Mathematically, the objective of this study is to find, by Finite Element Method (FEM), the best fit curve of the steady state phreatic line in an earth dam composed of homogeneous and isotropic bulk material, when an impervious core wall is placed in it in an inclined position, either towards the upstream or towards the downstream.

No mention could be found in existing literatures about intentionally placing a core wall in an inclined position and perhaps this study is the first attempt to introduce such a concept. The concept bears much practical significance because the possibility of using an inclined barrier to seepage can open up the prospect of using alternative core wall construction materials such as impervious geo-textile sheets which is likely to result in much savings in the time and costs of construction and supervision.

The problem involved is a scalar field problem governed by Laplace’s particular form of the general quasi-harmonic equation along with specified boundary conditions of the flow domain. The flow domain considered is two-dimensional and isotropic. The flow considered is steady. The dam is assumed to be composed of homogeneous bulk material. The dam base is assumed to be impervious.

Functional approach to FEM formulation adopted. Principle of minimum of potential energy used to develop the FEM model. Natural boundary conditions are incorporated in the model itself. Penalty approach is used to input the essential boundary conditions in the global stiffness matrix. The penalty value used is of order
Gauss elimination method is used to solve the set of resulting algebraic equations.

Total 42 pre-defined dam sections (6 test data sets consisting 7 dam sections each) with different core wall inclinations and core wall heights have been used to arrive at some conclusive theoretical solution. FEM solutions are also found for dam sections concerning a laboratory model and results verified experimentally. The user may also use his own set of data.

The author has improved upon the traditional FEM solution which offers solutions at discrete points by using the concept of best fit curve to make it possible to obtain the results in continuous form. Such improved continuous solution is more useful in describing the phreatic line. Legendre’s Method Of Least Square is used to construct the best fit curve equation.

Software FEMEDPHR has been developed by the author for computer implementation of the FEM procedure. The software is written in C++ and it consists several modules. Module tasks and function tasks along with local and global variables have been defined within the codes themselves. Results presented graphically.

An automatic adaptive mesh generation scheme has been specially developed for the problem. Error estimator is ‘a-posteriori’ type and used to modify the domain itself with every iteration. Finite elements used are three noded isoparametric and triangular. The mesh generation scheme is developed by the author and unique in its approach because of the concept of pivot points introduced by the author. The scheme used to test the working of the computer codes has 49 global nodes, 69 finite elements and 10
phreatic node. However, FEMEDPHR can generate a mesh of any number of elements depending upon the capacity of the computer.

The whole solution process is an iterative one and the number of iterations allowed is 20, though the allowable number can be re-fixed at any desired level depending upon the computer capacity.

The FEM results of the test data sets showed that as a general rule, core wall inclination towards the upstream side has the effect of lowering the exit point as done by a vertical wall, while inclination towards the downstream side has the reverse effect. The deviations from the position of the exit point corresponding to the vertical core wall become more prominent if the height of the core wall increases.

It is concluded from the study that the exit point of the phreatic line is pulled down by a core wall inclined towards the upstream side and pushed up by a core wall inclined towards downstream side.

It can, therefore, be recommended that a core wall, or for that matter any impervious barrier, inclined towards upstream side can be used to perform the task of a vertical core wall. But any inclination of the core wall towards the downstream side should be avoided. Also, a rigid vertical core wall can be technically replaced by inclined barrier made of any impervious material including PVC or flexible geo-textile sheets.

The study also showed that FEM can be used as a reliable method for finding the shape of a phreatic line. Further it showed that, for satisfactory numerical solutions, the degree of the phreatic line should be taken as 3 and not 2, as commonly used.