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Unsaturated Slope Stability and Seepage Analysis of a Dam

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Abstract

The paper presents stability and seepage analysis performed in unsaturated regime to take care of the infiltration through the dam. Seepage analysis is divided into two stages: steady state analysis and transient analysis. It will be determined the pore water pressure load, the ground water level, estimate the flow (path and quantity) and also, an advanced analysis considering rainfall and rapid drawdown. Van Genuchten model will be used for the unsaturated soil.

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*Keywords:*seepage analysis, slope analysis, unsaturated soil, pressure load

1. Introduction

The paper presents stability and seepage analysis performed in unsaturated regime to take care of the infiltration through the dam.

Seepage is the water reservoir finding its way downstream through pervious material or through imperfections in the dam. The force or pressure behind the seeping water can create new or enlarge existing seepage pathways. So, the control of seepage is extremely important in the design, construction and safe operation of dams. Seepage causes stability problems when high water pressure and saturation in the embankment and foundation soils cause the earth materials to lose strength. All earth dams will have some seepage and it is unrealistic not to expect this. If seepage is

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considered as a potential problem, countermeasures – such as filters, drains, clay blankets and flatter side slopes – introduced at the design stage can reduce any risks to a minimum.[1]

Seepage analysis can be divided into two: the steady state analysis and transient analysis. Steady state flow analysis is where the boundary conditions inside and outside of the ground does not change with time. Therefore, the inflow is always equal to the outflow within the analysis range. Transient analysis on the other hand, can display different inflow and outflow with time, even when the same boundary conditions as the steady state analysis are applied.[2]

Seepage flow occurs along the waterway that connects through the empty pores between soil particles. This flow complies with Darcy's law. According to this law, the seepage quantity through the soil volume is equal to the multiplication of permeability coefficient, hydraulic gradient and cross sectional area. Darcy's law originally started from the saturated domain, but can also be applied to the unsaturated domain.[2]

The unsaturated domain includes all non-saturated domains, from the fully dried condition to the almost saturated condition. As the degree of saturation falls below 100% , air bubbles will also exist in the pores and if the saturation is very low, the water particles will attached between soil particles in a concave form. Negative pore pressure is referred to as suction pressure. In most cases, suction pressure increases as the degree of saturation decreases.
Transient analysis is used when the boundary conditions inside or outside of the ground changes according to time. The main differences between transient analysis and steady state analysis are that the boundary conditions change as time passes and the fact that the transient analysis requires volumetric water content. When the underground water level goes up or down, the influence factors such as the water content in the unsaturated domain and porosity are needed. [2]

2. Case Study

The case study presents the stability and seepage analysis performed in unsaturated regime to take care of the infiltration through the Maneciu dam. The next figure presents the real section of Maneciu Dam and the simplified one for the next analysis.

Maneciu Dam is a 75 meter high earth dam situated on the Teleajen River, close to Maneciu-Ungureni. It opened in 1995, with the goal of supplying water and electricity to the towns situated on the Teleajenului Valley. [3]

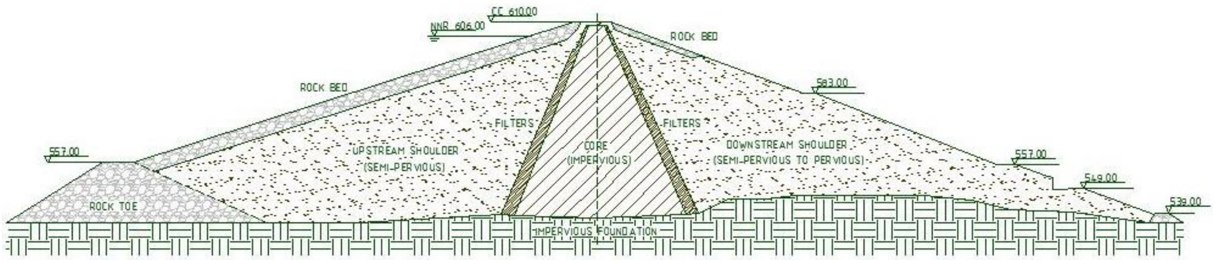

Figure 1a. Maneciu Dam Section AMC3 (Profile 9) [3]

The model used is a 3D dam of 78 m height, 200m width and 595 lenght. The dam layers are defined with the general elastic model 'Mohr-Coulomb'. The shear strength parameters used for each material are: Core – c = 30 kN/m2 and the frictional angel equal with 31º; Dam body with cohesion = 3 kN/m2 and Ø = 40º, Filter with cohesion = 10 kN/m2 and Ø = 33º and for Bedrock, the cohesion is equal with 80 kN/m2 and Ø = 45º.