

PERFORMANCE OF COTTON RAG PULP IN FIBER CEMENT SHEETS

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ABSTRACT

Cotton rag pulp produced from waste cotton rag generated by garment manufacturers has been evaluated as reinforcement in fiber cement products. It is processed in Hollander beater and no chemicals or additives are required. These fibers are longer, coarser than most wood fibers and do not contain any Acid or Lignin. Cotton rag pulp has been found to provide many benefits in fiber cement applications due to their high modulus, high fiber strength and low Lignin content. Laboratory preparations of multiple formulations of fiber cement sheets have been carried out incorporating these fibers and have found higher strength properties. Subsequent pilot plant and main plant trials confirm many of the laboratory findings and establish suitability of cotton rag pulp as reinforcement in fiber cement sheets. Fully cured fiber cement sheet made with this pulp reinforcement exhibits high modulus of Rupture (MOR), high fracture energy (toughness), flexibility and excellent dimensional stability. Accelerated aging tests were also run and high performance mix designs showed the most strength retention after aging.

KEYWORDS:

Fiber cement sheets, Hatscheck process, cotton rag pulp, cementitious composites, waste recycling

INTRODUCTION

Asbestos fibers can be replaced with alternate fibers to maintain same quality and productivity. A wide variety of wood pulp, synthetic fibers has been investigated academically as a replacement for Asbestos fibers. Industrial practice has settled primarily on soft wood pulp, Kraft pulp and to some extent on synthetic fibers such as PVA, PP, PET and glass fibers. Common industrial production uses the Hatschek, Flow-on or Mazza process.

Background

Cotton is a soft and staple fiber that grows in the form of a ball around the seed of a cotton plant. This fiber is spun into yarn or thread and used to make soft textiles. Cotton is the most used textile fiber in the world and accounts for 56 percent of all fibers used for apparel and home furnishings. Textile cloth is cut into desired lengths and shapes for making clothing and furnishings. In this process, pieces of textile cloth generated as waste is called cotton rag.

Cotton rag pulp produced from waste cotton rag is abundantly available in India and it is being used in speciality paper, filter paper and battery separator etc. Cotton pulp does not contain lignin and acids hence it is suitable to make better bonding with cementitious binders when compared to Kraft pulp and synthetic fibers. Cotton fibers are very resilient and their springy nature gives better flexural performance and strain-hardening behaviour for fiber cement sheets. Using cotton rag pulp in fiber cement products helps in disposal of waste generated by the garment industry and substituting wood pulp will prevent deforestation. Use of cotton rag pulp also reduces cost of production as it is much cheaper than wood pulp and any other synthetic fibers in India. Soft wood pulp and other synthetic fibers such as PVA are not available in India and they have to be imported from other countries. The approximate cost of soft wood pulp is US\$ 700 per ton, PVA fiber is US\$ 4100 per ton and cotton rag pulp is US\$ 350 per ton.

The Cotton Rag Pulping Process

Cotton rag waste collected from apparel industry is carefully sorted to remove any contaminants or inconsistent material. It is then chopped into small pieces by using shredder and mixed with water in tank. It is processed in Hollander beater (Figure 2) so that the yarn or threads disintegrate into pulp. This pulp in slurry form can be made into boards for storage as shown in (Figure 2) or further processed using refiners to get the required freeness. After refining the pulp, it is stored in machine chest and used as per requirement.

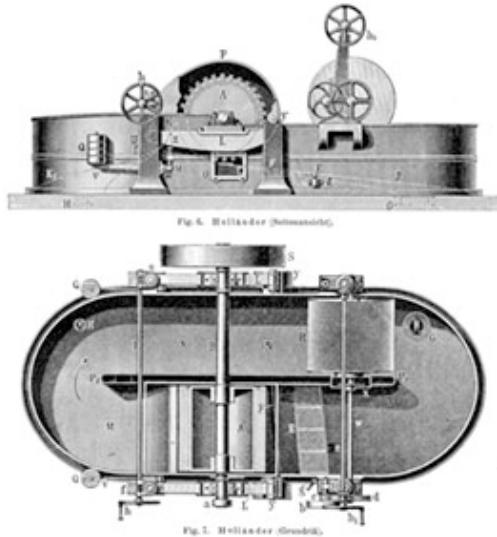


Figure 1



Figure 2

Properties of Processed Cotton Rag Pulp

The typical properties of cotton rag pulp are given in Table 1.

Table 1

| S.No. | Characteristics | Units | Value |
|-------|---------------------------------|-----------------|------------|
| 1 | Freeness | ⁰ SR | 32 - 35 |
| 2 | Buoyancy (5gms in 2000ml water) | cc | 1520 |
| 3 | Fiber length | mm | 2 – 6 |
| 4 | Fiber diameter | mm | 0.0205 Max |
| 5 | Tensile Breaking Length | Kms | 8.2 |
| 5 | Ash content | % | 1.5 max |

Experiment Conditions

Unless otherwise noted, all samples described in this paper are produced using the following compositions.

Fiber cement flat products (Autoclaved) - Cotton rag pulp, Portland cement, Fillers and additives.

Fiber cement corrugated products (Air cured) – Cotton rag pulp, PVA fiber, Portland cement, amorphous silica, Fillers and additives.

The cotton rag pulp is refined to various freeness levels depending on the type of product being prepared. Fiber refining process fibrillates surface of the cotton fiber for uniform web formation in the product, retains fine powder particles of binders, fillers. Freeness levels in this paper are given as Schopper-Riegler Freeness (⁰SR).

Conditioned and wet densities of the product sample are measured prior to testing. Oven dry density is determined after 72 hours in an oven at 105 + 5⁰C. Water absorption is determined by using the weight from wet and dry density measurements and is expressed as a percentage.

Fiber cement flat sheets are tested as per India standard IS 14862, ISO : 8336 and British standard EN 12467.

Fiber cement corrugated sheets are tested as per Indian Standard IS 14871, ISO : 9933 and British standard BS EN 494.

Lab Experiments

In one experiment 94% OPC cement, 6% processed cotton rag pulp was used and in another experiment 94% OPC cement and 6% processed Unbleached Soft Wood Pulp (UBSWP) was used for comparison. Fiber cement sheet of size 8"x3"x6mm thickness were made using laboratory press. These sheets are kept in humidity chamber for 16 hours for cement hardening. After hardening the samples are soaked in water for 36 hours for further curing. Cured sheets made with cotton rag pulp and soft wood pulp was tested and the results are given in Table 2.

Table 2

| S.No. | Property | Units | With cotton rag pulp | With soft wood pulp(UBSWP) |
|-------|--------------------|---------------------|----------------------|----------------------------|
| 1 | Dry density | g/cc | 1.612 | 1.624 |
| 2 | Modulus of rupture | Kgs/Cm ² | 128 | 92 |
| 3 | Water absorption | % | 29.46 | 29.28 |

The improved mechanical properties of fiber cement sheets with cotton rag pulp are attributed to removal of cuticle layer that consists of wax and pectin material on the cotton fiber during refining process. After removing cuticle layer from fiber surface it will have more active centres to make better bonding with cementitious materials compared to wood pulp. Apart from this cotton pulp does not contain any Acid or Lignin which improves bonding with cement binders.

Applications of Cotton Rag Pulp in Fiber Cement Sheets

Fiber Cement Flat Sheeta - Autoclaved

Fiber cement flat sheets of various sizes and thickness were made with processed cotton rag pulp on HATSCHECK machine as shown in Figure3.



Figure 3

Fiber cement flat sheets are autoclaved and tested as per India Standard IS:14862 , ISO : 8336 and British Standard EN :12467 and confirm to the specification of Category -3, Type B. Typical test results are given in Table3 which are comparable with sheets made with soft wood pulp.

Table 3

| Properties | Units | Values |
|--|--------------------------------|---------------|
| Standard Weight | Kg / m ² | 7.2 for 6 mm. |
| Free Moisture at Equilibrium Moisture Condition (at 240 ⁰ C and 50% RH) | % | 5 -11 |
| Drying Shrinkage (moisture movement) | mm/m | < 2.5 |
| Water Absorption | % | < 40 |
| Thermal Conductivity | W/m ⁰ K | 0.18 |
| Ignitability (BS-476, Part-5) | Class-P (not easily ignitable) | Class-P |
| Fire Propagation Index (BS-476. Part-6) | Limit < 12 | 3.7 |
| Surface Spread of Flame (BS-476, Part-7) | Class-1 to 4 (Best -1) | Class-1 |
| Screw holding capacity on face | Kg. | 320 |
| Nail holding capacity on face | Kg. | 220 |
| Heat / Rain Test | | Pass |
| Warm Water Test | | Pass |
| Soak Dry Test | | Pass |
| Freeze -Thaw Test | | Pass |
| Sound Transmission Coefficient | dB for 6mm | 34 |

Fiber Cement Corrugated Sheets – Air Cured

Fiber cement colour coated corrugated sheets as shown in Figure 4 are made with cotton rag pulp on Hatschek machine. After 14 days of air curing, sheets are tested as per Indian Standard IS 14871, ISO : 9933 and British standard BS EN 494. Fully cured sheets confirm to the standard specification of Category C, Class 7. Typical properties of fiber cement sheet are given in Table 4.



Figure 4

Table 4

| Properties | Units | Values |
|---------------|-------|--------|
| Thickness | mm | 5.8. |
| Breaking Load | N/m | 3.86 |

| | | |
|------------------------------|------|--|
| Impermeability | - | No water drops formation on the underside of the sheet |
| Apparent density | g/cc | 1.38 |
| Heat / Rain Test (25 cycles) | | No cracks, delamination or other defects |
| Warm Water Test | | No cracks, delamination or other defects |
| Soak Dry Test | | No cracks, delamination or other defects |
| Freeze -Thaw Test | | No cracks, delamination or other defects |

Fiber cement corrugated sheets made with cotton rag pulp are used for roof applications. (Figure 5)



Figure 5

CONCLUSION

Processed cotton rag pulp obtained from apparel waste has been shown to provide better performance than wood pulp in fiber cement composites produced by both air-cured and autoclaved process. Asbestos fibers and soft wood pulp are not available in all parts of the world. The use of locally available cotton rag pulp for fiber cement products is a good alternative. Cotton rag pulp processing is easy, simple and costs less than Asbestos and soft wood pulp. Using cotton rag pulp will reduce product cost and by substituting soft wood pulp with cotton rag waste we can prevent deforestation.

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