finger. Partially dried felts are subjected to mechanical drying to bring down m c to desired level.

Bamboo mats are also treated with resin in the process as same as mentioned above.



STABILIZATION AND DRYING OF RESIN COATED MATS

Resin coated felts and mats are dried in either a drying chamber or industrial dryers such as band dryer at a temperature of $90 \pm 5^{\circ}\text{C}$ till the m.c. comes down to 14 ± 2 percent.

ASSEMBLY OF COIR FELTS/MATS

Resin coated coir felt + resin coated bamboo mat + resin coated coir felt or Two resin coated coir felt + one bamboo mat + two resin coated coir felt as shown below were assembled on the metal caul plate with BOPP film on either sides of the assembly which facilitates the movement of felts/mats to form corrugation as well as to act as a releasing agent to prevent the sheets from sticking to the corrugated platens.



Hot pressing:

The assembled coir felts on a metal caul plate were then loaded into profiled platen fixed to the hot press and the metal caul plate was withdrawn before applying the pressure. Specific pressure of 40 kg/cm^2 were employed for making corrugated roofing sheets for a period of 8-10 minutes including 2 breathings given within 90 seconds of loading at a temperature range of $145 \pm 5^{\circ}\text{C}$. Photograph of loading and hot pressing is shown below. After stipulated period the hot press is released and the corrugated sheets are unloaded from the hot press. These sheets are then stacked horizontally on a uniform platform for a period of about 2-3 days for conditioning.

It has been observed pressure as high as 40 kg/cm^2 is enough to make smooth and glossy surface. Under this pressure the corrugated sheets become almost impervious and water penetration in 5 layer sheet becomes zero and almost negligible in 3 layered sheets.



Note:

- (1) Loading of assembly into hot press should be done only after platens have attained required temperature uniformly.
- (2) During removing of the aluminium carrier platen, care should be taken to see that BOPP film remains uniformly spread on either side of the assembly.
- (3) Opening of hot press should be slow process during breathing.

Conditioning of Coir Corrugates Sheet : Coir corrugated sheets should not be taken for trimming immediately after removal from hot press. After hot pressing, the sheets should be stacked on plain platform and kept for 2-3 days till the sheets attain room temperature.

DIMENSIONING AND FINISHING

The coir corrugated sheets after conditioning to room temperature are taken for dimensioning to required size by using Double Dimensioning saw. The size 2m x 1.05m x 3.5 -4.5 mm are manufactured.

Photograph of trimming is shown below



Physical-Mechanical properties of coir felt-bamboo mat corrugated sheet

Table I
Coir corrugated sheet - 3 ply

Sl. No.	Test	Prescribed value	Results
1.	Dimension	-	184cmx92cm
2.	Thickness	-	4.5-4.6 mm
3.	Density (gm/cc)	Min 0.75	1.411

4.	Water absorption (%)	Max 15	14.1
5.	Rate of burning ?(min)	Min 20	40
6.	Flame penetration (min)	Min 10	8.3
7.	Load bearing capacity (n/mm)		
	(a) Dry state	Min 4.0	2
	(b) Wet state	Min 3.0	1.60

Table II
Coir felt corrugated sheet - 5 ply

Sl. No.	Test	Prescribed value	Results
1.	Dimension	-	184cmx92cm
2.	Thickness	-	7.1-7.3 mm
3.	Density (gm/cc)	Min 0.75	1.208
4.	Water absorption (%)	Max 15	9.24
5.	Rate of burning ?(min)	Min 20	50
6.	Flame penetration (min)	Min 10	50
7.	Load having capacity (n/mm)		
	(c) Dry state	Min 4.0	5.65
	(d) Wet state	Min 3.0	4.04

Table III
Other Test performed on coir felt corrugated sheets

Sl. No.	Name of tests	Prescribed value	3 ply sheet	5 ply sheet
1.	Water permeability (for running water)	No water permitted on other side of board	Leakage in one or two place	No leakage
2.	Water permeability (for stagment water)	No water permitted on other side of board	Leakage in one or two place	No leakage
3.	Thickness swelling (after 24 hours soaking in cold water)	-	Max 2.8	Max 2.4
4.	Cyclic test (BWP grade of ID:848)	No delamination	No delamination	No delamination

Investment Required for Establishment of Manufacturing Unit

A. Land and Building

Sl. No.	Name of Item/ work	Cost(Rs. In lakhs)
I	Land and Land Development	
1.	Land cost of 2200 sq mt, @ Rs 2000/ sq.mt	44.00
2.	Development cost @ Rs. 80,000/ha.	0.80
	Sub- total I	44.80
II	Civil Work	
1.	Cement compound wall with barbed wire fencing @ Rs. 525/mt (100m x 100m)	2.10
2.	Two gates with RCC pillars @ Rs.75,000/- per gate	1.50
3.	Building, warehouse of 1250 sq metre @ Rs.7000/sq mtr	87.50
4.	Water storage, distribution/drainage and general piping	5.50
5.	Electrification	5.00
	Sub- total II	101.60
III	Administrative Building 200sq. m. @ Rs. 10000/sq.m.	20.00
	Vehicle (2 nos.)	14.00
	Grand Total (I - III)	180.4

B. Machinery and Equipment

Sl. No.	Name of the machine/ equipment	Quantity	Cost (Rs. in lakhs)
1.	Resin Applicator (2.6MX1.4MX0.5M)	1 no	Local make
2.	Band Dryer	1 no	40.00
3.	Hydraulic Hot Press with platen size 2.44mx1.22m - 10 Daylights opening with flat platens.	1 no	40.00
4.	Hydraulic Hot Press with platen size 2.44MX1.05M with 6 Daylight openings and having sinusoidal pattern moulded dies (corrugated)	1 no	60.00
5.	Guillotine Jointer with 1.22M Knife	1 no	6.00
6.	Squeezing Machine (Glue Spreader without Doctors roller) - 1.22M	1 no	3.00
7.	Air Drying Chamber with racks (optional)	2 nos	5.00
8.	Trimming Machine (D D Saw)	1 Set	3.00
9.	Spray Booth for Surface Coating	1 Station	1.00
10.	Resin Kettle (1 ton capacity)	1 no	8.00
11.	Thermic fluid Heater (Boiler) 15 lakh Kcals	1 no	20.00
12.	Dust Extraction System	1 no	2.00
13.	Scissor Lift	2 sets	3.00
14.	Alluminium Caul - 2.44mx1.22m	60 nos.	-
15.	Blower for cooling	1 no	0.25
16.	Air Compressor	1 no	0.25
17.	Transformer 500 KVA	1 no	10.00
18.	Generator 500 KVA	1 no	20.00

19.	Weighing Machine (one ton capacity)	1 no	0.50
20.	Storage Tanks for formalin, phenol and cardanol 10,000 litre capacity each	3 nos	6.00
21.	Trolley, Knap-sack sprayer and small hand tools	As required	1.00
	Total		189.00

C. RECURRING COSTS (size 2.44 x 1.05m x 3.5mm) 3 ply [for 2 shifts]

(Rs. In lakhs)

Sl. No.	Item	Coir corrugated sheets
I	Raw Material	
1	Coir felts (540 boards per day) 1080 coirs per day @ Rs.30 /sq mt 1 Felt of 3.5 sq m will cost Rs.105= 1080 x 300 x 105	340.20
2.	Bamboo Mats @ Rs.70/- per mat No. of mats required per day 540 for 300 days: 540 x 70 x 300	113.40
3.	PCF resin liquid (42% solids) required per Annum @ Rs.26 per kg 900 gms/sq m- 2.3 kgs per coir felt 1080x2.3x300 x26 =Rs. 193 lakhs Bamboo mats 1kg for 1 mat : 540x 1 x300 x 26 = Rs.42.12 lakhs Total adhesive cost =193 + 42.12 =235.12 lakhs	235.12
4.	Cost of preservative chemical @ Rs.150/kg 11,820 x 150 (1% on liquid resin)	17.73
5.	Releasing paper @ Rs.175/kg	31.50
6.	Aluminium cauls of 2 mm thick of size 2.5m x 1.25m after accounting for scrap value [one time investment]	3.00
	Total cost of Raw materials	740.95
II	Energy requirement	
1.	Electricity coverage 800 kwh/day @ 4.5/Unit = 800x 4.5 x 300	10.80
2.	Fuel	8.80
	Total cost of energy	19.60
III	Maintenance	
	Maintenance cost of machinery & equipment.(4% on Machinery cost)	7.47
IV	Management and Labour	

A	Managerial staff	
1.	General Manager 1 No.@ Rs.25,000	3.00
2.	Manager Production & Sales Manager – 2 Nos.@ Rs.15000	3.60
3.	Chemist and Quality Controller – 2 Nos.@Rs.10,000/-	2.40
4.	Maintenance Engineer – 1 No. @ Rs.8000 p.m.	0.96
5.	Machine operator– 3 Nos. (3 x Rs.6000/-)	2.16
6.	Boiler operator 3 Nos. (3 x Rs.4000)	1.44
	Sub-Total	13.56
B	Administrative staff	
1.	Accountant – 1 No.@Rs.5,000	0.6
2.	Clerk/Typist – 2 Nos. (2 x Rs.3000)	0.72
3.	Attendant – 1 No. (1 x Rs.2000)	0.24
4.	Driver – 1 No. (1 x 2500)	0.30
5.	Security guards – 4 Nos. (4 x 2000)	0.96
	TOTAL	2.82
C	Labour	
	Semi-skilled labours 45 Nos. Rs.100 x 300/ day	13.50
D	Social Overheads	
	Social overheads like Bonus, P.F., LTC, Medical benefits, Production incentives @ 25% of total management and labour cost	7.47
	Total cost of Management and Labour (A to D)	37.35
	Production cost of 162000 coir corrugated sheets(without sales promotion and commission cost	805.37
	Production cost per board in Rupees	497.14
	Sales promotion and commission	25.00
E	Total Production cost of 162000 coir corrugated sheets	845.87
F	Production cost per board in Rupees	522.14
G.	Add Depreciation	
	Buildings	3.07
	Machineries	10.52
	Total Manufacturing cost	859.46
	Production cost per sheet in Rupees	530.53
	Production cost per square meter in rupees	207.08