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Use of Geosynthetics in Civil Engineering Applications

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ABSTRACT:
Geosynthetics have defined their place in the domain of civil engineering. They find their applicability in geotechnical and geo-environmental engineering in retaining walls, landfill liners, ground improvement works, transportation engineering in rail and road networks, slope stability analysis and coastal engineering for coastal protection. Use of geosynthetics increases bond in the soil system due to the interlocking of soil particles with the reinforcement aperture as well as enhancing the bearing resistance of the transverse members of the reinforcement. The aim of this study is to enumerate the various types of geosynthetics and their beneficial applications and the requisite mechanical properties to attain high efficiency in all these applications.

I. INTRODUCTION:

Most of the geosynthetic materials presume a passive role as in acting as a barrier in trying to stop the passage of fluids or as a reinforcement to provide tensile strength. The geosynthetics are specially manufactures to play a specific function for the explicitly designed and constructed structures (Koerner,1994).In the recent years, the usage of geosynthetics has increased rapidly in various fields of civil engineering such as geotechnics with the expansion of the usage area of geotextile products with different functions and the creation of geomembrane, geogrid and geocomposite products (Han and Thakur 2015, Van Santvoort 1994).

Types of Geosynthetics and their functions

The major functions served by geosynthetics include filtration, and drainage, as a separator and as a reinforcement or for containment. Geosynthetics can be broadly classified into categories, based on method of manufacture as presented below:

- **Geotextiles** are continuous sheets of woven, nonwoven, knitted or stitch-bonded fibres or yarns (Vinod and Minu 2010, Laurinavicious et al. 2006). The sheets are flexible and permeable and generally have the appearance of a fabric. Geotextiles are used for separation, filtration, drainage, reinforcement and erosion control applications.
- **Geogrids** are geosynthetic materials that have an open grid-like appearance. The principal application for geogrids is the reinforcement of soil.
- **Geonets** are open grid-like materials formed by two sets of coarse, parallel, extruded polymeric strands intersecting at a constant acute angle. The network forms a sheet with in-plane porosity that is used to carry relatively large fluid or gas flows.
- **Geomembranes** are continuous flexible sheets manufactured from one or more synthetic materials. They are relatively impermeable and are used as liners for fluid or gas containment and as vapour barriers.
- **Geocomposites**are geosynthetics made from a combination of two or more geosynthetic types. Examples include: geotextile-geonet; geotextile-geogrid; geonet-geomembrane; or a geosynthetic clay liner (GCL). Prefabricated geocomposite drains or prefabricated vertical drains (PVDs) are formed by a plastic drainage core surrounded by a geotextile filter.
- **Geosynthetic clay liners (GCLs)** are geocomposites that are prefabricated with a bentonite clay layer typically incorporated between a top and bottom geotextile layer or geotextile bentonite bonded to a geomembrane or single layer of geotextile. Geotextile-encased GCLs are often stitched or needle-punched through the bentonite core to increase internal shear resistance. When hydrated, they are effective as a barrier for liquid or gas and are commonly used in landfill liner

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applications often in conjunction with a geomembrane.

- **Geopipes**are perforated or solid-wall polymeric pipes used for drainage of liquids or gas (including leachate or gas collection in landfill applications). In some cases the perforated pipe is wrapped with a geotextile filter.
- **Geocells** are relatively thick, three-dimensional networks constructed from strips of polymeric sheet. The strips are joined together to form interconnected cells that are infilled with soil and sometimes concrete.
- **Geofoam** blocks or slabs are created by expansion of polystyrene foam to form a low-density network of closed, gas-filled cells. Geofoam is used for thermal insulation, as a lightweight fill or as a compressible vertical layer to reduce earth pressures against rigid walls.

Fig.1: Pictorial Illustration of Geogrid and Geofoam.

Physical Properties of Geosynthetics

Geosynthetics are fibrous materials made of elements such as individual fibers, filaments, yarns, tapes, etc. that are long, small in cross section and strong in tension. It is desirable that the geosynthetics are flexible, highly durable and resist the hostile environment of adverse temperature and pressure conditions.

Applications of Geosynthetics

It is imperative that before design can take its place, it is very important to identify the expected functions of the geosynthetic in the considered application. The performance of geosynthetics when used as a reinforcement depends highly on the mechanical and hydraulic properties when serving as a filter and performing the drainage functions. When used in landfills, the geotextiles or geosynthetic clay liners are subjected to harsh conditions of permeation with highly contaminated leachate, high temperatures, pressures. Thus, while testing the geosynthetics for their performance, they ought to be tested for liquids possessing similar characteristics as leachate to substantiate the exact conditions and to adjudge the actual hydraulic conditions at site. Most applications involve transport and storage of materials, construction in relatively harsh environments and the necessity for a long service life, for which endurance and durability properties play a very significant role.

Use of geotextiles, geomembranes and geosynthetic clay liners in Landfills

A few decades ago, compacted clay layers of greater thickness were used to line the waste repositories before the advent of geosynthetics. Now, geosynthetics form an essential component of a barrier materials in landfills. Different engineered liner systems used nowadays include:

• Composite clay liner (CCL) – Currently engineered liner systems are usually a composite of a compacted clay layer and a geosynthetic membrane together with drainage and fluid collection layers. Generally, low permeability soil ($k < 10^{-9}$ m/s) is used as a barrier material in landfill/ containments so that it should resist the infiltration of water into the soil. However, it is not always possible to procure good quality clayey soils locally. If it is to be transported from long distances, it puts a financial constraint for the development of such disposal facilities, especially in developing countries like India. Due to burgeoning increase in the population and industrialisation, the land availability for taking out the earth/borrow sites has been limited and expensive.

• Fabricated Soil Liner (FSL) – If the soils found in thevicinity of a waste disposal facility are not sufficientlyclayey to be suitable for direct use as a liner material, itis advisable to blend natural soils available on or nearthe site with appropriate amounts of bentonite with/withoutadmixture to fabricate a liner. Bentonite is extremelyabsorbent granular clay formed from volcanic ash.

• Geosynthetic clay liner (GCL) – In many cases GCLsare used, which are factory-manufactured clay liners,5–10 mm thick consisting of a thin layer of bentoniteclay encased between two geotextiles or glued to ageomembrane. The use of GCLs appears suitable or isrecommended where vertical settlements are foreseen. Itis also used for the capping of landfills where stresses arelower and a high degree of flexibility is required (Bouazza 2002). The major benefits of GCL are the limited thickness providing more airspace, good compliance with differential settlements of underlying soil or waste and ease of installation.

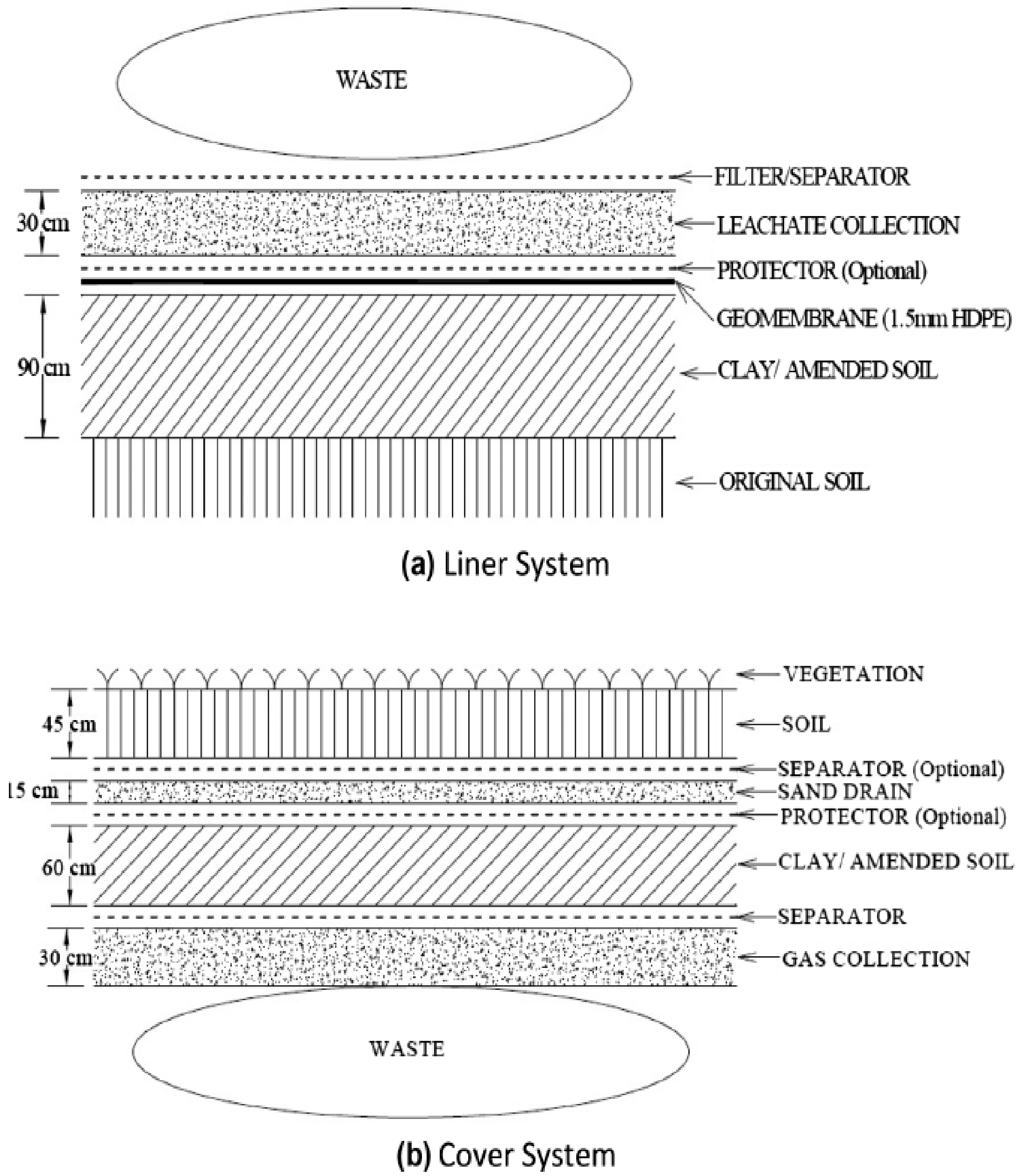

Fig. 1: Liner and cover system for Compacted Clay Liners and Fabricated Soil Liners (CPCB 2008)

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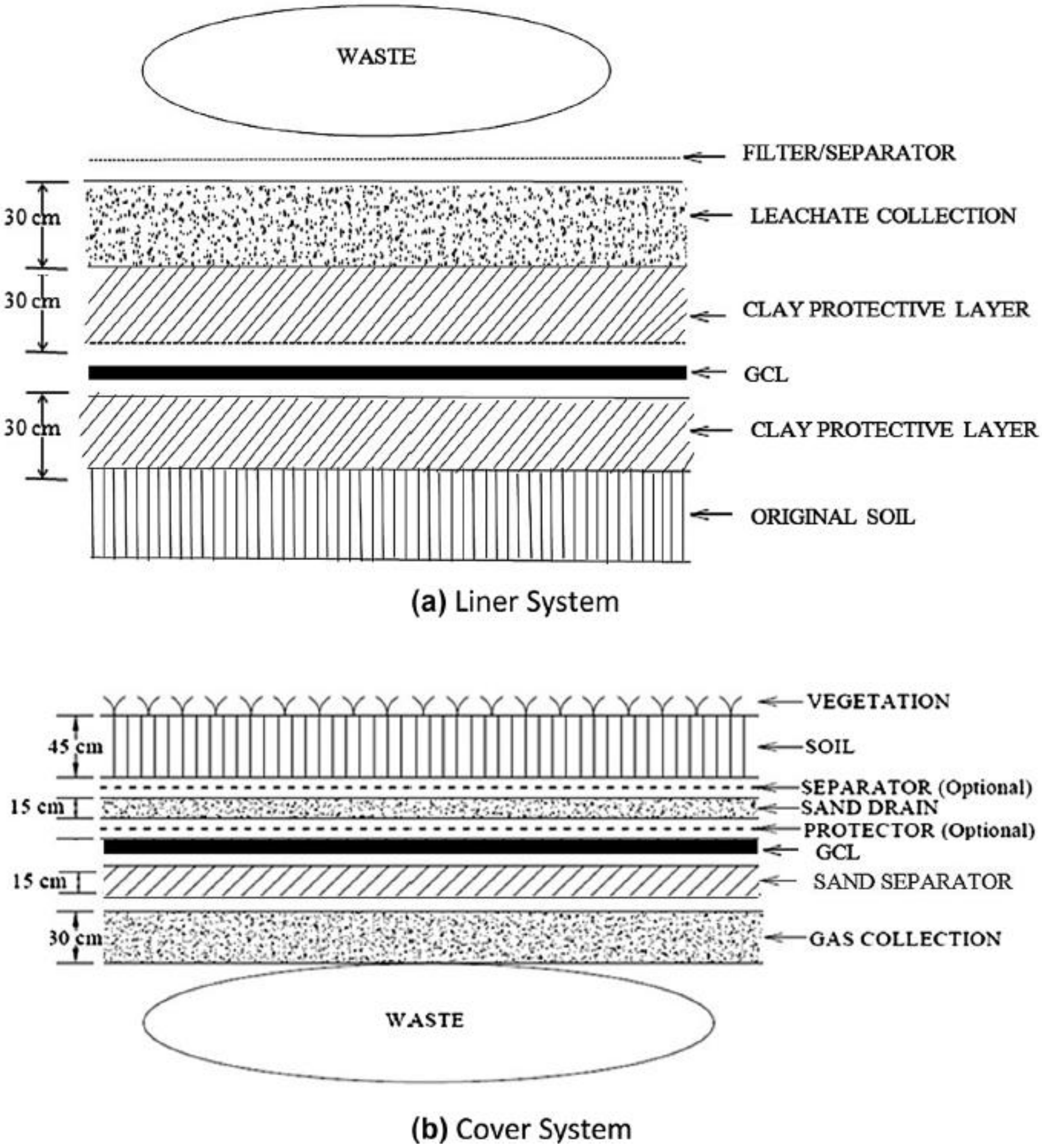

Fig 2: Liner and Cover systems for Geosynthetic clay liners (Sobti andSingh,2017)

Figures 1 and 2 show typical cross sections of liner and cover systems for CCL, FSL and GCLs. Liner system for CCL and FSL consist of a 0.9 m thick layer of compacted clay or amended soil, respectively, overlain by a 1.5–2 mm thick HDPE geomembrane along with leachate collection layer. The waste material is provided with a cover, 1.2–1.5 m thick, comprising a 0.3 m thick soil as gas collection layer, 0.6 m clay or amended soil and 0.15 m granular material for drainage purpose overlain by 0.45 m natural soil supporting vegetation. A layer of geotextiles may be provided at the interface between different component layers. For GCL as a liner material, a 0.3 m thick clay layer is provided above and beneath the GCL layer 5–10 mm thick, separated by a geotextile protective layer. A leachate collection layer is provided just below the waste material to be deposited. But, GCLs are mostly used for capping the landfills, which consists of a gas collection layer, drainage layer and a sand protection layer 0.15 m thick, below the GCL layer. At the top, a 0.45-m-thick soil layer is provided which supports the vegetation, like the CCL and FSL.

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Use of geotextiles in slope stability

In the hilly areas, especially in the rainy season, landslides are common. The unsupported slopes possess high shear strength when in dry state or partially saturated condition and remain stable usually at angle of inclination greater than the angle of internal frictionof the soil due to development of negative pore waterpressures. In rainy season, soil becomes saturated and the negative pore water pressure gets reduced leading to low effective stress and low shear strength resulting in slope stability issues. In such situations,geotextiles come to the rescue as they can be used as a reinforcement to strengthen the soil and improve upon the shear strength property. The geotextile may be used in multiple horizontal layers within theslope.

II. CONCLUSION

Geosynthetic materials which started to be used in the field of geotechnical engineering with the fabrication of geotextile materials in the 1960s, are now widely used in many fields of civil engineering. The safe disposal of waste materials, both domestic andhazardous, requires a detailed geoengineered solution. The usage of geosynthetics in landfills as liner materials have been discussed at length in this paper along with other applications. The possibility and successful applications of different categories of geosynthetics in other fields may also be explored further in this regard.

Competing Interest / Conflict of Interest
The author declare that they have no conflict of interests.
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