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Study on the Rapid Drawdown and Its Effect on Portal Subsidence of Heybat Sultan Twin Tunnels in Kurdistan-Iraq

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Abstract

The excavation of tunnels below the water table causes variations in the hydraulic level, pore pressure and effective stresses. In this regard, rapid drawdown is considered as a destructive phenomenon as to the change in the flow regime which has mostly been studied for the reservoirs of embankment dams. The rapid drawdown occurred at the upstream shell of the dam gives rise to increase in the pore pressure at the upstream shell. This is as a result of the incompliance between the water loss inside the shell and the reservoir water level. Hence, it would be more likely to have instability and sliding at the upstream slope on account of decrease in the effective stress. Lack of sufficient studies performed on this matter in tunnelling projects on the one hand and the knowledge on the most important parameter for decreasing the destructive effects of this phenomenon on the other hand necessitates performing further studies on this matter. To this end, the reasons for the occurrence as well as the affecting parameters were studied by modelling the large subsidence of the inlet portal of Heybat Sultan twin tunnels located in Kurdistan-Iraq making use of the variations of the groundwater boundary conditions under Phase2 code. The modelling results depict the importance of the drawdown rate and the permeability coefficient of the surrounding rock mass. In the interim, the rapid loss in the hydraulic gradient caused by the drainage of a considerable volume of precipitations into the tunnels led to the rapid decrease in the pore pressure and increase in the effective stresses up to total stress. This has resulted in the consolidation settlement in the tunnel portal.

Keywords: Rapid Drawdown; Subsidence; Pore Pressure; Effective Stress; Tunnelling.

1. Introduction

The construction of underground structures considerably affects the groundwater flow regime. The presence of water affects the structure stability in view of the induced deformation caused by the decrease in the effective stress, the shear strength and the seepage force applied on the tunnel boundaries and creates different kinds of failures in the tunnel [1]. Rapid drawdown is considered as a destructive phenomenon related to the rapid decrease in the water table. This phenomenon takes place mostly in embankment dams due to the incompliance between the water loss inside the core and the reservoir water level during the rapid drawdown. In this case, the hydrostatic pressure existing in the exposed face of the upstream slope (when the reservoir is impounded) disappears. Nevertheless, it is likely to come up with sliding at the upstream slope allowing for the presence of the regulating hydrostatic pressure inside the dam body. In general, there are various groundwater flow regimes into the tunnel relying upon two controlling factors of the tunnel long-term behavior including the permeability of the surrounding rock and the permeability of the tunnel lining [2]. There might be encountered two cases, if the lining is permeable and water flows into the tunnel: (a) fixed groundwater table as a result of the surface runoff recharge with the same volume as the water flowing into the tunnel, and (b) loss in the groundwater table in view of the insufficient surface runoff recharge and more water flowing into the tunnel. The second case causes rapid drawdown and is expected to have high void ratio and permeability ground, low water storage

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