

| | |
|---------------------------------------|-----------|
| 3.3.1 Initial Stiffness of Connection | 41 |
| 3.3.2 Bi-Linear Model | 44 |
| 3.4 Analysis with FE | 48 |
| 3.5 Other Methods | 48 |
| 3.6 Need for Future Research | 50 |

TABLE OF CONTENTS

| CHAPTER | Page |
|---|-----------|
| LIST OF TABLES | vi |
| LIST OF FIGURES | viii |
| CHAPTER 1 - INTRODUCTION | 1 |
| 1.1 Background | 1 |
| 1.2 AISC Construction Classification | 2 |
| 1.3 A Brief Discussion on Semi-Rigid Connection Research | 4 |
| 1.4 Scope of Study | 7 |
| CHAPTER 2 - SEMI-RIGID CONNECTIONS | 10 |
| 2.1 Behavior of Semi-Rigid Connections | 10 |
| 2.2 Characteristics of Connection Behavior | 11 |
| 2.2.1 Nonlinear Behavior of Connection | 12 |
| 2.2.2 Ductility and Strain-Hardening of ($M-\theta_r$) Relationship | 14 |
| 2.2.3 Loading-Unloading Behavior of Connection | 14 |
| 2.3 Effects of Semi-Rigid Connections on Frame Behavior | 15 |
| 2.3.1 Effects on Columns | 16 |
| 2.3.2 Effects on Beams | 19 |
| 2.3.3 Effects on Frame Drift | 21 |
| 2.4 Modeling of the Connection Moment-Rotation Relationship | 22 |
| 2.4.1 Background | 22 |
| 2.4.2 Curve-Fitting Models | 23 |
| 2.4.3 Analytical Models | 29 |
| 2.5 Selection of Connection ($M-\theta_r$) Model | 31 |
| CHAPTER 3 - ANALYSIS OF FRAMES WITH SEMI-RIGID CONNECTIONS | 32 |
| 3.1 Methods for Second-Order Analysis | 32 |
| 3.2 Exact Second-Order Elastic Analysis | 36 |
| 3.3 Approximate Methods of Analysis | 40 |

| | Page |
|--|---------|
| 3.3.1 Initial Stiffness and the Analysis of Frames | 41 |
| 3.3.2 Bi-Linear Models and the Analysis of Frames | 44 |
| 3.4 Analysis with Effective Length Factor | 46 |
| 3.5 Other Methods of Analysis | 48 |
| 3.6 Need for Practical Methods of Design Analysis | 50 |
| CHAPTER 4 - A SIMPLE METHOD FOR DESIGN ANALYSIS OF SEMI-RIGID FRAMES | 52 |
| 4.1 Introduction | 52 |
| 4.2 B_1 and B_2 Method of Analysis | 54 |
| 4.3 Modeling of Connection ($M-\theta_r$) Relationship | 57 |
| 4.3.1 Modified Initial Connection Stiffness (R_{ko}) | 58 |
| 4.3.2 Connection Stiffness by Beam-Line Method | 63 |
| 4.4 Effective Length of Columns | 66 |
| 4.4.1 Relative Stiffness Factor (G) | 66 |
| 4.4.2 Modified Relative Stiffness Factor for Nonsway Frames | 70 |
| 4.4.3 Modified Relative Stiffness Factor for Sway Frames | 80 |
| 4.5 Modified Stiffness of Beam (EI'_b) | 91 |
| 4.5.1 Modified Slope-Deflection Equations | 92 |
| 4.5.2 Beam Member Bent in Single Curvature | 94 |
| 4.5.3 Beam Member Bent in Double Curvature | 97 |
| 4.6 Outline of the Proposed Analysis Procedure | 99 |
| CHAPTER 5 - EVALUATION OF THE PROPOSED DESIGN ANALYSIS PROCEDURES FOR SEMI-RIGID FRAMES | 101 |
| 5.1 Moment-Rotation Curves and Connection Parameters | 101 |
| 5.1.1 Ultimate Moment of Connection | 101 |
| 5.1.2 Initial Stiffness of Connection | 102 |
| 5.2 Idealized Connection Models | 103 |
| 5.2.1 Modified Initial Connection Stiffness (R_{ko}) | 103 |
| 5.2.2 Connection Stiffness by Beam-Line (R_{kb}) | 105 |
| 5.3 Numerical Study | 106 |
| CHAPTER 6 - FRAME ANALYSIS ON PERSONAL COMPUTERS | 111 |
| 6.1 Introduction | 111 |
| 6.2 Implementation on Personal Computers | 114 |
| 6.2.1 Spreadsheet Format | 115 |
| 6.2.2 Advantages of Spreadsheet Programming | 116 |
| 6.3 Organization | 117 |

| | Page |
|---|------|
| 6.3.1 The Worksheet Program | 118 |
| 6.3.2 First-Order Analysis | 119 |
| 6.3.3 Frame Data Input | 120 |
| 6.3.4 Management of the Worksheet Data | 120 |
| 6.4 General Comments | 121 |
| CHAPTER 7 - SUMMARY AND CONCLUSIONS | 122 |
| 7.1 The Simplified Analysis Procedure | 122 |
| 7.2 Conclusions | 125 |
| REFERENCES | 194 |
| APPENDICES | |
| APPENDIX A | 201 |
| APPENDIX B | 204 |
| VITA | 211 |