Finite Element Study: Impact of Cut-off Wall Length on Seepage in Earth Dams (Hub Dam)

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ABSTRACT

Effective management of water seepage in earth dams is crucial for their stability and longevity. Seepage through the dam body or abutments can pose significant challenges, especially in the core zone where impermeability is vital. Conducting field investigations to assess seepage can be cumbersome and expensive. Therefore, utilizing calibrated numerical models presents a viable solution for simulating seepage scenarios. In this study, we numerically analyzed three geometric models of a non-homogenous earth dam under three scenarios: original design, partial cutoff wall, and full cutoff wall, using Geo-Slope (SEEP/W) software. The results indicate that the cutoff wall at its original shape and design performs better as the overall minimum seepage value of order 2.2117 x 10-4 ft^3/sec/ft, with an exit gradient of 0.099 and minimum seepage velocity 1.0020 x 10^{-6} ft/sec, at EL 270 ft reservoir level. Incremental changes in the cutoff wall length were found to be uneconomical, as they did not significantly reduce seepage. This study suggests that the Hub Dam has efficiently operated since its construction, demonstrating the efficacy of its original design in seepage control.

Keywords: SEEP/W model; Phreatic-line; Cut-off wall; Finite Element Analysis; Hub Dam.

INTRODUCTION

Earth dams, integral to water management systems since ancient times, serve as vital barriers for storing and redirecting water flow. However, flaws in design, construction, and maintenance can lead to structural failures, with seepage being a common concern across dam types (Arshad *et al.*, 2019) . Seepage, if left uncontrolled, can compromise dam stability, potentially leading to catastrophic outcomes such as piping and overtopping. Various techniques, including cutoff walls and filters, have been proposed to mitigate seepage issues (Parsaie *et al.*, 2018). This poster presents a detailed numerical analysis aimed at understanding seepage flow dynamics and evaluating the effectiveness of different seepage control measures, such as cutoff walls, in non-homogeneous earth dams (Arshad *et al.*, 2023). Through this research, we aim to contribute to the development of robust strategies for enhancing the stability and longevity of earth dams.

STEPS FOR MODELING

The investigation of the Hub dam's performance involved constructing three models in Geo-Slope (SEEP/W) software: one representing the original design and two variations with partial and full cutoff walls. Meshing was done with quad and triangle methods for accuracy, resulting in 957 nodes and 901 elements. Boundary conditions included zero hydraulic conductivity for interface materials and simulated free water conditions. The model incorporated various coefficients and parameters to study dam performance at different reservoir levels. Material composition comprised silt-clay for the core and a mix of fine sand, coarse sand, gravel, and impervious rock for the foundation. Calibration determined hydraulic conductivities and geological parameters, with simulations conducted separately for each scenario. The finite element modeling procedure was outlined, with relevant data tables provided for analysis reference.

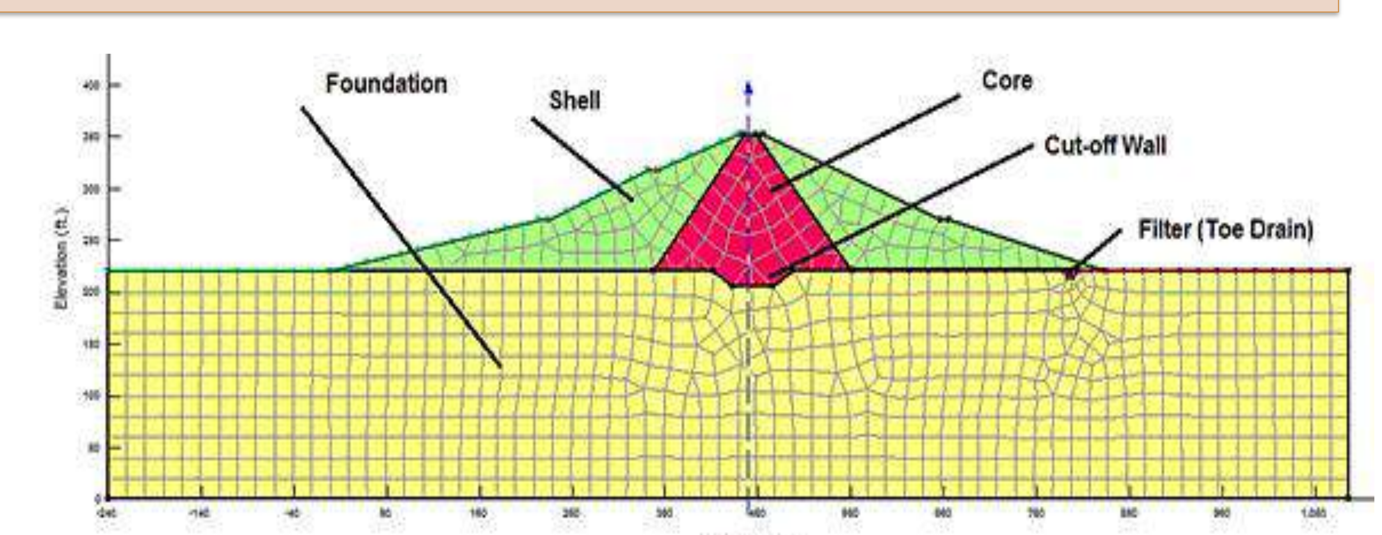

Fig. 01: The SEEP/W Mesh (Original Design)

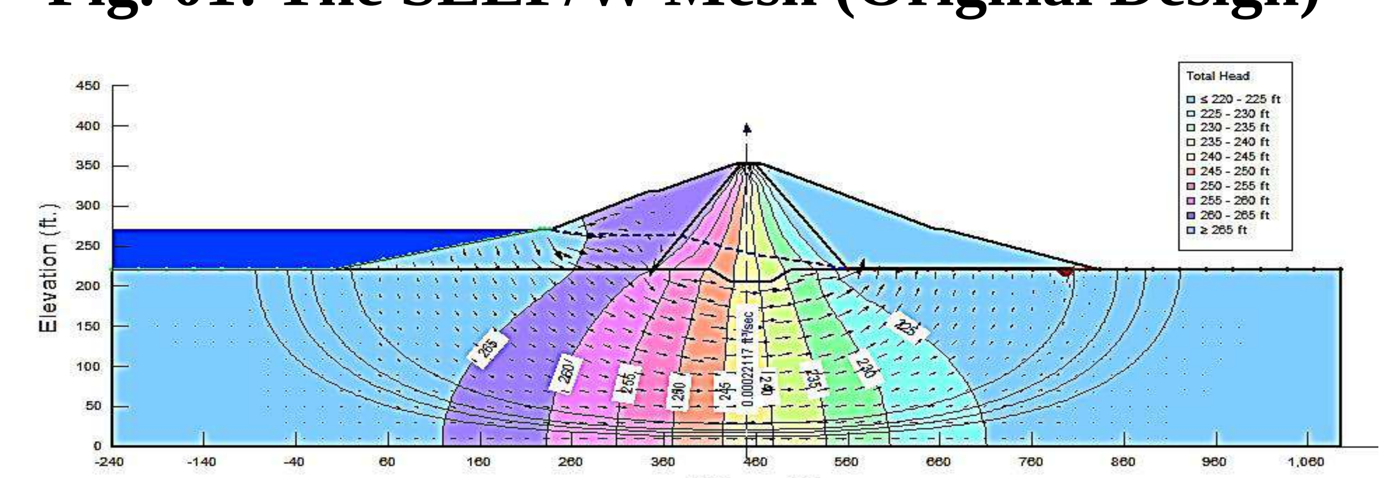

Fig. 02: SEEP/W Simulations for original design (Reservoir height = EL 270 ft.)

RESULTS – (FLOW-NET) ANALYSIS AND VELOCITY VECTORS

Flow net analysis of Hub Dam reveals seepage through foundation, necessitating remedial action. Minimal variance in seepage and exit gradient observed between partial and full cutoff wall scenarios. Normal behavior of seepage flow lines through core and filter drain observed.

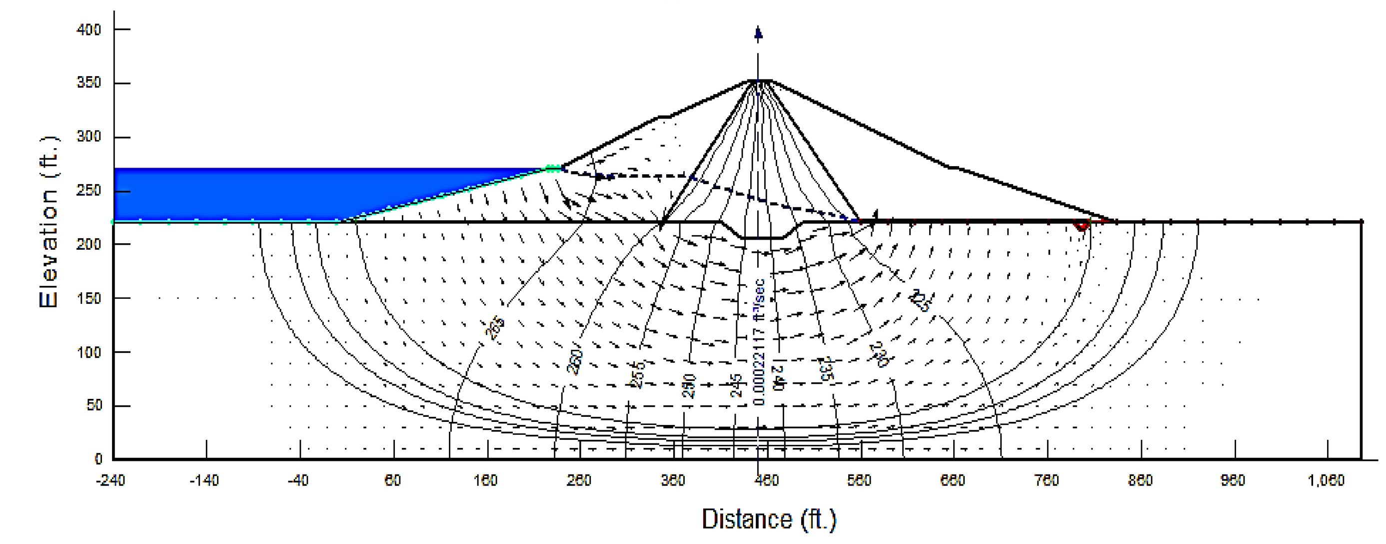

Fig. 03: Phreatic Line behaviour for original design (Reservoir height = EL 270 ft.)

CONCLUSION

Findings suggest the Hub Dam's original design, featuring cutoff walls, effectively manages seepage. Partial or full cutoff walls show minimal impact, with foundation material imperviousness being the primary factor. Numerical methods underscore the dam's ongoing effectiveness since construction.

REFERENCES

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