

## TABLE OF CONTENTS

|                                                                    |    |
|--------------------------------------------------------------------|----|
| <b>ACKNOWLEDGEMENT</b> .....                                       | v  |
| <b>ABSTRACT</b> .....                                              | vi |
| <b>CHAPTER 1 : INTRODUCTION</b> .....                              | 1  |
| 1.1. General.....                                                  | 1  |
| 1.2. Problem Description .....                                     | 2  |
| 1.3. Objectives .....                                              | 3  |
| 1.4. Methodology.....                                              | 4  |
| 1.5. Thesis Layout.....                                            | 4  |
| <b>CHAPTER 2 : LITERATURE REVIEW</b> .....                         | 6  |
| 2.1. Introduction.....                                             | 6  |
| 2.2. Local Scour .....                                             | 6  |
| 2.2.1. Scour Definition.....                                       | 6  |
| 2.2.2. Scour Classification .....                                  | 7  |
| 2.2.3. Local Scour at Bridge Piers or Piles .....                  | 9  |
| 2.2.3.1. local scour classifications .....                         | 9  |
| 2.2.3.2. Local Scour Mechanisms for Single Pile .....              | 10 |
| 2.2.3.3. Scour Mechanism for Piles Group .....                     | 13 |
| 2.2.3.4. Parameters Affecting Local Scour at Piers and Piles ..... | 15 |
| 2.2.4. Flow Pattern .....                                          | 16 |
| 2.2.5. Scouring Process .....                                      | 18 |
| 2.3. Previous Studies of Local Scour.....                          | 19 |
| 2.3.1. Previous Studies of Piers and Single Pile Scour .....       | 19 |
| 2.3.2. Previous Studies of pile groups Scour .....                 | 40 |
| 2.3.3. Previous Studies of Pile Scour Using Numerical Models ..... | 42 |
| 2.4. Discussion and conclusion.....                                | 42 |
| <b>CHAPTER 3 : NUMERICAL MODEL</b> .....                           | 43 |
| 3.1. Introduction.....                                             | 43 |
| 3.2. Model Purpose .....                                           | 43 |
| 3.3. Model Overview .....                                          | 44 |
| 3.4. Model Theoretical Basis .....                                 | 44 |
| 3.4.1. Water flow calculation.....                                 | 44 |
| 3.4.2. Sediment Flow Calculations .....                            | 47 |

|                                                                   |           |
|-------------------------------------------------------------------|-----------|
| 3.5. Model Input/Result files .....                               | 48        |
| 3.5.1. Boogie File.....                                           | 49        |
| 3.5.2. The Control File.....                                      | 50        |
| 3.5.3. The Result File.....                                       | 50        |
| 3.5.4. The xcyc and koosurf files.....                            | 50        |
| <b>CHAPTER 4 : MODEL DESCRIPTION AND VALIDATION .....</b>         | <b>51</b> |
| 4.1. Introduction.....                                            | 51        |
| 4.2. Mathematical Model description .....                         | 51        |
| 4.2.1. Grid Construction.....                                     | 52        |
| 4.2.2. Boundary Conditions .....                                  | 53        |
| 4.3. Mathematical Model Calibration.....                          | 53        |
| 4.3.1. Time Step Calibration .....                                | 53        |
| 4.3.2. Roughness Calibration .....                                | 55        |
| 4.4. Model Calibration Results .....                              | 55        |
| 4.5. Mathematical Model Verification.....                         | 55        |
| 4.6. Pile Groups Scour Prediction Program.....                    | 60        |
| 4.6.1. Runs identifications .....                                 | 60        |
| 4.6.2. Groups description .....                                   | 61        |
| <b>CHAPTER 5 : PRESENTATION AND ANALYSIS OF RESULTS .....</b>     | <b>64</b> |
| 5.1. Introduction.....                                            | 64        |
| 5.2. Piles Group Results And Analysis.....                        | 65        |
| 5.2.1. Piles Spacing Effect .....                                 | 66        |
| 5.2.1.1. First Group (G1) and Second Group (G2).....              | 66        |
| 5.2.1.2. Third Group (G3) and Fourth Group (G4) .....             | 67        |
| 5.2.1.3. Fifth Group (G5) To Eighth Group (G8).....               | 67        |
| 5.2.1.3.1. Effect of transversal spacing .....                    | 69        |
| 5.2.1.3.2. Effect of longitudinal spacing .....                   | 79        |
| 5.2.2. Modification Factor Assessment.....                        | 82        |
| 5.2.2.1. First Method (Piles Number Effect) .....                 | 82        |
| 5.2.2.2. Second Method (Spacing Effect).....                      | 83        |
| 5.2.2.3. Third Method (General Equation) .....                    | 88        |
| <b>CHAPTER 6 : SUMMARY, CONCLUSIONS AND RECOMMENDATIONS .....</b> | <b>90</b> |
| 6.1. Research Summary .....                                       | 90        |

|                                                              |            |
|--------------------------------------------------------------|------------|
| 6.2. Conclusions.....                                        | 91         |
| 6.3. Recommendations.....                                    | 92         |
| <b>APPENDIX A : MODEL DATA SETS DEFINITIONS .....</b>        | <b>99</b>  |
| A.1. Introduction.....                                       | 99         |
| A.1.1. T Data Sets .....                                     | 99         |
| A.1.2. F Data Sets .....                                     | 99         |
| A.1.3. G Data Sets .....                                     | 101        |
| A.1.4. S Data Sets .....                                     | 101        |
| A.1.5. I Data Sets .....                                     | 101        |
| A.1.6. N Data Sets .....                                     | 102        |
| A.1.7. B Data Sets.....                                      | 102        |
| A.1.8. W Data Sets.....                                      | 102        |
| A.1.9. K Data Sets .....                                     | 102        |
| <b>APPENDIX B : SCOUR FOR COMPLEX PIER FOUNDATIONS .....</b> | <b>103</b> |
| <b>APPENDIX C : OUTPUT SUMMARY TABLES .....</b>              | <b>108</b> |