Chapter 1

Introduction
1.1 OVERVIEW

Engineers today are having the choice of more than 50,000 materials ranging from conventional materials (e.g. copper, cast iron, brass etc.) to advanced materials (composites, ceramics etc.) for developing new products for various applications. Right material and manufacturing process selection is the key parameter for success of any business due to wide choice of materials available. Based on their major properties like stiffness, density, melting temperature etc. these materials can be divided into four broad categories: 1) metals 2) plastics 3) ceramics 4) composites [1].

1.2 WHY A COMPOSITE

Technical advancements in field of composites have made it possible to manufacture laminated composite materials possessing unique customised properties such as high strength/stiffness for lower weight, superior fatigue response characteristics, facility to vary fibre orientation, material and stacking pattern, resistance to electrochemical corrosion etc. Due to this there is increased demand of such materials in a large variety of structures including aerospace, marine and civil infrastructure [2]. Availability, renewability, low density, and price as well as satisfactory mechanical properties are some of properties due to which natural fibre like jute, coir, kenaf, hemp etc. are much more preferred over glass, aramid and other artificial fibres [3, 4].

The natural fibre composites are more eco friendly, and are used in transportation (automobiles, railway coaches, aerospace), military applications, building and construction industries (ceiling panelling, partition boards), packaging, consumer products, etc.
1.3 WHAT IS A COMPOSITE

A composite material can be defined as a combination of two or more materials that results in better properties than when the individual components are used alone. As opposed to metal alloys, each material retains its separate chemical, physical and mechanical properties. Individual components of composite can easily be identified by naked eye on macroscopic examination. The two constituents are normally a fiber and a matrix. Typical fibers include glass, aramid and carbon, which may be continuous or discontinuous. Matrices can be polymers, metals or ceramics [5, 6]. The reinforcing fiber or fabric provides strength and stiffness to the composite, whereas the matrix gives rigidity and environmental resistance. Reinforcing fibers are found in different forms, from long continuous fibers to woven fabric to short chopped fibers and mat. Each configuration results in different properties.

Fig. 1.1 Formation of composite material [1]
As defined by Jartiz [7], composites are multifunctional material systems that provide characteristics not obtainable from any discrete material. They are cohesive structures made by physically combining two or more compatible materials, different in composition and characteristics and sometimes in form.

According to Berghezan [8], The composites are compound materials which differ from alloys by the fact that the individual components retain their characteristics but are so incorporated into the composite as to take advantage only of their attributes and not of their shortcomings in order to obtain an improved material.

Kelly [9] very clearly stresses that the composites should not be regarded simple as a combination of two materials. In the broader significance, the combination has its own distinctive properties. In terms of strength or resistance to heat or some other desirable quality, it is better than either of the components alone or radically different from either of them.

Van Suchetclan [10] explains composite materials as heterogeneous materials consisting of two or more solid phases, which are in intimate contact with each other on a microscopic scale. They can be also considered as homogeneous materials on a microscopic scale in the sense that any portion of it will have the same physical property.

1.4 CLASSIFICATION OF COMPOSITES

Geometry of reinforcement is the major factor contributing towards mechanical properties and excellent performance of composites. Based on it composites can be classified into two major categories as (1) Particulate composites (2) Fibrous composites. Fig. 1.2 shows the classification of various composite materials.
Composite materials

Fiber-reinforced composite (Fibrous composites)  Particle-reinforced composite (Particulate composite)

Random Orientation  Preferred orientation

Single layer composites  Multi-layered (angle-ply)
And multi-layered composite
Composites having same Properties in each layer

Laminates  Hybrids

Continuous-fiber-reinforced Composites  Discontinuous-fiber-reinforced Composites

Unidirectional Reinforcement  Bidirectional Reinforcement (Woven reinforcements)
Random orientation  Preferred orientation

Fig. 1.2 Classification of composite materials [11].
(1) Particulate composites
It comprises of particles embedded or dispersed in matrix body. The particles may be in form of flakes or powder. Square, triangular and round shapes of reinforcement are known, but the dimensions of all their sides are observed to be more or less equal. They improve stiffness of composite to some extent but cannot improve fracture resistance. Particle fillers are widely used to improve the properties of matrix materials such as to modify the thermal and electrical conductivities, improve performance at elevated temperatures, reduce friction, increase wear and abrasion resistance, improve machinability, increase surface hardness and reduce shrinkage.

(2) Fibrous composites
Fiber composites consist of matrices reinforced by short (discontinuous) or long (continuous) fibers. Fibers are generally anisotropic and examples include carbon and aramids. Examples of matrices are resins such as epoxy, metals such as aluminum, and ceramics such as calcium–alumino silicate. The performance of a fiber composite is judged by its length, shape, orientation, and composition of the fibers and the mechanical properties of the matrix [12].

1.5 NECESSITY OF INCORPORATING RED MUD FILLER IN COMPOSITE

The higher cost of composites is the only factor hampering its use in majority of industrial applications in spite of possessing customised properties specific to given application. Researchers have found that the most effective way to bring down the cost of composites is to add low cost and easily available filler to it. However, mechanical properties of the composites should not be degraded in the attempt of reducing the cost. Therefore, purpose of use of fillers is firstly to improve the mechanical, thermal or tribological properties, and secondly to reduce the cost of the component [13].
Extraction of alumina from bauxite by Bayer’s process leads to generation of large quantity (55-65%) of red mud which is a waste material. Red mud is being accumulating at an increasing rate throughout the world (nearly 30 million tons per year). Disposal of red mud is a severe problem as it is highly alkaline and produced in huge quantities [14]. Because of leakage of alkaline red mud liquor into the ground there is a probability of ground water contamination. Also it can cause dust pollution in arid region as it is mostly in form of fine dust with particle size of order of 42 microns. Bauxite processing industries in Jamaica produces red mud which is sufficient to bury 700 football grounds and their goal posts [15]. Direct disposal of red mud into sea creates problem to marine flora and fauna. It also reacts with magnesium of sea water and creates additional finely divided solids changing the physico-chemical conditions of area. Therefore, an attempt is made here to use red mud as particulate filler in polymers for developing composites to obtain low cost, light weight, high strength, and wear resistant composites.

1.6 THESIS OUTLINE

The remaining thesis is organized as follows

Chapter 2 involves literature review of existing knowledge pool in area of interest and presents the work done by various researchers in area of fiber and particulate reinforced polymer composites.

Chapter 3 explains details of raw materials, manufacturing methods and test procedures used for mechanical characterization of composite under study.

Chapter 4 discusses the experimental set up and finite element analysis, boundary conditions, loading details for buckling analysis.

Chapter 5 is concerned with experimental and finite element vibrational analysis using ANSYS 12.1. It explains the details of TMR211 analyzer for
experimental vibrational analysis and also the loading and boundary conditions for vibration analysis using ANSYS.

Chapter 6 includes the results and detailed discussion of mechanical characterization to determine tensile, flexural, hardness and compressive properties. It also gives details of results of bucking and vibration analysis done to determine critical buckling load and natural frequency of vibration of composite plates.

Chapter 7 provides summary and conclusion drawn from above analysis along with scope for future research

Fig. 1.3 gives the complete flowchart of research work
Fig 1.3 Flowchart for research work

- Start
  - Mixing polyester resin and coir fiber along with filler
  - Preparing composite plates with hand layup method
  - Cutting specimens from plates for testing as per ASTM standards

- Mechanical Properties obtained
  - Yes → Buckling Analysis (ANSYS)
  - No

- Experimental Buckling Analysis
  - Is critical buckling load same by ANSYS and Experiment
    - Yes → Vibration Analysis (ANSYS & MATLAB)
    - No

- Experimental Vibration Analysis
  - Is fn(ANSYS) = fn(Exp)
    - Yes → Data Analysis and Plotting
    - No

- End