Proceedings of the 5th International Conference on Civil Engineering Fundamentals and Applications (ICCEFA 2024)
Lisbon, Portugal- November 18 - 20, 2024
DOI: 10.11159/iccefa24.005

Influence of Climatic Factors on the Performance of Geotechnical Works

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Abstract

Climate change has become a critical factor influencing geotechnical engineering, requiring an innovative and adaptive approach to the planning and execution of infrastructure. The increasing frequency and intensity of extreme weather events, such as floods, droughts, storms, and heatwaves, directly affect soil behaviour and the stability of geotechnical structures.

The effects of climate change manifest in various ways: higher infiltration rates caused by intense rainfall lead to increased pore water pressure, reduced effective stress, and, in extreme cases, soil liquefaction. On the other hand, prolonged droughts can result in shrinkage and cracking in fine-grained soils, compromising foundations and retaining systems. Additionally, freeze-thaw cycles in colder climates may cause frost heave and slope instability, while soil erosion and contaminant migration threaten engineered landfills and groundwater resources.

Geotechnics also faces challenges related to slope instability due to vegetation loss caused by extreme conditions, as well as the degradation of geotechnical materials designed for now outdated environmental conditions. These changes compel engineers to reconsider not only design parameters but also material choices and construction techniques, ensuring infrastructure resilience in an ever-changing environment.

To mitigate the impacts of climate change, geotechnical research is focusing on sustainable solutions, such as developing thermo-hydro-mechanical models that simulate soil behaviour under varying climatic conditions. Bioremediation techniques, new composite materials, and design methods integrating projected climate data are essential to creating adaptable and durable infrastructures.

Integrating climatic factors into geotechnical designs is, therefore, an urgent necessity to ensure the safety, functionality, and sustainability of infrastructures in a context where climate change will continue to reshape the paradigms of the sector.

This presentation addresses how soil-atmosphere interactions and patterns of extreme events in a changing climate can modify soil properties and loading conditions, thereby impacting the performance of partially saturated geotechnical structures. The behaviour of an embankment under its own weight and varying climatic conditions is also analysed through numerical modelling. For the study, two regions in Portugal with markedly contrasting climatic characteristics were selected: Ponte da Barca, in Minho, and Alcáçovas, in Alentejo. In both regions, the impact of climate on the embankment was evaluated during the construction phase and over the long term.