2 CHAPTER TWO - Materials and Methods

2.1 Production of Woven Coir-Geotextiles

Coir fibres obtained from extraction process are twisted and made into coir yarns using machine or spinning wheel. Thereafter two such yarns are doubled and twisted together into a 2-ply coir yarn (rope). According to the end-use of coir-geotextiles twist inserted and the number of fibres in the cross section of coir yarn or rope can be varied in the spinning process.

Coir-geotextiles are produced from coir rope (strands) by using a special loom designed for this purpose. A warp beam is prepared from rope and fed from the back of the loom and is interlaced with wefts at the required spacing to form the matting. The weft is manually inserted and therefore speed of production is very low. The size of rope and distance between two weft strands and the distance between two warp yarns can be varied according to the need of the application.

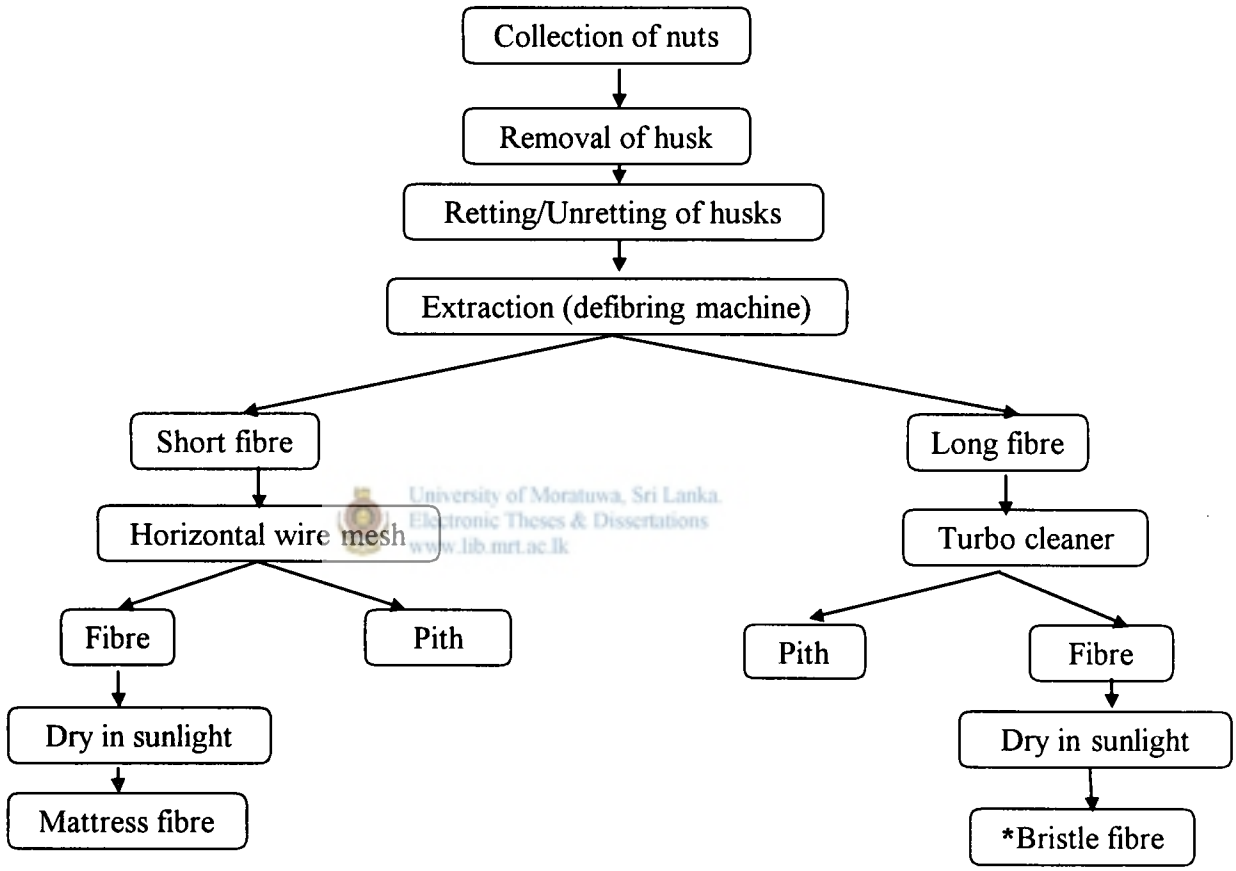
2.2 Materials

2.2.1 Coir Fibre Sampling Method

Coir fibre samples from Kurunegala District were chosen for this research. Kurunegala District was selected because it is the district, which produces the highest percentage of coir fibre in Sri Lanka. In the Kurunegala district, two main different types of coir fibres are produced to give the appearance of two colours namely brown and white. According to the information given brown coir fibre is obtained after retting the dry or semi-dry husks for a period of one to eight months in stagnant fresh water while white coir fibre is directly obtained without retting from the mature green husks.

The extraction process of coir fibre was given in figure 2.1. Specially designed machines called defibring machines were used in the process. Two drums are arranged parallel one after other but not having the same axis. One half of the husk is torn by the first drum while other half is torn by second drum. The inner cylinders of the two drums are made of iron with coarse and widely spaced nails (4 to 5 cm apart)

protruding out of the cylinder to cover the entire outer surface. The soaked husks are introduced into this vessel between the nails and outer surface. The pin-nails tear apart the husk thereby separating fibres from the outer shell. This is the procedure that is predominantly adopted in Sri Lanka. After extraction of white fibre, unlike in the case of brown fibre, the fibre is washed with fresh water three consecutive times to prevent them turning to brown colour.



* Important for research work

Figure 2.1: Extraction Process of Coir Fibre

From the extraction process, two main grades of coir fibres are obtained, which are graded according to the length i.e., long fibres called bristle grade and short fibres called mattress grade [25]. Bristle grade coir fibre is used in making geotextiles therefore, all the tests are carried out in this research on bristle grade coir fibres.

Brown and white coir fibres were collected from eight different fibre mills, from the Kurunegala District. For each laboratory sample a weight of about of 500-1000g

samples were chosen from 20 different bundles of one fibre mill according to the sampling method described in BS2545: 1965 standard [26].

After conditioning, 2g of fibre samples were taken (according SLS 115: 1981 part 1 standard [27]) with thorough mixing from each fibre sample from 20 different places and then fibres that are shorter than 18cm were discarded. Crimp tester was used in the measurement of length. Both linear and branched fibres in these samples were tested. Brown coir fibre sample containing approximately 100 fibres and white coir fibre sample containing approximately 75 fibres, all of which are longer than 18cm were used in the tests. Thereafter, for each test a 2g of coir fibre, sampled as above was used.

2.2.2 Coir Yarn Sampling Method

It was not possible to draw random samples of coir yarns from mills. However, 1000m of coir yarns including both white and brown were selected before making into coir rope from four different mills situated in the Kurunegala District. These coir yarns are all manufactured manually using a spinning wheel. From these samples, 50, 1m long strands were cut and labelled to be used in tests.

2.2.3 Chemicals Used in the Experiments

I. Sodium hydroxide Pellets (AR)
II. Aqueous Ammonia (AR)
III. Hydrochloric Acid (AR)
IV. Disodium hydrogenorthophosphate (GPR)
V. Sodium dihydrogenorthophosphate (GPR)
VI. Sodium acetate anhydrous (AR)
VII. Acetic acid (AR)
VIII. Sodium Chloride (AR)
IX. Magnesium Chloride anhydrous (AR)
X. Distilled Water

2.3 Methods

2.3.1 Method Used for Coir Fibre Tensile Properties Testing

All test materials were conditioned at 27±2°C and 65±2% RH for at least 4 hours before any measurements were taken at standard textile testing atmosphere [28]. Shirley crimp tester was used to measure the length of fibres to the nearest 0.1cm. Analytical balance was used to measure the mass to nearest 0.0001g and a projection microscope was used to measure the diameter to the nearest 0.01mm at three different places of each fibre. All these tests carried out done according to BS standards [29 & 30]. Totally 414 such brown fibres and 299 such white fibres contained in a collection of four fibre samples were tested.

The breaking strength and breaking elongation of coir fibres were measured using a constant rate of extension method with the use of instron tensile tester. Considering the average length of the fibre, which is 21cm and fibre breaking time to be within range of 20s to 30s, a gauge length of 15cm and a strain rate of 100mm/min were used according to the BS 3411 [31]. Strength versus elongation graph was obtained form the above experiment and values for initial modulus were obtained form that graph.

2.3.2 Wet Strength and Wet Elongation at Break of Coir Fibre

Tensile tests were repeated with wet fibres immersed in distilled water for 24 hours at room temperature. The coir fibres were then subjected to tensile testing immediately after taking out from the water bath.

2.3.3 Strength Retention of Coir Fibre in Seawater

Artificial seawater was prepared according to AATCC 106-1986 standard [32] and test sample of both coir fibre types were immersed in the saline solution for a 24-hour period at ambient temperature. Then fibres were subjected to tensile test immediately after taking out from the seawater bath. Same test was carried out for longer periods as explained in section 2.3.11.

2.3.4 Strength of Coir Fibre in Different pH Buffer Environments

Coir fibres were immersed in water baths having five different pH buffer conditions (pH 5, 6, 7, 8 & 9) for 24 hours at ambient temperature to study the tensile properties

of the coir fibre in different chemical environments. Buffer solutions prepared using 0.01M acids and bases/salts solution and then two solutions were mixed according to the required ratio. Required pH solutions were prepared according to table 2.1 given below.

Table 2.1: Chemicals used to Prepare pH Solutions [33]

Chemical	pH
Acetic Acid- Sodium Citrate	3.7-5.6
Disodium hydrogenorthophosphate- Sodium dihydrogenorthophosphate	6.0-9.0
Aqueous Ammonia-HCl	9.2-11.0

After the end of the given time period, coir fibres were dried at room temperature and conditioned for 4 hours at standard conditions. These samples were subjected to tensile tests.

2.3.5 Moisture Regain of Coir fibres

Conditioned coir fibres were initially weighed and dried in an electric oven at 105 ± 2°C, after every 15 minutes coir fibre samples were taken out from the oven and allowed to cool in a desiccator and the weight was measured. This procedure was repeated until the samples were dried to a constant weight and the difference between two successive weighing was within 0.01%.

2.3.6 Behaviour of Coir Fibres in NaOH

The coir fibres were soaked in (10, 15 & 25 %) NaOH solutions at 25°C maintaining a liquor ratio of 50:1. The fibres were kept immersed in the alkali solution for 15, 30 & 45min.The fibres were then washed several times with fresh water to remove any NaOH sticking to the fibre surface, neutralized with dilute acetic acid and finally washed again with distilled water until the final pH reached was 7. The fibres were then dried under standard laboratory condition for 48 hours. Then the tensile properties of coir fibres were measured.

2.3.7 Coefficient of Friction of Coir Fibres

Coefficients of friction of coir fibres were measured using incline plane test [34]. First fibre samples were pasted parallel to each other on two papers and then one paper was pasted on the incline plane and the other was pasted at the bottom face of the weight. Then the weight was placed on the incline plane and a force was applied on the weight. The value of the force when the weight starts to slip was noted down and the coefficient of friction of coir fibres was calculated.

Same test procedure was repeated for jute and polyester fibres, for the validation of the test procedure.

2.3.8 Tensile Properties of Coir Yarns

The yarn breaking strength and elongation at break was measured simultaneously using a constant rate extension instron tensile tester according to the BS 1932: part 1 test method [35]. Gauge length of 50cm and strain rate of 300mm/min was used in these tests. From the same experiment strength versus elongation graphs were obtained. Initial modulus of each yarn was calculated using the graph.

2.3.9 Twist of Coir Yarns

Twist of coir yarns was obtained using the Twist Tester. Fifty samples of coir yarn from each type were tested where the test length was 10cm. This test was done according to BS 2085 [36].

2.3.10 Linear Density of Coir Yarns

Weight of 50, 1.00m length coir yarn sample was measured and the tex values were calculated (according to BS: 2010) [37].

2.3.11 Durability of Coir Fibre in Different Chemical Environments

For the Durability test, tensile properties coir fibres were measured after immersing in acidic (pH=5), alkaline (pH=8), distilled water (pH=5.89) and seawater (pH=8) for periods of 1, 2 and 3 months at ambient temperature. In the preparation of acidic medium HCl acid was used while that of the basic medium NaOH was used. Seawater medium was prepared as explained in 2.3.3.

After a specific period of time coir fibres were washed with distilled water and dried at room temperature. Then coir fibres were conditioned for 4 hours in a standard atmosphere before testing. Then the tensile properties of fibres were tested for each medium and for each fibre type.

2.3.12 Microstructure of Coir Fibre

Representative samples were taken from the two types of coir fibres i.e., 20 coir fibres having different linear densities were immersed in same chemical environments and durations as in 2.3.11.

Microstructure of untreated brown fibre, untreated white fibre, HCl treated brown fibre and white fibre treated with distilled water were investigated to verify the observed tensile properties and results in section 2.3.11. The treatments in HCl and distilled water were carried out for a period of three months.

Due to the non-availability of SEM after three months treatment coir fibres were washed with distilled water and covered using oilpaper and were kept in desiccator for one month before tests were carried out.

To investigate the surface of above coir fibres they were cut into 5mm length specimens and pasted on metal stub using double sided gum tape. Then the metal stub was placed on the stage of SEM and scanning electron micrographs of coir fibre samples were taken at 200x magnification.