**CONTENTS**

| ACKNOWLEDGEMENT | i |
| ABSTRACT        | ii |
| LIST OF FIGURES | xi |
| LIST OF TABLES  | xv |
| NOTATIONS       | xvii |

### CHAPTER 1 INTRODUCTION

1.1 General

1.2 Practical Utility Of The Study

1.2.1 Utility From The Design Point Of View

1.2.2 Utility From The Construction Point Of View

1.3 Theoretical Objective Of The Study

1.4 Scope Of The Study

1.5 Literature Survey

1.6 Method Of Investigation

1.6.1 The First Stage Of Investigation: Numerical Solution

1.6.1.1 The Finite Element Method (FEM)

1.6.1.2 Software Development For FEM Implementation

1.6.2 The Second Stage Of
Investigation:
Laboratory Experiment

1.7 Results And Conclusion 12
1.8 Bibliography 12

CHAPTER 2 LITERATURE REVIEW
2.1 General 13
2.2 Discussions 13
2.3 Summery 25

CHAPTER 3 FINITE ELEMENT FORMULATION OF THE PROBLEM
3.1 Governing Equation 26
3.1.1 Assumptions Made 27
3.1.2 The Flow Domain And The Boundary Conditions 28
3.2 Finite Element Formulation 31
3.2.1 Choice Of The Element 33
3.2.2 Shape Functions Of Three Noded Triangular Element 33
3.2.3 Isoparametric Triangular Element 36
3.3 FEM Modelling Of The Problem 37
3.3.1 Treatment Of Boundary Conditions 42
3.3.2 Method Of Solution 43
3.3.3 Error Estimates And Two Factor Approach
3.4 Results In The Form Of Best-Fit-Curve
3.5 Summery

CHAPTER 4 DEVELOPMENT OF THE FINITE ELEMENT SOFTWARE "FEMEDPHR"

Part-I
4.1 General 46
4.2 Pre-Processing Modules 46
4.3 Processing Modules 48
4.3.1 Adaptive Mesh Generation By Computer Codes
4.3.1.1 Input For Mesh Generation 50
4.3.1.2 Different Automatic Mesh Generation Schemes 51
4.3.1.3 Numbering Of The Global Nodes And Finite Elements 53
4.3.1.4 Identifying The Phreatic Nodes 54
4.3.2 Element Equations And Element Stiffness Matrices (ESMs) 54
4.3.3 Connectivity Array 55
4.3.4 Assembly Of Element Equations And The Global Stiffness Matrix 55
4.3.5 Treatment Of Boundary Conditions

4.3.5.1 The Penalty Approach Of Treatment Of Boundary Conditions

4.3.6 Solution Of The Assembly Of Equations: Gauss Elimination Approach

4.3.7 Modification Of Assumed Value Of The Phreatic Node Elevations

4.3.7.1 Two Factor Scheme To Improve Assumption Of Elevation Of The Phreatic Nodes For Each Iteration

4.3.8 Continued Iterations And Error Estimates

4.4 Post-Processor Modules

4.4.1 Text Output Modules

4.4.2 Graphics Output Modules

4.5 Some C++ Tools Developed In This Study

4.6 Summery

Part-II

Software FEMEDPHR

CHPATER 5 LABORATORY VERIFICATION OF FEM RESULTS

5.1 General
5.2 Description Of The Laboratory Set-Up 189
5.3 Experiment Procedure 190
5.4 Some Notes On Conducting The Experiment 192
5.5 Limitations 193
5.6 Further Scope For Using The Laboratory Model 194
5.7 Results Of The Experiment And Comparison With Mathematical Results 194

CHAPTER 6 RESULTS

Part-I Results Of Application Of FEM Software FEMEDPHR To The Test Data Sets Of Table 4.2 197-252
Part-II Results Of Laboratory Experiment And Comparison With FEM Results 253-270

CHAPTER 7 ANALYSIS OF RESULTS, CONCLUSIONS AND RECOMMENDATIONS FOR FURTHER STUDIES

7.1 General 271
7.2.1 FEM Analysis Of Test Data Sets 271
7.2.2 Validity Analysis 271
7.2.3 Reliability Analysis 272
7.2.4 Convergence Analysis 272
7.3 A Few Observations Made During The FEM Analysis 272
7.3.1 Effect Of Assumed Position Of The Initial Phreatic Line 272
7.3.2 Effect Of Assumed Degree Of The Best-Fit Curve 272
7.3.3 Matching Of The Best-Fit Equation Values With Computed Values 273
7.3.4 Zone Of Approximation 273
7.4 New Concepts Of FEM Analysis Introduced In This Study 273
7.5 New Tools For C++ Programming 274
7.6 Summery Results 274
7.7 Limitations 275
7.8 Conclusions 276
7.9 Recommendations 277
7.9.1 Regarding The Design Aspect Of An Earth Dam 277
7.9.2 Regarding The Construction Aspect Of An Earth Dam 277
7.9.3 Regarding Further Study 277

BIBLIOGRAPHY 278