CHAPTER 1

INTRODUCTION

1.1 GENERAL

The development of transportation infrastructure is the key to overall development of a country. For countries like India, where resources are limited, the importance of rural / unpaved roads is to be highly emphasised. The subgrade, which is the bottom most layer of the pavement, is made up of compacted soil and so also for the highway and railway embankments. The road alignment is decided based on many factors of which one is the availability of good soil along the proposed alignment. In early days, areas having weak soil deposits were avoided while fixing up the alignment. But with scarcity of land and other resources, we do not have the choice of land and hence roads and embankments have to be built on weak soil deposits. These problematic soils have one or more of the short comings viz., low shear strength, high compressibility, low hydraulic conductivity, swelling and shrinkage, susceptibility to frost action etc., and hence are associated with problems such as low bearing capacity, high settlement, high seepage loss, liquefaction during earthquake and instability of foundation excavation. In such cases, it is often impossible to build a stable base course over soft subgrade, without loosing expensive base material which penetrate into the soft subgrade soil and hence a ground improvement method has to be resorted to.

Ground improvement is a general term used for the modification of soil to enhance the strength and other engineering properties. There are many methods of ground improvement such as using additives (like cement, lime etc.), compaction (both static
and dynamic), thermal stabilisation etc. One of the methods, which got momentum in recent years, is the concept of reinforced soil. Though the principle was not clearly enunciated, people have used techniques of reinforcing earth for centuries. The modern concept of reinforced soil was however coined by Henri Vidal in 1963 (Vidal, 1969). The reinforced earth system proposed by Vidal used metal strips as reinforcements. With the development in the field of polymer technology, a wide variety of geosynthetic materials have come up. Geosynthetics, both natural and polymeric, establish a family of geomaterials, which are used in a wide variety of civil engineering applications.

According to ASTM D4439 (2004) a geosynthetic is defined as “a planar product manufactured from polymeric material, used with soil, rock, earth or other geotechnical related materials, as an integral part of a human made project, structure or system”. There are eight types of geosynthetics, namely, geotextiles, geogrids, geonets, geomembranes, geosynthetic clay liners, geopipes, geofoams and geo composites (Koerner, 2005). These products generally have a long life and do not undergo biological degradation, but are liable to create environmental problems in long run.

Geotextiles form one of the largest groups of geosynthetics. Its growth rate in the industry during the past fifteen years has been nothing short of awesome. They are indeed textiles in the traditional sense, consisting mainly of synthetic fibres, though natural fibres are also used for manufacturing. They can be Woven or Non-woven type. There are enormous specific application areas for geotextiles, even though the fabric always performs at least one of the five discrete functions, viz., separation, reinforcement, filtration, drainage and moisture barrier (when impregnated). One of
the most popular applications of these materials is in the construction of pavements and embankments on soft soil.

The consumption of polymeric geotextiles in India is insignificant compared to the worldwide consumption. The main factor inhibiting the use of geotextiles on a large scale in India is their high cost (Rao and Balan, 1994). In addition to the low cost of natural fibres, the growing concern over the impact of the use and disposal of synthetic materials has recently led to a renowned interest in the possible advantages of natural geotextiles. In many ground-engineering problems, geosynthetics are mainly required to perform its function in full capacity, only for a limited duration: for example, within temporary haul roads, basal reinforcements for new embankments, vertical drainage to increase shear strength, etc.. In most of the cases, the geosynthetic capacity is surplus to the requirements during the later periods of the working life of such systems. In such situations, the deliberate and designed use of a geosynthetic system, which has a predictable reduction of capacity with time, is a good engineering practice. Natural geotextiles made of coconut fibre, jute fibre, sal, etc. can be used as an alternative to polymeric geosynthetic materials. It is even possible to have tailor made composites of natural fibres to produce a material with required strength - time profile.

Coir geotextiles with Indianised connotation “Coir Bhoostra”, a generic member of the geosynthetic family, is made from coconut fibre extracted from the husks of coconut fruit. Like their polymeric counter parts, coir geotextiles can also be synthesised for specific applications in civil engineering like erosion control, ground improvement, etc. (Rao and Balan, 2000). The use of biodegradable natural materials is gaining popularity in rehabilitation of areas damaged either by natural or industrial
causes, especially in the light of growing awareness of sustainable development throughout the world.

1.2 MOTIVATION

India is one of the leading coir producing countries. Coir industry provides employment to people belonging to weaker sections of the society in rural and coastal areas. To protect the traditional coir industry and to make it possible to meet the challenges in structured development of the nation, the development of new products and new horizons of varied applications of the existing products is necessary. At present, coir geotextiles account for only a fractional share of the global market of geotextiles. While the world focus is shifting to natural geotextiles, India as a producer of coir geotextiles, has much to gain by using it for meeting the domestic as well as global demands. The country’s limited exposure to engineering projects using geotextiles, limited eco sensibility, priority resource constraints for environmental issues are reasons for coir geotextiles not being consumed for engineering applications in the country. The potential end users, designers and, rather, the decision makers are not fully aware of the product availability and its applicability in different areas. More research works need to be carried out to explore the possibilities of utilising coir fibre based products. Coir geotextile is one among them, which has wide and versatile application in civil engineering and infrastructure development. The proper utilisation of coir geotextiles in various applications demands large quantities of the product, which in turn, can create a boom in the coir industry.

Though huge amount of research work has been done and reported in the area of unpaved roads and embankments using polymeric geotextiles, only very limited work has been reported in the area using natural geotextiles. Even in the area of natural
geotextiles, work utilizing coir geotextiles are comparatively less. The majority of works carried out in the field of coir geotextiles are related to erosion control and watershed management. Only a few works have been reported regarding the utilisation of coir geotextiles for roads and embankments and a systematic research work in this area is lacking.

The present work aims at establishing the potentiality of coir geotextiles for the construction of unpaved roads and embankments, by analysing its various engineering properties, including the strength and drainage aspects.

1.3 ORGANISATION OF THE THESIS

In chapter 1, a brief introduction is presented where the state-of-the-art technology of using geotextiles is highlighted. The motivation behind the work is also discussed.

Chapter 2 discusses the objectives and scope of the investigations. The significance of the work also forms a part of this chapter.

Chapter 3 presents a comprehensive summary of the literature associated with the present study. Use of geotextiles, both polymeric and natural, for pavements and embankments are reviewed in detail. Analytical and experimental investigations dealing with frictional characteristics of coir geotextiles, strength aspects in terms of California Bearing Ratio, unconfined compressive strength, bearing capacity, drainage aspects and behaviour of soil-fibre composites are given due attention.

In chapter 4, a detailed description of coir geotextiles is given. All aspects of production, properties and application areas of coir geotextiles are discussed.
The property characterisation of the various materials used in the study is discussed in chapter 5. The properties of soils, coir geotextiles and aggregates are also detailed.

Chapter 6 presents the details of the laboratory experimental works conducted to study the interface friction characteristics of coir geotextiles with different subgrade materials used in unpaved road construction. The test set-up developed and fabricated for the present study is well explained. The procedure for experiments conducted is also explained in detail.

The experimental works to obtain the strength parameters, particularly CBR, of the coir-reinforced soil under varied conditions are detailed in chapter 7. A regression model is built to estimate the modified CBR of the subgrade soil, in terms of the strength characteristics of the soil and the coir geotextiles, which is also discussed here.

Chapter 8 presents the study related to the bearing capacity of coir reinforced soil. Details of the experimental set-up, the test procedure and the results in terms of bearing capacity ratio in dry and saturated conditions are discussed.

In chapter 9, the rut behaviour of coir reinforced unpaved road sections are dealt with. Effects of wheel loads were studied by conducting tests on water bound macadam sections with coir geotextiles at subgrade - base interface. The experimental set-ups for both static and repetitive loading conditions along with discussion of the results are given.

Preparation of design charts and design methods of unpaved roads using coir geotextiles are described in chapter 10. Design charts are prepared for the design of
unpaved roads for different rut depths. Step by step procedure for three design methods are explained with illustrative design examples.

Effects of coir geotextiles on the drainage aspect in road embankments in the form of vertical drains are discussed in chapter 11. Fabrication and installation of two different types of drains are discussed along with different configurations, their time-settlement behaviour and efficiency.

Chapter 12 contains the details of the experimental work done on soil-coir fibre composites, which forms the part of the subgrade after degradation of coir geotextiles. Effects of fibres on strength and compressibility characteristics of soil are studied and the results are discussed.

Major conclusions drawn from the present investigations, and a mention about the scope of future works are presented in chapter 13. This chapter is followed by references and bibliography.