ABSTRACT

Landfills are usually located on outskirts of the cities on flat ground in plain regions. In hilly regions, flat ground for landfilling is scarce. Available unconventional landforms such as sloping grounds, side-hills, valleys, gullies, draws, etc. have to be utilized for making a landfill conforming to regulatory requirements. From literature it is observed that, in hilly regions, landfills are generally constructed at the following potential locations: (a) on a sloping ground; (b) on the side of a hill; and (c) within a valley. However there are several documented major failure cases of landfills in hilly regions which were constructed at such locations.

On the comparatively flat ground in hilly regions potential mode of failure is rotational failure which occurs through the waste mass. Whereas on sloping terrains in hilly regions, the failure along the inclined liner system influences the stability of landfills. The shape of the landfills are different in different landform locations based on the different shape of the terrain/landforms. This fact differs the stability of landfills in hilly regions from plain regions (flat ground). Literature related to the stability of landfills in hilly regions are studied and the present study is undertaken as there is no specific guidelines for design of landfills in hilly regions could be found. The associated challenge is the lack of understanding of the parameters governing the stability of engineered landfills in hilly regions and their consequences in design. Literature related to stability enhancement of landfills with earthen toe berm are not specific about the extent of stability enhancement of landfills in case of hilly regions.

The objective of the present study was to assess the influence of critical parameters on stability of landfills in hilly regions at the three possible locations such as at the three possible locations and to investigate the influence of shear strength parameters of waste as well as interfaces in composite liner system, parameters related to landfill geometry (base length, height of waste, landfill front slope) and terrain/landform geometry (base slope, back slope (side-hill), valley side slope, valley base width, and tapering angle).

In the present work an analytical studies have been undertaken to assess the stability of landfills on a sloping ground; on the side of a hill; and within a valley. For the analyses, range of variation of the values of each parameter has been considered based on extensive literature study. The influence of each parameter on stability of each type of landfills have been investigated by conducting slope stability analyses on a base case by varying the values of the parameters within their respective ranges.

Limit equilibrium methods have been adopted for slope stability analysis. For the sloping ground and side-hill landfill, only two dimensional (2D) limit equilibrium analyses have been performed whereas for the valley fill landfills, three dimensional (3D) limit equilibrium method (LEM) of analysis over and above 2D has been adopted. The analysis have been performed using commercially available 2D (Slope/W) and 3D (Slide3) limit equilibrium based software. In both 2D and 3D analysis results are obtained for Morgenstern & Prices's (M&P) method or General Limit Equilibrium (GLE) method.

The results and findings of the present study provide a better understanding of the critical parameters which governs the stability of landfills in hilly regions and extent of their influence. From the present study, some major findings for each type of landfills have come out. These findings are new and useful for stability analysis of landfills in hilly regions. The major findings for each type of landfills are given as below.

(a) In case of sloping-ground landfills, the most important factor is the critical base inclination ($\beta_{b\text{(critical)}}$) beyond which the failure of the landfill occurs along the entire weakest interface of the liner system. $\beta_{b\text{(critical)}}$ is influenced by the relative shear strength of the waste and interface shearing resistance of the weakest interface of the composite liner system. that high shear strength of the waste and low interface shear strength (along the weakest interface of the base liner system) causes a reduction in $\beta_{b\text{(critical)}}$ and vice-versa.

(b) In case of side-hill landfills, the most important factor is the critical base length $L_b{*}_{\text{(critical)}}$, upto where the influence of back slope (side-hill) is observed. $L_b{*}_{\text{(critical)}}$ is in the range of four to eight (4 to 8) times of height of the waste, H_w*. The influence of back slope is usually to lower the stability of the landfill as in such cases the failure of the landfill occurs along entire weakest interface of the composite base and back liner system. $L_b{*}_{\text{(critical)}}$ is influenced by the relative shear strength of waste mass to the shear strength of weakest interface of the composite liner system. High shear strength of the waste and low interface shear strength (along the weakest interface of the base liner system) causes $L_b{*}_{\text{(critical)}}$ to be high.

(c) In case of valley landfills, the most important factor is the critical valley front base width, ($B_{VF\text{(critical)}}$) upto which the influence of resistance offered by the valley side slopes is observed. The resistance offered by the valley side slopes enhances the stability of a valley landfill. The ($B_{VF\text{(critical)}}$) is influenced by the relative shear strength of the waste and interface shear strength (along the weakest interface of the base and valley side slope liner). High shear strength of the waste and low interface shear strength (along the weakest interface of the base and valley side slopes liner system) cause $B_{VF\text{(critical)}}$ to be high and vice-versa.