

TABLE OF CONTENTS

List of Figures	iii
List of Tables	vii
Chapter 1: Introduction	1
1.1 Overview of adaptive techniques	1
1.2 Adaptive process	2
1.2.1 Error estimation	2
1.2.2 FE-model refinement	3
Chapter 2: Adaptive analysis of RC frames	6
2.1 2D frame modelled by 1D beam-column elements	6
2.1.1 Adaptivity of RC frame by Izzuddin	7
2.1.2 Elastic formulation	8
2.1.3 Elasto-plastic formulation	9
2.1.4 Automatic mesh refinement	10
Chapter 3: Adaptive analysis of RC frames with microplane joints	12
3.1 Introduction	12
3.2 Adaptive analysis	13
3.2.1 Automatic mesh refinement	15
3.3 Microplane material model	16
Chapter 4: Analysis of RC frame using 3D segment	17
4.1 Dynamic relaxation using optimum load time history for nonlinear analysis	17
4.2 Three dimensional 8-node solid element with independent rotation field	18
4.2.1 Implementation of independent rotation field	19
4.2.2 Integration schemes	21
4.3 Numerical verification	22
4.3.1 Influence of reinforcement	23
4.3.2 Influence of different finite elements	23
4.3.3 Computational schemes	24
Chapter 5: Design of 1D segment of RC frame	27
5.1 Pseudo-microplane material model	27
5.2 Fitting of pseudo-microplane material model parameters	31
Chapter 6: Geometrical modelling of RC beams	38
6.1 Universal slave DOF	38
6.1.1 Definition	38
6.1.2 Implementation	40

6.1.3	Hanging node	41
6.1.4	Rigid arm node	42
6.1.5	Utilisation	42
6.2	Geometrical model of 3D segment	43
6.3	Connection between 1D and 3D segments	44
Chapter 7:	Verification Examples	49
7.1	Materials	49
7.2	Geometry	49
7.3	FE model	50
7.4	RAN-HN and RAN connection	52
7.5	Verification examples	52
7.6	Example 1 - single RC beam structure	53
7.6.1	Verification of pseudo-microplane material model	54
7.6.2	Verification of geometrical model	58
7.6.3	Verification of adaptive analysis	61
7.7	Example 2 - symmetric one-storey RC frame	65
7.8	Example 3 - two-storey RC frame	69
7.9	Conclusion	70
Chapter 8:	Summary	75
Bibliography		76
Appendix A:	Three dimensional 8-node solid element with independent rotation field	80
A.1	Variational formulation	80
A.2	FEM implementation	81
A.3	Element stiffness matrix	87
A.4	Numerical verification	89
A.4.1	Integration schemes	90
A.4.2	Eigenvalue analysis	90
A.4.3	Patch test	92
A.4.4	Conclusion	92
Appendix B:	Fitting of pseudo-microplane material model parameters	93