Numerical modeling on the drainage problem for a landfill site on a hillslope

Chia-Cheng Fan and Ching-Feng Wu
Department of Construction Engineering, Kaohsiung University of Science and Technology
Kaohsiung, Taiwan China

ABSTRACT

The drainage design is a major concern for the stability problem of a landfill site built on a hillslope subjected to rainfall. Reinforced earth retaining structures are normally designed at the downslope of the landfill to retain waste disposal. The hydrological behavior in the landfill during rainfall can be a critical factor in the long-term stability of reinforced earth retaining structures if the drainage system at the bottom of the site is not properly designed and maintained during the period of operation. This research carries out 3-D numerical analyses to investigate the influence of malfunction in the drainage system on the distribution of water pressures in the waste residual subjected to pumping water in the landfill. The numerical modeling is based on a real landfill site. The performance of total discharge for various scenarios of malfunction in the drainage system at various times is analyzed and discussed.

KEY WORDS: Landfill; drainage; malfunction; numerical modeling

INTRODUCTION

Reinforced earth structures are well developed techniques as retaining structures. For a landfill rested in a hillslope, reinforced earth retaining structures are frequently built at the downslope of the landfill site in order to increase the capacity of the waste materials. The drainage design is a major concern for a landfill site built on a hillslope subjected to rainfall and in turn affects the hydrological behavior in the waste materials in the landfill. It can be a critical factor in the long-term stability of reinforced earth retaining structures if the drainage system at the bottom of the landfill site is not properly designed and maintained during the period of operation. Fan and Chou (2002) reported two failed reinforced earth retaining structures rested at the downslope side of the landfill site in a slope at Wugu and Sanzhi township in Taiwan. Both of the landfill sites were located in a ravine. The reinforced earth retaining structure at Wugu collapsed three days after a torrential rainfall induced by Typhoon Zeb on October 14, 1998. The failure was mainly induced by unexpected water pressure and rainfall-induced infiltration in the landfill. In addition, the reinforced earth retaining structure located at the lower elevation of the landfill at Sanzhi also failed twelve days following the rainfall induced by Typhoon Zeb. The Sanzhi landfill was located in a slop. The inadequate drainage in the landfill was the main cause for the failure of the retaining structure. In addition, Koerner and Koerner (2011) summarized failure cases of eighty-two geosynthetic reinforced earth walls and indicated that sixty-eight percent of them were caused by the improper drainage control. The performance of the drainage system in the landfill subjected to rainfall may be affected by the malfunction in the drainage pipes, e.g. clogging and dislocation in the connection of the pipes.

To investigate the influence of malfunction of drainage pipes on the behavior and performance of the drainage system in a landfill, numerical models (FE analyses) are established based on a real landfill site rested on a hillslope. The effect of malfunction of the drainage system on the distribution of water pressure in the landfill and efficiency of discharge is analyzed and discussed.

NUMERICAL MODELING

The landfill site

The landfill is mainly used for retaining residual wastes that remain after the waste treatment process in an incinerator. The landfill site is rested in a hillslope, and the area of the landfill is 9.17 hectares. To increase the capacity of the landfill, the hillslope was excavated to an elevation of 65 m. The depth of the excavation ranges from 2.5 m to 27 m. Capacity of the landfill is 676,504 m³. The maximum design thickness of the waste is 25 m. The landfill site has been operating for about 15 years. The reinforced earth retaining structure rested at the downslope of the landfill is 12 m high and 110 m long. The reinforced earth retaining structure in the landfill site experiences a noticeable outward deformation on its face, and the subsidence in the reinforced earth retaining structure is significant and reaches about 1.5 m. Considerably high moisture content in the backfill of the reinforced earth retaining structure can be observed through the water stains on the front face. Figure 1 shows the landfill site in February, 2013. The waste materials have been dumped to the elevation of the top surface of the reinforced earth retaining wall in 2012. The landfill site prior to construction is mostly covered by top soils underlain by sandstones embedded with thin-layer mudstones. Thickness of the top soil is 2 to 4 meters. The rock bed is exposed at the bottom of the landfill site prior to operation.