This section describes the details of various materials used for preparation of composite plates and their processing methods.

### 3.1 RAW MATERIALS

The raw materials used in this work are as follows.

#### 3.1.1 Fiber

Fiber imparts necessary strength and stiffness to composite material. In present work coir fiber (obtained from Central Coir Board Ahmedabad, India) has been used as reinforcing material in the polyester matrix to manufacture composite plates with various configurations. The fiber was used in random chopped form with uniform length of 50mm. The diameter of fiber varied from 0.1-0.3mm with relative density from 1.12-1.15. It is used in current investigation due to its excellent physical and chemical properties. Table 3.1 shows physical properties of coir fiber and Table 3.2 show chemical properties of coir fibers

**Table 3.1 Physical properties of coir fiber [140]**

<table>
<thead>
<tr>
<th>No.</th>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fiber length</td>
<td>50-100 mm</td>
</tr>
<tr>
<td>2</td>
<td>Fiber diameter</td>
<td>0.1-0.4mm</td>
</tr>
<tr>
<td>3</td>
<td>Modulus of elasticity (GPA)</td>
<td>19-26</td>
</tr>
<tr>
<td>4</td>
<td>Ultimate tensile strength (MPa)</td>
<td>120-200</td>
</tr>
<tr>
<td>5</td>
<td>Relative density</td>
<td>1.12-1.15</td>
</tr>
<tr>
<td>6</td>
<td>Elongation</td>
<td>10-25 %</td>
</tr>
</tbody>
</table>
Table 3.2 Chemical properties of coir fiber [140]

<table>
<thead>
<tr>
<th>No.</th>
<th>Content</th>
<th>Proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lignin</td>
<td>45.84%</td>
</tr>
<tr>
<td>2</td>
<td>Cellulose</td>
<td>43.44%</td>
</tr>
<tr>
<td>3</td>
<td>Hemi-cellulose</td>
<td>0.26%</td>
</tr>
<tr>
<td>4</td>
<td>Pectin</td>
<td>3%</td>
</tr>
</tbody>
</table>

**Fig. 3.1 Coir fiber**

### 3.1.2 Matrix material

The major function of matrix material in composites is to transfer load between fibers, holds the fibers in proper position, provides wear resistance and to incorporate interlaminar shear strength. Properly chosen matrix material is key to successful composite fabrication as it provides thermal resistance, chemical resistance, moisture resistance, cures at lowest possible temperature and has long pot life without being toxic[5]. Polymeric matrices can either be thermosets or thermoplastics.

Thermoset resins comprises of resin and a compatible curing agent which when mixed form low viscosity fluid that cures due to exothermic
reaction or externally applied heat resulting into formation of three dimensional molecular chain called cross linking as shown in Fig. 3.2[1].

![Cross-linking of thermoset molecules during curing](image)

**Fig 3.2 Cross-linking of thermoset molecules during curing**

The most prevalent thermoset resins used for composite matrices are polyesters, vinyl esters, epoxies, bismaleimides, polyamides and phenolics. Unsaturated isophthalic polyester resin with density of 1.35 gm/cc and elastic modulus 3.23GPa was used as matrix material. The term unsaturated polyester resin is generally referred to the unsaturated (means containing chemical double bonds) resins formed by the reaction of dibasic organic acids and polyhydric alcohols. Polyester resins can be formulated to obtain a wide range of properties ranging from soft and ductile to hard and brittle. Their advantages include low viscosity, low cost, fast cure time and above all least toxic.

### 3.1.3 Particulate Filler

Red mud obtained from HINDALCO Belgaum, India is used as particulate filler for this investigation. The red mud was used in dry powdered form with particle size 70-90 µm and having bulk density in range of 1.36-1.6 g/cc. Fig. 3.3 shows the photographic view of red mud particulate filler.
3.1.4 Hardener and accelerator

Methyl ethyl ketone peroxide (MEKP) was used as hardener and cobalt naphthalene as accelerator.

3.2 MATERIAL PREPARATION

A wooden mould of dimension (250×250×10) mm$^3$ was used for casting the composite plate. In the present investigation four composites plates were manufactured without red mud and another four composites plates were manufactured with red mud. Rachchh et al. [141] have studied the effect of varying filler content on mechanical properties of coir red mud composite and concluded that the best properties are available with 10% filler loading. So in this work for composite plates with red mud, 10% red mud content was fixed and fiber content varied between the 10%, 15%, 20%, and 25% respectively. For composite with red mud, red mud, polyester resin, hardener and accelerator were thoroughly mixed with gentle stirring to minimise air entrapment. But in case of composite plate without red mud, resin, accelerator and hardener were thoroughly mixed. Then by using hand layup technique, first layer of slurry was prepared. Above that chopped coir fibers were arranged and then slurry was poured and so on. This procedure was followed...
until the required thickness is achieved. Inner surface of mould was covered with mould release spray to ensure fast and smooth removal of composite plates. Care was taken to avoid formation of air bubbles. Pressure was then applied from the top and the mould was allowed to cure at room temperature for 24 hrs. This procedure was adopted for preparation of composites plates. After 24 hours the plates were taken out of the mould, cut into different sizes for further experimentation. Fig. 3.4 & Fig. 3.5 show composite plates with and without red mud respectively.

**Fig. 3.4 Composite plates without red mud**

**Fig. 3.5 Composite plates with red mud**
3.3 SAMPLE PREPARATION

Five samples were prepared from each composition plate according to relevant ASTM standards and average readings of properties were considered for results. For density measurement, samples were prepared according to ASTM-792 while for flexural, tensile and compressive properties samples were prepared according to ASTM D-790-10, ASTM D-638 and ASTM D-695 respectively. For barcol hardness ASTM D-2583 was followed. The samples for flexural, tensile and compressive are shown in Figs. 3.6a to 3.6c respectively. All the testing was carried out as per the relevant ASTM standards.

Fig 3.6 Samples cutting for (a) flexural testing (b) tensile testing
Fig 3.6 Samples cutting for (c) compressive testing