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Effect of Seepage Responses in Seepage Flow of Water under Different Concrete Dam

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Abstract

Seepage analysis is necessary for concrete dam design. Irregular seepage through the concrete dam may be thread to the integrity and stability of the structure and could lead to the failure of the dam. This work used the finite element analysis (FEA) based GeoStudio software to analyze the effect of seepage behaviour of three types of concrete dams with different types of concrete dam including variation of depth of concrete block. Firstly, in order to determine the applicability and accuracy of the formulation and modelling as presented in the work, the results of seepage discharge rate and seepage velocity obtained by the present method applied in first model i.e. CD-I are compared and verified. The grid impendency test has been employed with varying the mesh size viz. 2.5 m to 0.5m. Finally, the effect of seepage in concrete dam, the variation of depth of concrete block (D) are applied in the range of 2m – 5m (2, 3, 4 and 5m).

Keywords: *Concrete Dam; Finite Element Analysis; GeoStudio; Seepage Analysis.*

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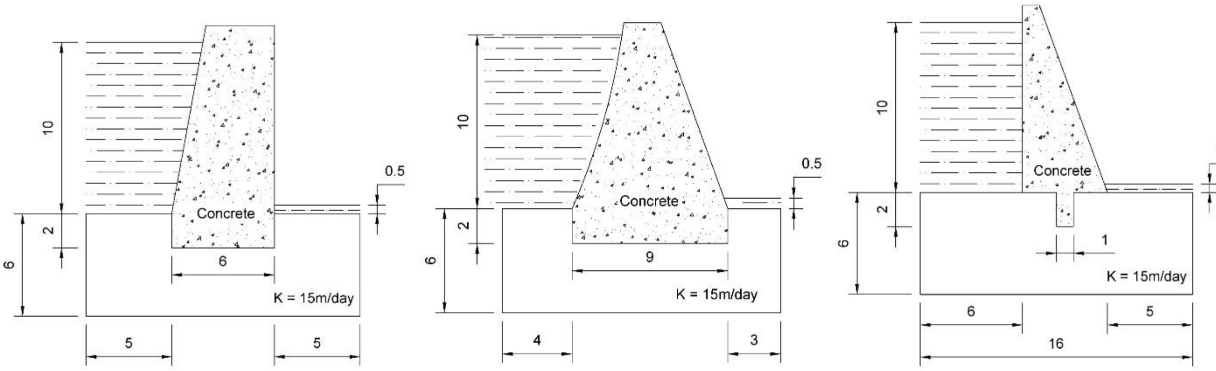
1. Overview

The most critical phenomenon to be taken into account when planning and designing dams is the seepage of water through and under the body of the dam. If seepage occurs without maintenance, after a period of time, the dam may well collapse, causing loss of life and property. The important quantities which must be estimated when studying this phenomenon include seepage quantity (flow rate), uplift pressure, and exit gradient. The flow of water below the dam creates uplift pressure on its floor, and if the thickness of the floor is insufficient, its weight will be unable to resist this pressure, and the floor will become cracked, leading to a failure of the structure.

In hydrology, seepage flow refers to the flow of a fluid (water) in permeable soil layers such as sand. The fluid fills the pores in the unsaturated bottom layer and moves into the deeper layers as a result of the effect of gravity. The soil has to be permeable so that the seepage water is not stored. The permeability of the soil is described by the permeability coefficient kf in m/s and is dependent on the grain size and the useful pore space. In less permeable soils the seepage water can be stored temporarily.

2. Methodology

The finite element analysis is the simulation of any given physical phenomenon using a numerical technique called finite element method (FEM). Engineers use this method to reduce the number of physical prototypes and experiments, and to optimize components in their design phase to develop better products, faster. In order to investigate the effect of different model GeoStudio finite element analysis software is used.

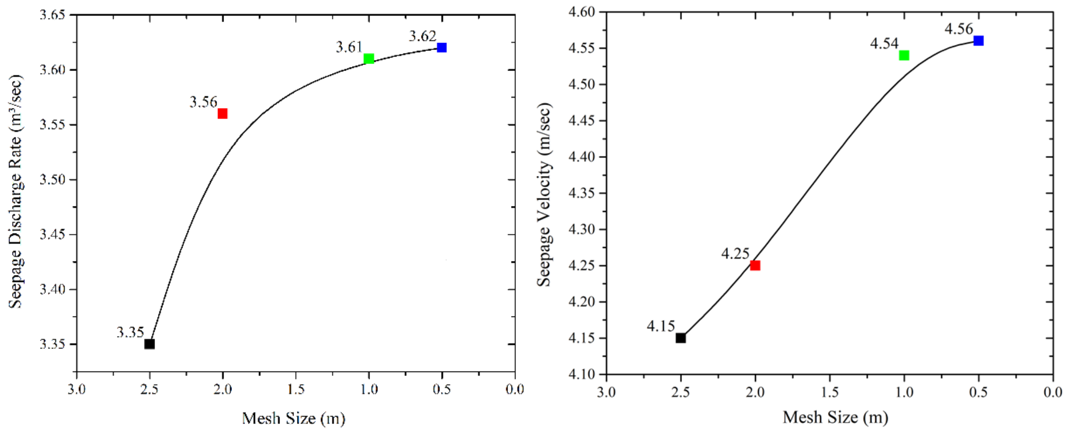


(a) (b) (c)

Figure 1. Three different concrete dam (CD) configuration (CD-I, CD-II and CD-III) of concrete dam for present work

3. Results and Discussion

In this chapter, detailed discussions about the grid impendency test and numerical simulation of the seepage flow characteristics has been obtained using finite element analysis.

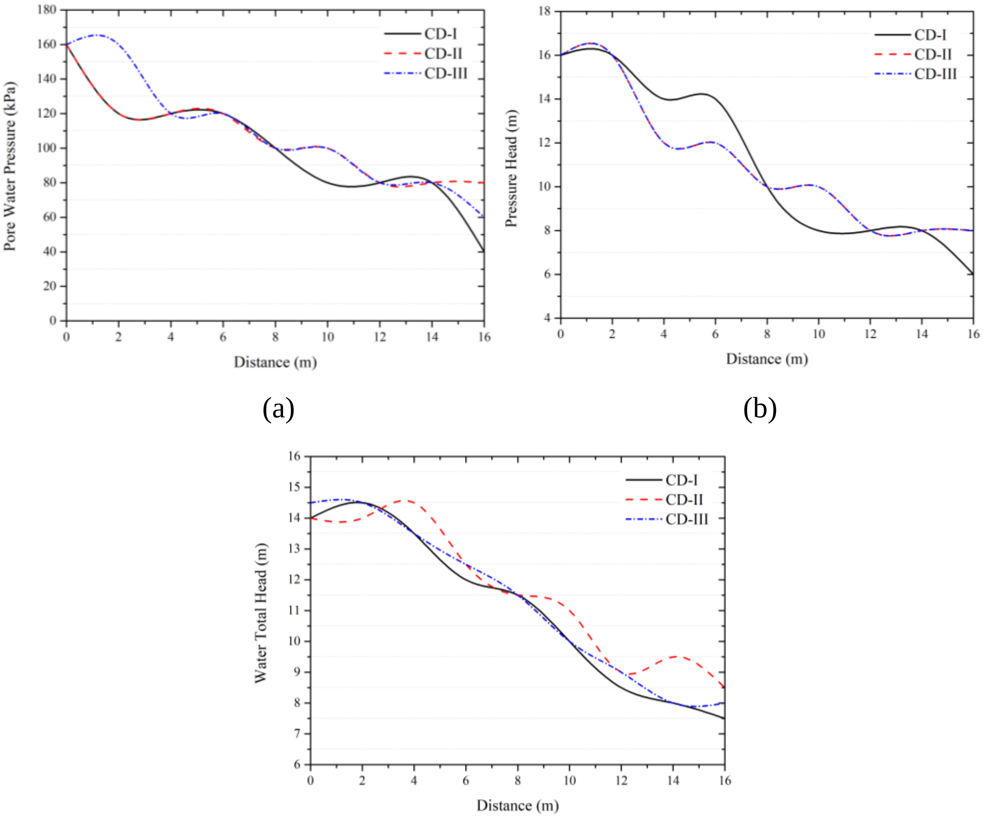


(a) (b)

Figure 2. Grid impedance test in seepage discharge and velocity on present model (CD-I) with variation of mesh size.

3.1 Effect Seepage in Different Concrete Dam

After grid impendency test (convergency test) of the model and method; the work is achieved the effects of seepage effect in three different concrete dams with maintaining the retaining wall depth (depth concrete block) 2m for all model.



(a) (b)

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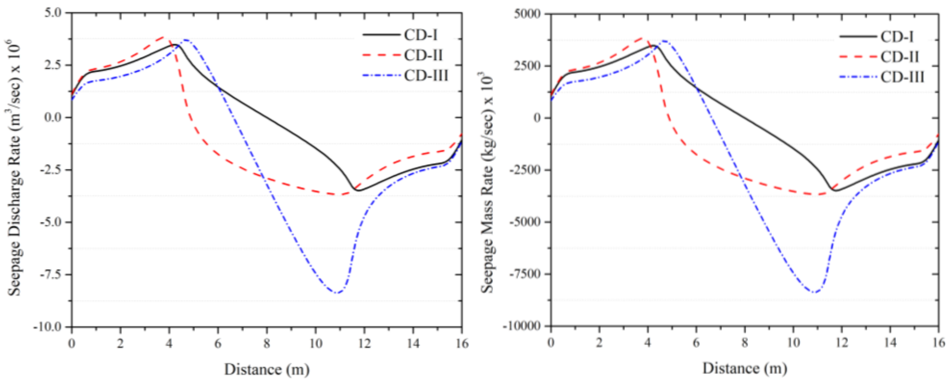
Figure 3. Variation of pore water pressure, pressure head and water total head with respect to horizontal distances in different concrete dam



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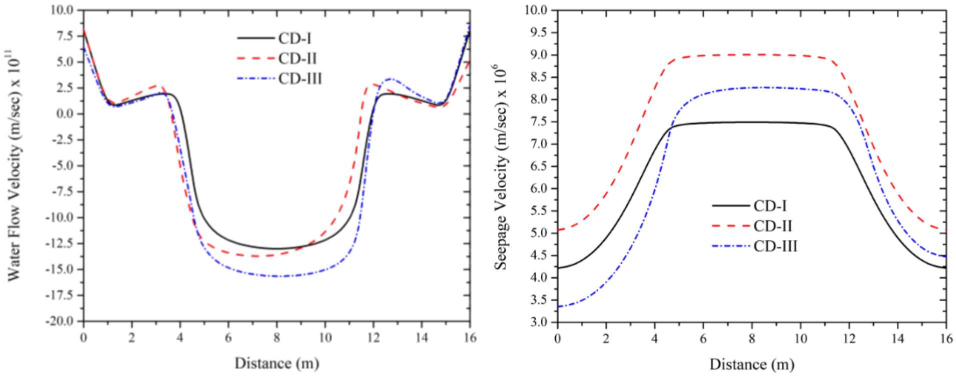

(c) (d)

Figure 4. Graphical representation of seepage discharge rate, seepage mass rate, water flow velocity and seepage velocity in different concrete dam

5.3 Effect Seepage in Variation of Depth Concrete Block in Concrete Dam

Now, to obtained the effect of seepage in concrete dam, the variation of depth of concrete block (D) are applied in the range of 2m – 5m (2, 3, 4 and 5m). The numerical results achieved in this challenging example demonstrate, on the one hand the effectiveness and robustness of the proposed method and model, and on the other hand the importance of predictive modeling of the seepage system for performance and safety assessments of designs.

4. Conclusion

- From work it has been seen the variation of pore water pressure, pressure head and water total head developed in the concrete dam (CD-I, II and III) respectively. The pore water pressure arises with starting of the dam core and simultaneously reduced with another end. The maximum pore water pressure is 160kPa and minimum pressure is 40kPa found but less pressure is obtained in CD-I type.
- Similarly, the pressure head and water total head respectively decreases with starting to another end. The minimum pressure head and water head is obtained in CD-I type in both.
- One may observe that with the increase of the depth of concrete block 2m – 4m, the seepage velocity is slightly reduced, but the after 4m, the depth of concrete block is 5m, the seepage velocity is increased. This indicates that the commonly used depth of concrete between 2m – 4m is suitable in engineering.
- It can be further observed that the variation of the depth of concrete block in the specified range of 2m – 5m has been significantly affect the flow rate out of the concrete dam.
- Also, it has been found that the if depth of block increases 2m – 4m the seepage flow rate decreases and after that, if 5m depth of block, the seepage flow rate increased.
- The future scope of the work is to in future the work is varying dame type and method to improve or efficiency of dam. Also, optimization can be apply in future for optimized results.

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