GEOTECHNICAL CONSIDERATIONS FOR WASTE DISPOSAL IN LANDFILLS

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ABSTRACT

Top covers of waste landfills conventionally contain a drain layer over a low-permeable clay liner usually containing smectite minerals. The rate of percolation of the clay liner, which may require tens of years to become water-saturated, determines the downward transport of ions released from the underlying waste to and through the bottom clay liner. The percolation rate is controlled by the composition and density of the upper liner, which should be as tight as possible. This implies a high density and therefore a high swelling potential which must be moderated by proper design. The bottom clay liner is a less effective and reliable barrier since cation exchange will increase the hydraulic conductivity and cause a significant rise in percolation rate and risk of chemical attack by the percolate. The top liner will undergo very moderate strain if the ash fill is effectively compacted and undergoes little self-compaction. Processes that may cause degradation are freezing and drying and require proper design.

I. INTRODUCTION

Solid waste management, in its broad sense, is concerned with the generation, on site storage, collection, transfer, process and recovery, and disposal of solid wastes. The five strategies of the solid waste management may be summarized as:

SOURCE REDUCTION*:* Upto 25% reduction of the per capita waste generation rate may be achievable through increased awareness and the commitment by the public and the industries. For example, purchasing product with minimal packaging, substitute reusable products instead of disposal single use products.

- **RE USE*:*** Re use means finding another or similar use for a product rather than discarding it.
- **RECYCLING:** Recycling involves the changing of the material into another usable form .Examples are uses of recycled papers.
- **ENERGY FROM WASTE*:*** Capturing the heat energy from incineration of refuse.
- ***LAND FILLING:*** Regardless of other options, wastes that cannot be resold as recycles, incineration ashes, will ultimately be disposed of in a landfill.

Clearly, so simple strategy can be used in isolation. The solid waste management field is seeing gradual changes in the mix of the strategies. Whatever is the strategy adopted there may always be a residue that is non recyclable, non combustible and non compostable, making the land filling option as the essential one. The focus of the present text is on the land filling.

The land fill planning and design process usually consists of a phased approach comprising of three stages namely:

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- Planning
- Main design
- Construction – operation design

In the planning phase, the process of site selection, site characterization, finalization of the completed land form layout and section, evaluation of land fill capacity and selection of operating methodology are undertaken. The main design stage deals with design of land fill components – liner and leachate collection facility, gas control facility, cover system, landfill stability, surface water drainage system and environmental monitoring system. The construction operation design process involves detailing of the components like site development, construction schedules, material and equipment requirements, and environmental control during operation as well as closure and post closure programmes. Each of these stages are briefly reviewed here after.

SITE SELECTION

The efficacy of any landfill for solid waste disposal depends upon the selection of proper site and there are several issues that have impact for site selection broadly they can be divided into three categories:

- Economic
- Socio – economic
- Environmental

The geotechnical including the geological and hydro-geological parameters fall within the environmental category. The ultimate aim is to select a site where the greatest protection to the environment is provided. Generally, the silting process involves several stages with a purpose to narrow the list of possible sites. This process finally leads to one or more sites for detailed investigation and analysis. Table1 represents the possible factors that may be considered in assessing the suitability of a site.

II. SILTING CRITERIA

The significance of the criteria with respect to the environmental performance is shown in table below:

Definition and significance of silting criteria

Criteria	Sub criteria	Definition	Signifance
Soils	Permeability	Soil property that governs the rate at which water moves through it	Sub soil permeability impacts release of pollutants to ground water. lower subsoil permeability is preferable for silting
	pH	Indication of acidity and alkalinity	Characterizes tendency of soil to absorb heavy metals greater ph is preferable for silting
	Cation exchange capacity	Capacity of soil to exchange cations	Higher cec is preferable for silting.

		expressed as a sum for all exchangeable cations	
	Surficial soils	Unconsolidated material at the earths surface	Affects degree of attenuation and the need for liners. surgical soils with lower permeability are preferred for silting
Geology	Bed rock and outcropping		Carbonate rocks are susceptible to solution. Fractured rock facilitates pollution migration. sites with more overburden are preferred
	Continuity and mass permeability	Related to open discontinuities , solution channels	Controls the potential of the migration of contaminants
	Faults	Mapped planes or zones of rock fracture along which displacement has occurred	Impacts the stability of the facility and potential release of pollutants

III. LANDFILL LAYOUT

A landfill site will comprise of the area in which the waste will be filled as well as additional area for support facilities. A typical site layout is shown in fig. 1.0 below. Within the area to be filled, work may proceed in phases with only a part of the area under active operation.

LANDFILL SECTION

Landfills may have different types of sections depending on the topography of the area, the depth of the ground water table and availability of the suitable covering material.

- **Trench landfill:** Waste is spread and compacted in an excavated trench . Cover material taken from the excavation is then spread and compacted over the waste to form a basic cell structure. The excavated trenches are usually lined with synthetic membrane liners or low permeability clay or a combination of two to limit the movement of both landfill gases and leachate. Ideally suited to the locations where adequate depth of the covering material is available at the site and where water table is not shallow.
- **Area landfill:** A bulldozer spreads and compacts the waste over the prepared site with a liner and leachate control system . Cover material is then hauled by truck or earth moving equipment from adjacent lands or borrow pits. High ground water conditions necessitate the use of area type landfills.
- **Valley landfills:** Valley, slopes, canyons etc. have been used for landfills the technique to place and compact solid waste in such landfills vary with the geometry of the site.

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IV. LANDFILL CAPACITY

On the basis of the landfill layout and the landfill section, the nominal capacity of the landfill can be computed using the contour map of the area. The actual (usable) capacity of the landfill will depend upon the volume occupied by the cover material (daily, intermediate and final cover) as well as the compacted density of the waste. In addition, the amount of settlement a waste will undergo due over burden stress and due to biochemical degradation should also be taken into account.

V. PRINCIPLES OF DECOMPOSITION IN LANDFILLS

The solid wastes deposited in the landfills decompose by the combination of chemical, physical and biological processes. The decomposition produces solid, liquid and gaseous by products, all of which may be of concern in the overall management of a landfill.

Physical decomposition of the solid waste results from the breakdown or movement of the refuse components by physical degradation and by the rinsing and flushing action of the water movement.

Chemical process resulting in refuse decomposition include the hydrolysis, dissolution / precipitation, sorption / desorption, and ion exchange of the refuse components. Chemical decomposition generally results in altered characteristics and greater mobility of the refuse components, thereby enhancing the rate at which the landfill becomes more chemically uniform.

Biological decomposition occurs with a naturally present bacteria. It is a complex process within landfill sites consisting of biologically mediated sequential and parallel pathways by which refuse is decomposed to various end products.

As a result of the combination of the above mentioned processes the landfill is the form of biochemical reactor.

VI. LANDFILL COVER DESIGN

The primary purpose of the landfill cover is to minimize post closure leachate generation arising from percolation of rainfall and to convert the percolation into surface runoff or evapo – transpiration without eroding the cover. The additional performance of landfill cover design include the following:

- To operate with the minimum of post closure maintenance.
- To allow the site to be returned to some beneficial use as quickly as possible.
- To make the site aesthetically acceptable to nearby residents.
- To accommodate settlement.
- To prevent the blowing of the litter or dust on to adjacent properties.
- To suppress fire dangers.
- To contain gases and vapours.
- To allow placement as each cell is completed.

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The designer has no control over the factors such as weather that affects the water balance at a landfill. Other features will function adequately only if they are designed as a part of the overall cover system. For example, a clay soil cover can be placed to minimize percolation. However, if it is left exposed it may crack and not retain its integrity and will be subjected to erosion.

Consequently, in normal practice the design of a cover employs a series of components. The role of individual components varies, but their combined effect is intended to achieve the desired objectives.

The basic cover contains two primary layers:

- The surface layer
- The hydraulic barrier layer

Additional layers assist the primary function of minimizing the downward passage of surface water into the refuse. The table below illustrates these layers and their primary role.

Primary role of various components within a landfill cover

Cover component	**Primary role**
Vegetative soil cover	Reduces infiltration and wind erosion and provides root zone and temporary moisture retention
Filter layer	Prevents shifting of overlaying cover soil into the drainage layer
Drainage layer	Provides a lateral path for water to exit rapidly
Clay layer	Minimizes infiltration through the cover

VII. GEOSYNTHETICS

The utilization of geosynthetics is a new and rapidly emerging industry with potential application that go far beyond the landfills. The term geosynthetics include geotextiles, geomembranes, geonets, and geogrids. The section of the geosynthetic appropriate for a specific circumstance depends on its required function. Examples of specific function include:

- **Geonets :** For drainage
- **Geogrids :** For slope stability as a reinforcement
- **Geomembranes :** For isolation as a liquid barriers
- **Goetextiles :** For reinforcement, separation, filtration and drainage
- **Geomats :** For prevention of erosion of exposed slopes such as landfill caps

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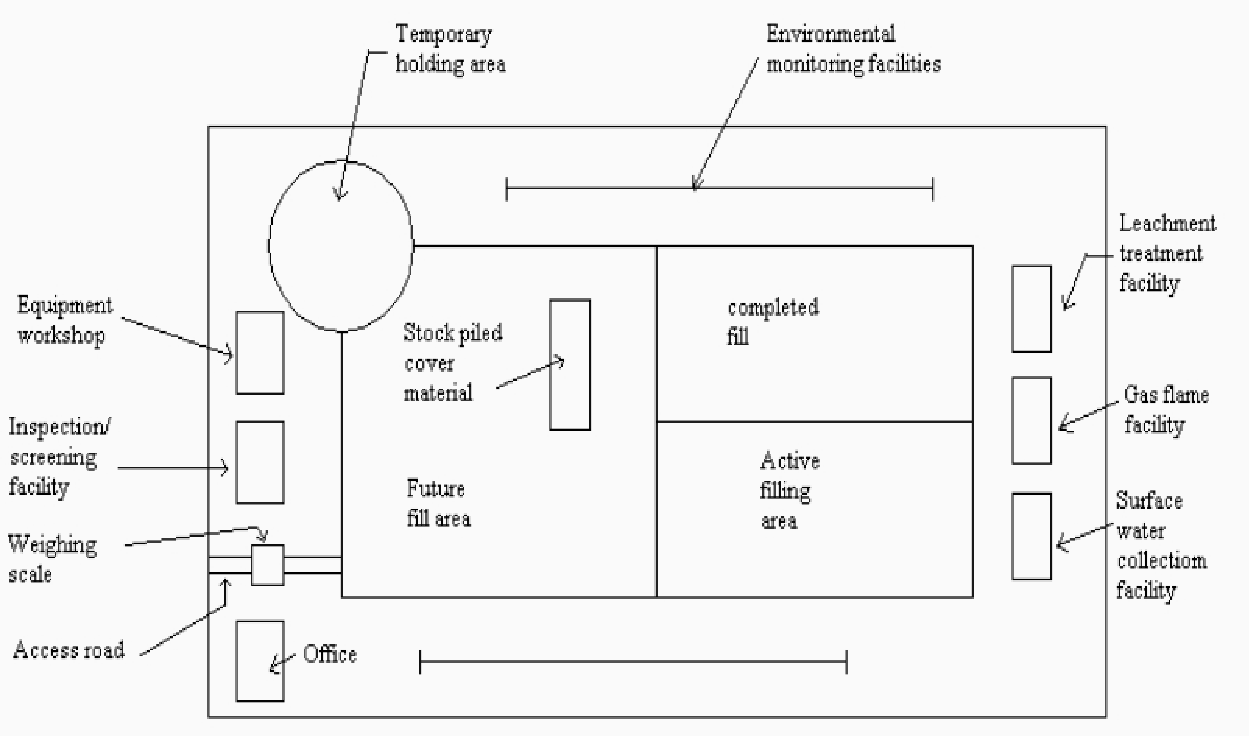

Fig. 01: Typical Layout of land fill site

Fig. 2.a: Above GL landfill

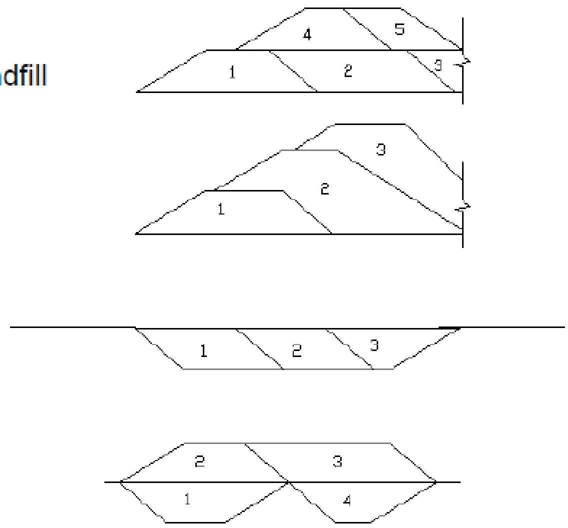

Fig. 2. b: Below GL trench landfill

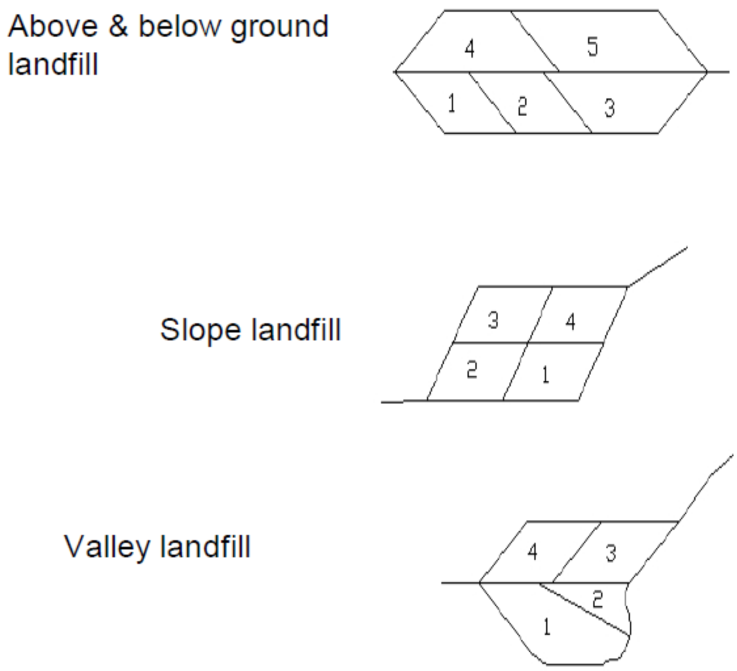

Fig. 3.0: Various possible locations of landfill on grou

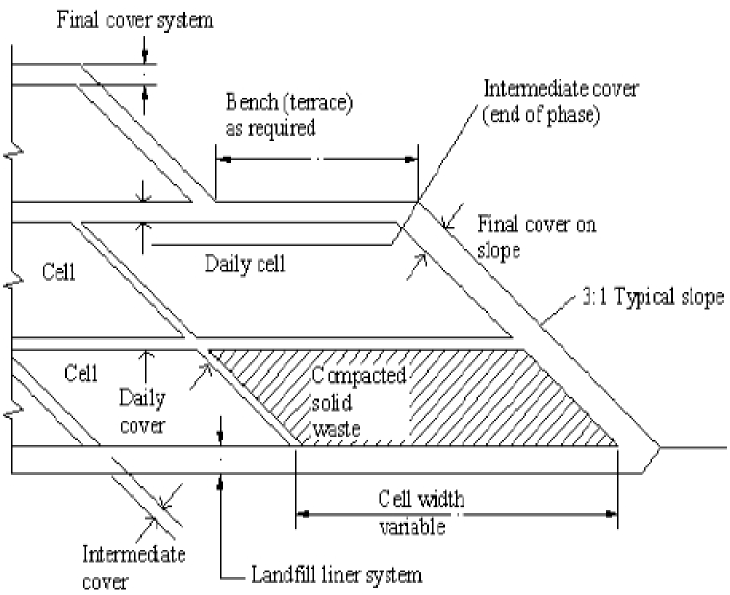

Fig. 4.0: Landfill Details

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VIII. CONCLUSIONS

The most suitable situation of landfill on the ground is in the valley. Geosynthetics works as a effective solution to the easy and efficient operation of landfills. The bottom clay liner is a less effective and reliable barrier since cation exchange will increase the hydraulic conductivity. Physical decomposition of the solid waste results from the breakdown or movement of the refuse components by physical degradation and by the rinsing and flushing action of the water movement. Chemical decomposition generally results in altered characteristics and greater mobility of the refuse components, thereby enhancing the rate at which the landfill becomes more chemically uniform. Biological decomposition occurs with naturally present bacteria, a complex process within landfill sites consisting of biologically mediated sequential and parallel pathways by which refuse is decomposed to various end products. Clay Liners are reinforced composites in covered environmental applications, this material is utilized as an efficient and cost effective replacement for conventional compacted clay with long term performance in harsh environmental conditions.

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