

# ATTEMPTS TO USE COIR DUST IN THE PREPARATION OF BUILDING SLABS OR HARDBOARD

(Tropical Products Institute Report G. 35—October 1968) \*

## INTRODUCTION

At the request of Mr. B. G. A. Smith, Research Officer, Department of Agriculture, Seychelles, attempts have been made to utilise coir dust in the making of building slabs and hardboard.

## TEST METHODS

Arrangements were made to examine mixtures of coir dust and cement by the test procedure described in B.S. 2028 : 1953, i.e. "Precast Concrete Blocks".

In this standard, a concrete mix suitable for use in external loadbearing structures must, after curing for seven days in an atmosphere of 90% R.H. and a temperature of 20°C, have a compressive strength of not less than 500 p.s.i. Alternatively, if the concrete is to be used for internal non-loadbearing structures then the maximum transverse load which can be supported at the middle of a specimen of overall dimensions 17 5/8" × 8 5/8" × 2", when supported on fulcrums 15" apart, must not be less than 140 lb. (no standard specification for compressive strength of non-loadbearing concrete is given).

### *Preparation of the coir dust.*

The coir dust on arrival at Tropical Products Institute consisted of a mixture of dust and short fibres. Some of the dust passed a No. 22 B.S. Sieve and about 5 per cent (by weight) of short fibres was present in the sample. The moisture content as received, was 52 per cent which was later reduced to between 5 and 8 per cent by oven drying.

Because of the irregular size of the particles, the coir dust was passed through a laboratory knife mill to produce two separate samples of different particle size. The sample containing the larger particles, classified as 'coarse', and a size analysis of

|                               | Percent |
|-------------------------------|---------|
| on 1/4" sieve ...             | 23      |
| Thro' 1/4" : on 22 B.S.S. ... | 53      |
| Thro' 22 B.S.S. ...           | 24      |

The other sample classified as "fines" consisted of

|                               | Percent |
|-------------------------------|---------|
| Thro' 1/4" : on 22 B.S.S. ... | 50      |
| Thro' 22 B.S.S. ...           | 50      |

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## LOADBEARING CONCRÉTE

Concrete compression test cubes of internal dimensions  $2.78" \times 2.78" \times 2.78"$ , were prepared in standard metal moulds, using first the coarse and then the fine, oven-dried coir dust, mixed with different proportions of ordinary Portland cement.

The cement/coir dust ratio was increased from 1 to 6 in increments of one unit and at the same time the quantity of water added was varied to suit the changing conditions of the mix.

When the proportion of cement reached, the upper limit, i.e. cement : coir dust : : 6 : 1 the compressive strength of the test cubes, as determined on a compression tester, was still insufficient to justify the use of the concrete for loadbearing purposes. It was therefore decided to saturate the coir dust in fresh water before preparing the mix and thus avoid the possibility of the cement being deprived of water during hydration.

The previous experiments were repeated with saturated coir dust replacing the oven-dried material. When removed from the soaking bin, the coir dust contained about six times its own weight of water, and this excess water was partially removed by hand prepressing until the moisture remaining was equal to the weight of dry coir dust. The compressive strength of the resulting concrete was improved, but it was not until a mixture containing a weight of cement equal to six times the weight of aggregate, was tested, that the concrete was found to be strong enough for loadbearing purposes.

This mix was considered much too rich for practical purposes and the idea of using coir dust as an aggregate with cement to produce loadbearing structures, was abandoned.

### *Non-loadbearing concrete*

To determine if the coir dust (soaked as described above) could be used with cement for non-loadbearing indoor structures, a number of panels of densities 40, 60, 70 and 80 lb/ft<sup>3</sup> and dimensions of  $17 \frac{5}{8}" \times 8 \frac{5}{8}" \times 2"$  were prepared in a metal mould from a mix composed of cement : dry coir dust equivalent 4 : 1. When cured, these panels were tested transversely as described previously.

It was found that the minimum density necessary to ensure that the panel withstood loads up to 140 lb. without fracture, was 60 lb/ft<sup>3</sup>. To produce a panel of this description it is necessary to maintain a pressure on the mould during the time the cement is setting. This raises production problems such as the number of moulds required and the most suitable method for maintaining the pressure in the mould.

### *Hardboard :*

A possible alternative to the use of coir dust as an aggregate, is its use in the preparation of hardboard.

It is known, for example, that under the combined effect of compression and heat, some cellulosic materials can be bonded together by the plasticisation of the non-cellulosic constituents, and arrangements were made to examine the feasibility of such a process.

The British Standards Specification No. 1142 : 1961 states that medium hardboard has a density between 30 and 50 lb/ft<sup>3</sup> and is of nominal thickness  $\frac{3}{16}"$ ,  $\frac{1}{4}"$ ,  $\frac{5}{16}"$ ,  $\frac{3}{8}"$  or  $\frac{1}{2}"$ . For each thickness there is a prescribed minimum bending stress and a maximum water absorption. By adopting the requirements of a medium hardboard of nominal thickness  $\frac{1}{4}"$  it became necessary to produce hardboard test samples  $8" \times 4" \times \frac{1}{4}"$ , capable of withstanding a bending load

of 45 lb. between fulcrums 6" apart. This is equivalent to a Modulus of Rupture of 1620 p.s.i. and at the same time the amount of water absorbed by the test piece after being submerged for 24 hours in fresh water must not exceed 30 per cent of the conditioned weight of the sample.

#### *Design of mould for hardboard sample :*

A rectangular mould was prepared consisting of a mild steel frame 8" x 4" x 2 1/2" deep reinforced at the corners and provided with a separate base 13" x 9" x 1/2" thick. The upper surface of the base was traversed by small, vee-shaped channels at right angles to each other 1/32" deep and spaced 1/16" apart. These channels terminated in a larger collecting channel 1/4" deep cut around the perimeter of the base and fitted with a drain at one end. The purpose of these channels was to provide an outlet for excess water during the pressing and drying stage of the hardboard preparation.

By filling the mould with the saturated raw material and then pressing a block of mild steel 7 7/8" x 3 7/8" x 2 1/4" between the platens of a 150 ton electrically-heated hydraulic press, until the upperside of the block was flush with the top of the mould, a hardboard test piece 8" x 4" x 1/4" was produced.

For a successful test piece it was also necessary to promote the escape of the steam which formed in the mat during pressing. This was done by including a "breathing" period in the pressing cycle. The most successful pressing cycle consisted of pressing the mat for 2 minutes at 700 p.s.i. pressure, followed by 3 minutes 'breathing' during which time the pressure on the mould was reduced to zero and the mat continued to dry because of contact with the hot platens of the press and then, finally, the full pressure of 700 p.s.i. was restored and maintained for 10 minutes.

It was possible to vary the density of the test pieces by increasing, or decreasing, the amount of material placed in the mould at the beginning of each operation.

To begin with, quantities of oven-dried coir dust were subjected to pressures up to 700 p.s.i. in the mould, and to temperatures between 140° and 170° C. Although attractive looking samples were produced, they disintegrated when submerged in water.

Thereafter only coir dust saturated in fresh water was used, first without any form of additive and later with different types and quantities of synthetic resins.

## RESULTS

Table I shows Modulus of Rupture and the water absorption characteristics of a number of hardboard test pieces made from coir dust mixed with either water or resin. Each sample tabulated represents a mean value of at least three test samples.

It is evident from sample 1 that by compressing the coir dust in the dry condition, the mass retains its shape only by the compressive forces existing between the individual particles. Because of the immense capacity for absorption of water which characterises coir dust, the particles expand as absorption proceeds and the sample disintegrates. This method of production is therefore of no practical use for any form of hardboard.

Samples 2 to 6 inclusive indicate that there is an immediate improvement in strength and water absorption when the oven-dried coir dust is replaced by coir dust saturated in fresh water. Also, within the range of medium hardboard, i.e. those having densities between 30 and 50 lb/ft<sup>3</sup>, the water absorption is reduced and the strength of the board increased as the density is increased but neither properly meets the requirements of the British Standard Specification.

It is not until a compressive pressure of 5000 p.s.i. is used to produce a hardboard of density 68 lb/ft<sup>3</sup> that a reasonably strong board is produced. The water absorption, however, is still much too high at 69 per cent. Efforts to improve the quality of the hardboard by adding different proportions of coir fibre (Nos. 7 and 8) had the effect of making the board more porous, thus increasing the water absorption, without any appreciable difference in the strength of the board. Further samples (Nos. 9 and 10) were prepared by soaking the coir dust in solutions of urea formaldehyde resin in concentrations of 1½ and 3 per cent. This is equivalent to adding from about 1 to 2 per cent of resin solids to the finished board and whilst an increase in strength can be observed at the upper limit of concentration, the water absorption was too great.

When attempts were made to use more concentrated solutions, the moisture channels in the base of the mould were choked with resin pressed from the mat and it was impossible to get rid of the excess moisture sufficiently quickly to avoid laminations and blisters, which formed in the board because of entrapped steam.

Samples 11 and 12 were prepared by spraying oven-dried coir dust in a rotary mixer, first with 10 per cent and then with 15 per cent of urea-formaldehyde resin, using high pressures to produce densities of 73 and 70 lb/ft.<sup>3</sup> respectively.

It will be seen that in each case the high density and increased resin content resulted in a board, strong enough to satisfy B.S. requirements but the water absorption is unacceptable.

Sample 13 shows the results of tests on a commercial board and sample 14 gives the B.S. requirements. These last two samples were included for comparative purposes.

## CONCLUSIONS

Coir dust must be saturated in water before mixing with cement to form either loadbearing or non-loadbearing concrete. This is to ensure that water added during the preparation of the mix is used exclusively in the hydration of the cement and not absorbed by the coir dust.

The presence of small proportions of soluble substances in coir dust inhibits the setting of cement, making it necessary to use an excessively rich mix if British Standards requirements are to be complied with. Alternatively, it is probable that the addition of a mineralising agent (say, Calcium chloride) would neutralise the inhibiting effect of these substances. In practice, however, this would complicate the process and increase production costs. The effect of additives was therefore not examined. When using a 4 : 1 mix to produce a non-loadbearing unit, the density of the unit should not be less than 60 lb/ft<sup>3</sup>. To do this it becomes necessary to maintain a pressure on the mix during the time the cement is setting and this, in turn, increases capital expenditure and production costs beyond the economic limit.

The naturally occurring binding material which exists in coir dust, can be used to advantage by saturating the material in water and then heat-pressing the mat so that, at the end of the pressing cycle, the board is dried to a moisture content of less than 10 per cent and the particles are firmly bonded together. Compressive pressures of 700 p.s.i. will produce medium hardboards (i.e. 30-50 lb./ft.<sup>3</sup>) but the corresponding bending strength is low. It is not until pressures of the order of 2-3 tons per sq. inch are employed to produce boards with a density in the region of 60 lb/ft<sup>3</sup>. that the bending strength becomes adequate. Under these extreme conditions of pressure and density, the water absorption remains excessive and attempts to improve this by employing oven-dried coir dust mixed with proportions of urea-formaldehyde resin up to 15 per cent, had only slight effect.

It would seem unlikely, therefore, that coir dust can be used satisfactorily in the manufacture of hardboard, for any application involving the use of water, unless the manufacturer is prepared to use extreme compressive pressures and still greater proportions of resin,

TABLE I

| Sample No. | Density lb/ft. <sup>3</sup> | Water absorption 24 hours percent | Modulus of Rupture p.s.i. | REMARKS  |
|------------|-----------------------------|-----------------------------------|---------------------------|--|
| 1          | 48                          | Disintegrated                     | 232                       | Oven-dried coir dust                                       |
| 2          | 41                          | 107                               | 406                       | Coir dust saturated in fresh water                         |
| 3          | 44                          | 79                                | 450                       | Coir dust saturated in fresh water                         |
| 4          | 51                          | —                                 | 454                       | Coir dust saturated in fresh water                         |
| 5          | 59                          | 74                                | 924                       | Coir dust saturated in fresh water                         |
| 6          | 68                          | 69                                | 1268                      | Coir dust saturated in fresh water                         |
| 7          | 50                          | 79                                | 435                       | Coir dust saturated in fresh water + 1 per cent coir fibre |
| 8          | 49                          | 93                                | 465                       | Coir dust saturated in fresh water + 5 per cent coir fibre |
| 9          | 52                          | —                                 | 400                       | Coir dust saturated in 1 1/2 per cent U-F resin            |
| 10         | 50                          | 61                                | 451                       | Coir dust saturated in 3 per cent U-F resin                |
| 11         | 73                          | 66                                | 1610                      | Oven-dried coir dust sprayed with 10 per cent U-F resin    |
| 12         | 70                          | 57                                | 1930                      | Oven-dried coir dust sprayed with 15 per cent U-F resin    |
| 13         | 62                          | 23                                | 3910                      | Commercial sample  |
| 14         | 30-50                       | 30                                | 1620                      | B.S. No. 1142 : 1961                                       |