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Structural Behavior of Pipelines Buried in Expansive Soils under Rainfall Infiltration (Part I: Transverse Behavior)

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Abstract

Landslides, fault movements as well as shrink/swell soil displacements can exert important additional loadings on soil buried structures such as pipelines. These loadings may damage the buried structures whenever they reach the strength limits of the structure material. This paper presents a two-dimensional plane-strain finite element analysis of an 800 mm diameter water supply pipeline buried within the expansive clay of the Ain-Tine area (Mila, Algeria), considering the unsaturated behavior of the soil under a rainfall infiltration of 4 mm/day intensity and which lasts for different time durations (8, 15 and 30 days). The simulations were carried out using the commercial software module SIGMA/W and considering different initial soil suction conditions P1, P2, P3 and P4. The soil surface heave and the radial induced forces on the pipeline ring (i.e., Axial F_A, Shear F_S forces and bending moments M_B) results indicated that following the changes of suction the rainfall infiltration can cause considerable additional loads on the buried pipeline. Moreover, these loads are proportionally related to the initial soil suction conditions as well as to the rainfall infiltration time duration. The study highlighted that the unsaturated behavior of expansive soils because of their volume instability are very sensitive to climatic conditions and can exert adverse effects on pipelines buried within such soils. As a result, consistent pipeline design should seriously consider the study of the effect of the climatic conditions on the overall stability of the pipeline structure.

Keywords: Finite Element Analysis; Unsaturated Soil; Buried Pipeline; Rainfall Infiltration; Suction; Radial Internal Forces.

1. Introduction

Buried pipelines are important lifeline infrastructures used by many countries and companies to transport fluids (i.e., water or gas) to remediate the strong hydraulic and energy resources inequalities over the world. The geotechnical and structural engineers faced many challenges to safely and durably design and build these budget-consuming projects. Landslides, fault movements as well as shrink/swell soil displacements can exert important additional loadings on structures especially for pipelines buried within expansive soils. These loadings may damage these structures or disturb their normal operations whenever their magnitudes reach the strength limits of the structure material.

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