

SUITABILITY OF GEOCOMPOSITE LAYER FOR FLY ASH PONDS

Suresh Kommu Research Scholar, Department of Civil Engineering,
Koneru Lakshmaiah Education Foundation, Vaddeswaram, Guntur, Andhra Pradesh, India

Assistant Professor Department of Civil Engineering,
VNR Vignana Jyothi Institute of Engineering and Technology, Hyderabad, Telangana, India

SS.Asadi Associate Dean Academics & Professor, Department of Civil Engineering, Koneru Lakshmaiah Education Foundation, Vaddeswaram, Guntur, Andhra Pradesh, India

sureshkommu2015to19@gmail.com

ABSTRACT: At present main source of energy in India are thermal power plants that run on coal for energy production. An estimated total fly-ash produced as by-product from these electric plants yearly accounts to 100 million tons. Fly ash utilisation has picked up by cement factories and others but still percentage is unsatisfactory. This fly-ash is pumped into the ash pond which with time escapes into the environment at the bottom level or from surface. Thus the hazardous waste is a critical challenge to the environment and water bodies, therefore, must be managed at the earliest. Recent GCL or HDPE bottom lining layers are a suggestive solution for preventing toxic materials from seepage into the surrounding areas.

Keywords: Waste dumping yard, fly ash ponds, toxic materials, GCLs, HDPE.

INTRODUCTION:

Due to increasing population and industrialisation efficient disposal and management of the hazardous municipal/industrial wastes are a serious challenge to the environment and human health. Therefore its disposal and treatment should be properly carried out to prevent environmental contamination. Solid/liquid wastes from the industries and households containing toxic chemicals and substances is directly drained into the nearby landfills, mine shafts, lakes, deep wells or ponds. These wastes are hazardous to the underlying ecosystem and in return harmful to human beings itself. Waste from the thermal power plants is dumped into the dumping grounds or fly ash ponds. [1] Disposing such hazardous waste requires it to be isolated from the environment, underlying soil and water to prevent fatal contaminations.

Different methods have been utilised for the fly-ash disposal by thermal power plants, out of which building ash-pond for the discharge of ash slurry is in use widely. Water mixed fly ash slurry (1 part ash with 20 parts water) is pumped into the ash ponds, located at distant location from power plant.

Different measures have been taken to check seepage of leachate into the groundwater, such as lining the bottom layer using clay or synthetic liners. In recent years the Geosynthetic Clay Liner (GCL) system has gained worldwide attention due to its efficiency and cost effectiveness. GCLs are efficiently used as potential hydraulic barriers in landfills by the industries and municipalities for the dumping of hazardous solid/liquid wastes. Layers of Geotextiles/geomembrane along with bentonite, compositely form a GCL system. The GCLs have high hydraulic retention, adsorption, swell capability, etc.

OBJECTIVE:

To find the suitability of Geocomposite layers for the waste dumping yards and fly ash ponds.

GCLs or Geosynthetic Clay Liners

GCLs (Geosynthetic clay liners) are used as anti-seepage lining of the municipal/industrial solid waste landfills, ash ponds, construction of reservoirs, sewage, rainwater storage water pits, tunnelling system, etc. to prevent contamination of underlying soil and ground water by seepage of waste water into the ground water. Geosynthetic clay liners (GCLs) forms a hydraulic barrier or waterproofing layer to the water leaching and thus are gaining acceptance widely as bottom liners and final covers.

GCLs are manufactured by factories using composite layers of sodium bentonite (natural or synthetic) or other highly absorbent low-permeable material inserted between the layers of geotextiles or geomembranes



(formed from HDPE, LDPE, PVC, etc). Utilisation of GCL accounts back to 1982 by its inventor Arthur J. Clem, and since then has gained a worldwide acceptance in a number of environmental containments in protecting soil and ground water from leachate. GCLs are uniquely advantageous over conventional liners and final covers, such as Compacted Clay Liners (CCLs) by the usage of bentonite layers instead of compacted clay, shear performance and cost effectiveness. Major differences between GCLs and CCLs are shown in Table 1 and Figure 1. Bentonite offers low-permeability and its extremely absorbent quality makes it a preferred material for perforations.

Clay Material: Sodium Bentonite / Calcium Bentonite -

Bentonite is a highly expandable clay mineral which gets its name from its place of discovery and use - Fort Benton, America. The multiple properties of bentonite are hydration, swelling, water adsorption, viscosity which makes it a multiple utilisation product for diverse industries. Primarily two varieties of bentonite are available - sodium bentonite (high swelling, gelling and thermal durability) and calcium bentonite (more commonly available worldwide but with less swelling).

An ion exchange can occur at the Sodium (Na) portion of the GCL layer may occur on exposure to cations such as potassium (K), Magnesium (Mg) or Calcium (Ca) from the leachates. Hence, it could affect the hydraulic conductivity performance (HCP) of GCLs and may adversely impact the swelling capacity.

Bentonite is granular clay, formed from volcanic ash which is highly adsorbing. Bentonite due to its hydrophilic capacity rapidly hydrates when exposed to water, leachates, liquids or moisture. Bentonite "self-heals" the GCLs barrier lining by self-hydration, as a result repairing holes and preventing leakage. In laboratory tests on bentonite, it was demonstrated by the researchers that holes up to the size of 35-75 millimetres will self-repair itself, making GCLs an effective barrier system against seepage.

Characteristic properties of Bentonite:

The main criteria for the selection of GCL that defines it as an effective barrier against leakages are its hydraulic conductivity that makes it impervious. The technology of the GCLs should be taken into consideration before choosing barrier systems to ensure its hydraulic conductivity, damage resistance, and other characteristics, with relation to particular landfill sites.

The hydraulic characteristics and conductivity of GCLs are mostly dependent on the quality of the clay used. Bentonite (generally sodium bentonite), formed from the volcanic ash, is a naturally found compound that gives GCLs its distinctive properties. The hydraulic properties of bentonite clay are enhanced by the addition of further additives.

The GCLs must be first allowed to saturate upto certain amount through taking up subsoil water, in order to hydrate the underlying clay (bentonite in most of the cases). This facilitates in the barrier performances and should be done after installation and prior to putting it into function of waste-water management. [7]

The effects of coarse grain soil or subgrade structures (geonets, gravel, etc.) was reported by Rowe *et al.* 2003 stating that an internal erosion was observed under higher hydraulic gradients. [8] Commonly these include ponds, canals, lagoons and wet terrains. Although needle-punched GCLs with reinforced non-woven geotextiles can prevent bentonite erosion and boost performances under laboratory conditions (Rowe *et al.* 2003). A very significant diversity in the exchange mechanism of the liquids among the powdered and granulated bentonites was reported by Bouazza *et al.* [9] while Gates *et al.* [10] showed that the fine powdered bentonite forms an effective seal and hydrates quicker than the coarser granules of bentonite.

Hydraulic Conductivity:

GCL system provides barriers with low hydraulic conductivity (i.e., low permeability). Permeability of GCL products depends on various factors, such as amount and type of bentonite, geosynthetic material, additives and the product organization.

Shan and Lai reported that testing of GCLs swell-percentage showed to have better self-healing features. Further he also declared that the bonding methods for the GCL composites (needle-punching adhesive bonding or stitch-bonding), had a major impact on the self-repairing property of the GCLs. [11]

High-density polyethylene (HDPE):

The HDPE geomembranes are impervious thin layers of films made up of synthetic rubber or plastic. These are highly seepage resistant and have a wide range of applications containment lining and final covers. HDPE geomembrane lining in progress can be seen in Figure 3. HDPE is a thermoplastic polymer of petroleum and is called as alkathene or polythene when utilised for pipes.

HDPE geomembranes are most widely used due to the availability and relative low material costs. It is an excellent replacement that provides UV, Ozone and chemical resistance and is suitable for such application in larger areas. The product is transported in large rolls, having 22.5 width which are heat welded in fields during installation. These geomembranes are highly cost-effective in large, exposed lining projects, and suitable for waste water treatment plants, lagoons, mining applications, landfills, ash ponds. Thickness of HDPE ranges from 40 - 120mil.

HDPE geomembranes are available in smooth, textured and conductive surface finishes. Smooth HDPE are suitable for low permeability projects, while textured are suitable for lining of steep slopes as they provide a high-friction angle against slippage of layers. The differential scanning calorimetry (DSC) and derivative thermogravimetry (TG/DTG) revealed an increase in the thermal stability and in the degree of crystallinity of the HDPE.

Common effects on ground and human health:-

Basically earth’s ecosystem is disturbed

Due to degradation, alterations and disturbances and addition of xenobiotics (human-made) chemicals the natural soil environment earth’s ecosystem is extremely troubled. Improper waste disposal, industrial wastes, agricultural chemicals have lead to such degradations. The chemicals most common to causing hazardous effects are heavy metals, hydrocarbons, solvents, petroleum hydrocarbons, lead, pesticides, naphthalene and benzoates, etc, that are the contaminants mostly produced from the effect of industrialization and increased use of chemicals.

Direct contact with the contaminant vapours, contaminated soil, or the contamination of ground water leads to health hazards and other environment related issues. A time to time mapping and cleanup of the contaminated areas and soil is a time consuming process and expensive task that requires an extensive amount of skills related to computers, geological skills, hydrology and industrial chemistry. Installation of GCLs lining could be a convenient approach and cost effective method to prevent further environmental spoils and health hazards.

Methodology:

FREE SWELL INDEX OF SOILS (IS : 2720 (Part XL) – 1977)

An increase in volume of a soil by free swell test, on submergence in water , without any external constraints. Due to swelling the structures may be damaged, so expensive clays need be identified, firstly, expansion characteristics. Take two 5 g of soil of oven dry soil passing through 425-micron IS Sieve.

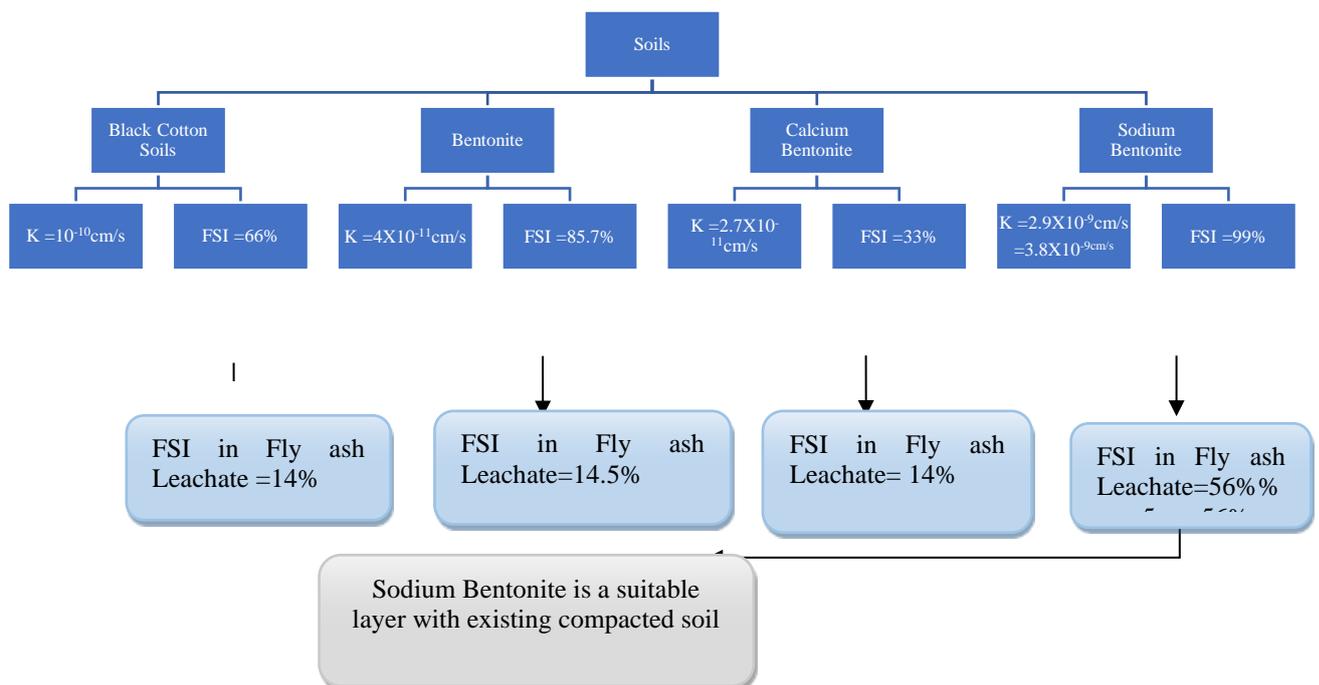
Two specimen shall be poured in the two glass graduated cylinders of 100 ml capacity. One cylinder shall then be filled with kerosene and the other with distilled water up to the 100 ml mark. By removing the entrapped air, the soils in both the cylinders shall be allowed to settle. After 24 hrs. the soil sample to attain equilibrium state of volume without any further change in the volume of the soils. The final volume of soils in the cylinders shall be read out. The free swell index of the soil shall be calculated as follows:

$$\text{Free swell index, percent} = [(V_w - V_k) / V_k] \times 100$$

where V_w = the volume of soil specimen read from the graduated cylinder containing distilled water, and V_k = the volume of soil specimen read from the graduated cylinder containing kerosene.

The following flow chart shows the free swell index values in distilled water and fly ash leachate, in both the cases free swell is more for Bentonite clay. Hence it was suggested as suitable clay liner for fly ash ponds and municipal dumping yards.

Flow Chart:



CONCLUSION:

The hazardous waste from industries and municipal is leading into pollution of the groundwater and the surrounding sources. The toxic materials as chemicals and solid wastes add to the water bodies as leachate and thus contaminating it. Geotextile Clay Liners are advisable for the prevention of waste water seepage and into the surrounding areas. GCLs are suitable and more efficient over Compacted Clay Liners, as they are cost effective, easy to install, require less man power, require lesser time for the installation, the air-space needed for the lining is less therefore more volume is left for the wastes. Due to the presence of bentonite, it is self-repairing a good hydraulic barrier. GCLs are also suitable as they can be installed anywhere due to their availability and transportability. GCLs can hydrate from the subsoil and therefore can be used in arid areas. Moreover geomembranes provide lower permeability than geotextiles they are preferred over geotextiles. And also it is found that swelling is more than the other soils for Bentonite clay, hence it is suitable layer for fly ash ponds as well as municipal waste dumping yard.

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