Geosynthetic Clay Liner as Landfill's Leachate Barrier

Mochamad Arief Budihardjo, Amin Chegenizadeh and Hamid Nikraz

***Abstract*—**Most of landfill sites in developed countries have used Geosynthetic clay liners (GCLs) as landfill leachate barriers to protect the environment. GCLs have some advantages in their shape, availability, easy in installation and mostly hydraulic performance. However, the GCLs also have some limitation for their resistance toward puncture, shear strength and bentonite loss in transport and handling. During their installation, more attention should be putting on to reduce the risk of GCLs' damage that can compromise their performance. In this paper, a discussion of some advantages and disadvantages of GCLs as landfill liners will be presented to provide a clear understanding of GCLs.

***Keywords* —** GCL, landfill, liner system

I. Introduction

THE amount of solid waste generated increases each year, making it difficult to manage due to the limited space available for disposal as most of the waste ending up at landfill. The most common problems of the landfill site are environmental degradation and groundwater contamination caused by leachate produced during the decomposition process of organic material and rain water fall [1, 2]. The common health effects associated to residence in the area contaminated by landfills' leachate are low birthweight infant and high risk of cancers. It has also been reported that there was an increased of health symptoms such as headaches, sleepiness and fatigue of people living in surrounding landfill areas [3].

According to Rowe Rowe [4], landfill is expected to be able to protect the environment impact specifically groundwater contamination by preventing leachate transport for over decades from opening to closure. Landfill operator formerly lays compacted clay liner (CCL) at the bottom of the landfill site, as a common practice to prohibit leachate infiltration. Over decades, geosynthetic clay liner (GCL) has replaced CCL, and it has been used for landfills liners, in some developed countries.

This paper will summarize the geosynthetic clay liner (GCL) performance based on some research findings and technical paper focusing on landfill application.

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II. Characteristic of GCLs

Geosynthetic clay liner (GCL) is made from some materials. Mainly, it consists of a thin layer of sodium bentonite which is placed in between two layers of geosynthetic (commonly geotextile). These two layers are known as carrier and cover geotextile. The bentonite can be in the form of granular or powder. Commonly, the thickness of GCL ranges of 5 mm to 10 mm. The carrier and cover geotextile can be woven, non-woven or even both. They stick together to form a composite by adhesives, needle punching, stitch bonding or combination of them.

According to some laboratory testings and technical data from the manufactures, the hydraulic performance of GCL is quite promising as a leachate barrier. It has approximately 1 x 10^{-6} cm/sec (dry) to 1 x 10^{-9} cm/sec (saturated) in hydraulic conductivity [5]. According to Rowe and Orsini [6], CGL also be able to hold high hydraulic gradient up to 70 m when placed in a compacted sand as subgrade material. This result shows that the GCL can perform as landfill liner when leachate moulding occurred.

Considering shear strength when the GCL will be installed in a slope, some GCLs are strengthened with a stitchbonding or needlepunching which offers extra internal resistance to shear. The reinforced GCL can provide considerable shear strength in need of specific configuration and composition of the barrier system. However, the reinforced GCL will be more costly comparing to the standard GCL [7].

III. Advantages of GCLs

Comparing to compacted clay liner (CCL), GCL has some advantages mainly in its hydraulic conductivity performance which is lower than CCL when completely saturated and its limited thickness which offers more landfill capacity to the landfill's owner or designer. The GCL also leads in its installation, needs less skilled labour and low cost. The GCL has resistant to the effect of freeze/thaw cycles and easy to repair [7]. The GCL also can perform self repair when posed with any puncture during handling and installation which cause damage of the GCL. Small defect can be healed by the bentonite of the GCL itself after a slight rise of the hydraulic conductivity [8].

The GCL offers flexibility to transport since it can be packed in a roll with about 4-6 meters long and 0.75 m in

diameter. Furthermore, some manufactures can also produce the specific dimension required by landfill owner. This will cut down the dependency on local soil availability and reduce the cost for landfill lining. Even the exact cost per square meter can be vary depending on location, some landfill's designers believe that GCL will be least expensive than CCL, moreover to landfill's site which is quite far from clay quarry.

IV. Disadvantages of GCLs

Among all of the advantages, the GCL also has some limitation and weaknesses. The thin layer of GCL cause the GCL has a possibility to be punctured during or after installation. Even a self healing mechanism can encounter this problem, but a slightly increase in hydraulic conductivity before self repair can result in escaping leachate from the barrier [9]. According to Guyonnet, Touze-Foltz [10], GCL also has a problem with its shear strength, moreover for unreinforced GCL after hydration phase. The internal shear of bentonite inside GCL will be fairly low after swelling; this will trigger instability of the unreinforced GCL to be placed on an extreme slope. Another disadvantage of GCL is loss of bentonite during placement especially for powder bentonite. The loss of bentonite will reduce the GCL performance since the key for hydraulic performance of GCL is dependent to the amount of bentonite per unit area and its uniformity [11].

V. Installation of GCL

According to Rowe and Orsini [6], the GCL will perform optimum as leachate barriers system when laid over a compacted sand although the research conducted by the author also found a low hydraulic conductivity of GCL when lying on other subgrades. Koerner and Narejo [12] suggested to cover GCL with a thicker cover soil since they found that the bentonite will migrate when the particle size of cover soil increased. However, some manufactures recommend using gravel as cover since soil will be eroded easily and flow to the leachate collection system.

During transport and installation, GCLs are more vulnerable to damage. The installer should be careful in handling and laying the GCL during and after installation to avoid hydration. Unconfined swelling of the bentonite will cause the geotextile layers to pull apart and destruct the GCL formation thus will reduce the hydraulic performance of GCL [5]. Manufacturers usually provide with a specific installation procedure to guarantee the optimum performance of GCL, however, the site condition in each landfill location could be vary. A certain consideration should be taken in place in order to maximize the performance of GCL.

The hydration process of the GCL starts immediately when it is laid on the subgrade which content some moisture. The GCL will take up some water from its subgrade. Moreover, when the GCL is covered with soil, the hydration process will be faster. The installer should provide enough seams between each layer of the GCL to avoid any unwanted opening edge among GCL layer.

Some GCL's manufacture usually provide some technical supports to assist the installer in order to obtain maximum performance of the GCL. Since the characteristic of the GCL may varies among manufactures, a careful consideration and installation manual should be follow precisely [5].

VI. GCLs performance issues

GCL can pose an internal erosion or bentonite migration. Some certain condition can cause the occurrences of internal erosion for example subgrade, puncture and static pressure. Rowe and Orsini [6] showed that internal erosion of GCL occurred when placing in gravel and geonet subgrade resulting the rise of hydraulic performance of the GCL. The gravel subgrade also will make significant variation of the thickness of the GCL after consolidation by a certain effective stress [8]. Protection layer of GCL also contributed to reduce the thickness of GCL by giving too much uniform pressure that push the bentonite aside and thinner the GCL in some area. Even the hydraulic conductivity remained remarkably low, but the resistance and durability of the GCL still under questioning.

An upward water pressure should also be considered when a planner decides to employ the GCL as bottom liner in an area with a high groundwater level. Some problems may arise during installation and operational stage. Premature hydration of the GCL will reduce its optimum performance or even worse will destroy the liner system. The underneath water pressure effect is not revealed yet, but it seems a heterogeneous deformation will occur in correlation to different load pressure above the GCL during the operational stage.

Another concern on the GCL is the internal shear resistance of bentonite-geosynthetic or geotextile which is generally low when the GCL is fully saturated. The low internal shear resistance will trigger GCL sliding and collapse when it is installed on a slope. The planner should avoid steep slope to prevent any liner failure [13]. The high hydraulic gradient which is generated by leachate moldings would also put on pressure to the liner system stability.

VII. Summary

Geosynthetic clay liner has become more popular as landfill liner and substitute compacted clay liner in some landfill site in some developed country. The low hydraulic conductivity, thin thickness, easily in transport and installation are some of benefits of GCL among CCL. In spite of its advantages, GCL also has some limitation such us shear strength which is related to instability when installed on the slope and its thickness that make more vulnerable toward puncture. By following the manufacture's procedure installation and some technical consideration such as subgrade, protection layer and handling procedure, the optimum performance of the GCL as landfill liner will be achieved. Other issues remain questioning regarding to GCL are the occurrence of internal erosion and low shear strength that will affect the performance of GCL as leachate barriers system. More consideration should be made when install the GCL in an area with high groundwater.

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