

**PROGRESSIVE COLLAPSE ANALYSIS OF PRECAST  
CONCRETE CONNECTIONS USING THE APPLIED  
ELEMENT METHOD**

By

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## **Dedication**

The author would like to dedicate this work to her passed away father, may god bless his soul.

# Table of Contents

<b>Acknowledgments.....</b>	<b>i</b>
<b>Dedication.....</b>	<b>ii</b>
<b>Abstract .....</b>	<b>xiii</b>
<b>1 Chapter 1: Introduction .....</b>	<b>1</b>
1.1 Progressive Collapse of Precast Structures .....	1
1.2 History of Progressive Collapse .....	1
1.3 Research Objectives .....	2
1.4 Organization of the Thesis.....	3
1.4.1 Chapter 2 .....	3
1.4.2 Chapter 3 .....	3
1.4.3 Chapter 4 .....	3
1.4.4 Chapter 5 .....	3
1.4.5 Chapter 6 and Chapter 7.....	4
1.4.6 Chapter 8 .....	4
1.4.7 Chapter 9 .....	4
<b>2 Chapter 2: Literature Review.....</b>	<b>5</b>
2.1 Introduction .....	5
2.2 Literature Review .....	5
<b>3 Chapter 3: The Methodology .....</b>	<b>12</b>
3.1 The Applied Element Method (AEM).....	12
3.1.1 The Applied Element Method (AEM) .....	12
3.1.2 AEM VS. FEM.....	17
3.1.3 Introduction on the ELS (Extreme loading of structure) software.....	18
<b>4 Chapter 4: The Applied Element Method(AEM) Validation for precast elements .....</b>	<b>19</b>
4.1 Precast concrete connections under cyclic loading .....	19
4.1.1 Material Properties .....	19
4.1.2 Model of specimens .....	19
4.1.3 Numerical modeling and simulation .....	21
4.1.4 Results and Failure pattern.....	25
4.1.5 Failure Pattern .....	25
4.2 Precast Concrete Connection Under Column Removal Scenario .....	28
4.2.1 Material Properties .....	28
4.2.2 Model of specimens .....	28

4.2.3	Results and Failure pattern .....	32
<b>5</b>	<b>Chapter 5: Case Study.....</b>	<b>34</b>
5.1	The Case Study .....	34
5.1.1	Building Description .....	34
5.1.2	The Connection Description and Design .....	34
5.1.3	Investigation Procedure.....	39
5.1.4	Column Removal Scenarios .....	40
5.2	Analytical Model .....	41
<b>6</b>	<b>Chapter 6: Numerical Results for OMC, MC Enhanced and FSM-WS</b>	<b>45</b>
6.1	Numerical Results .....	45
6.1.1	Connection 1 .....	45
6.1.2	Connection 2 .....	61
6.1.3	Connection 3 .....	72
6.1.4	Connection 4 .....	81
6.1.5	Connection 5 .....	95
6.1.6	Connection 6 .....	110
<b>7</b>	<b>Chapter 7: Numerical Results for the Analysis of Full Structure Model Including Slab (FSM-S) .....</b>	<b>121</b>
7.1	Analytical Model .....	121
7.2	Numerical Results .....	121
7.2.1	Connection 1 .....	121
7.2.2	Connection 2 .....	129
7.2.3	Connection 3 .....	136
7.2.4	Connection 5 .....	142
7.2.5	Connection 6 .....	148
<b>8</b>	<b>Chapter 8: Summary and Discussion.....</b>	<b>159</b>
8.1	Summary.....	159
8.2	Discussion.....	159
8.2.1	Failure Pattern and Proposed Connection Enhancement .....	159
<b>9</b>	<b>Chapter 9: Conclusion and Future Recommendation.....</b>	<b>166</b>
9.1	Conclusion .....	166
9.2	Future Recommendations .....	168

## **List of Tables**

Table 5.1 Beam Dimensions and Reinforcement .....	35
Table 5.2 Corbel Dimensions and Reinforcement .....	35
Table 8.1 Summary of the Proposed Enhancement * .....	163
Table 8.2 Maximum Rotations in Beams and Columns.....	164
Table 9.1 Percentage of deflection reduction between different cases .....	168

# List of Figures

Figure 1.1 Ronan point Building .....	2
Figure 1.2 Murrah Federal Office Building .....	2
Figure 2.1 Structural Behaviour of different case studies under column loss.....	6
Figure 2.2 Analytical diagram for calculating the basic tie strength adopted in the British code.....	7
Figure 2.3 Comparison between Numerical results and experimental data of frame specimen. ....	7
Figure 2.4 Flow chart for the proposed design procedure.....	8
Figure 2.5 Pressure–impulse diagram of the column and different blast loads on columns.....	9
Figure 2.6 Force–displacement relationships .....	10
Figure 3.1 Modeling of structure to AEM.....	12
Figure 3.2 Stresses in springs due to relative displacements.....	13
Figure 3.3 Constitutive models in for concrete and steel .....	14
Figure 3.4 Cracking criterion in AEM .....	14
Figure 3.5 Different techniques for the post-cracking modeling .....	14
Figure 3.6 Modeling of Steel Members.....	15
Figure 3.7 Corner- to-Corner Contacts.....	16
Figure 3.8 Edge-to–edge contacts .....	16
Figure 3.9 Corner- to-Ground Contact .....	16
Figure 3.10 Analysis domains of both the FEM and the AEM.....	18
Figure 4.1 Dimensions and details of the three tested specimens (Cont.) [26].....	21
Figure 4.2 Mesh Sensitivity.....	22
Figure 4.3 Load application for Measuring the Mesh Sensitivity .....	23
Figure 4.4 The loading data that simulates lateral cyclic loading .....	23
Figure 4.5 PC1 model and Reinforcement detailing in ELS .....	24
Figure 4.6 PC2 model and Reinforcement detailing in ELS .....	24
Figure 4.7 PC3 model and Reinforcement detailing in ELS .....	25
Figure 4.8 PC1 Hysterisis Curve .....	26
Figure 4.9 PC2 Hysterisis Curve .....	26
Figure 4.10 PC3 Hysterisis Curve .....	26
Figure 4.11 Failure and Crack Propagation in ELS and Experimental Work .....	27
Figure 4.12 Details of OM Specimen [27] .....	29
Figure 4.13 Details of PC-CRW Specimen [27] .....	29
Figure 4.14 Details of PC-CRS Specimen [27].....	30
Figure 4.15 Mesh Sensitivity.....	31
Figure 4.16 MC Specimen [27] .....	31
Figure 4.17 PC-CRW Specimen [27].....	32
Figure 4.18 PC-CRS Specimen [27] .....	32
Figure 4.19: Load versus central deflection .....	33
Figure 5.1 Building 3D Model .....	34
Figure 5.2: Prototype Building .....	36
Figure 5.3 Reinforcement Detailing of Exterior Frame connection (L-Beam).....	37
Figure 5.3 Reinforcement Detailing of Interior Frame connection (Inverted T-Beam) .....	38
.....	38
Figure 5.5 Different Locations of Column Removal.....	40

Figure 5.6 ELS models for Phase 1 Local Connection .....	42
Figure 5.7 ELS models for the Whole Structure .....	43
Figure 5.8 ELS models for the Full Structure Model with slab .....	43
Figure 5.9 ELS Connection Detailing (Connection 1,2 and 5) .....	44
Figure 5.10 ELS Connection Detailing (Connection 3) .....	44
Figure 5.11 ELS Connection Detailing (Connection 4 and 6) .....	44
Figure 6.1 Beam Compression Arching Behaviour (Enlarged Scale) for Connection 1 .....	46
Figure 6.2 Beam Deflection and Rotation for connection 1 .....	47
Figure 6.3 Magnified Deformed Shape of the Frame of Connection 1 .....	48
Figure 6.4 Magnified Deformed Shape of the column movement in different times ..	48
Figure 6.5 Side Column Rotation and Beam Internal Axial Force for Connection 1 ..	49
Figure 6.6 Normal stresses in Top Reinforcement at the middle and the side connections for Connection 1 .....	50
Figure 6.7 Normal Stresses in Dowels at removed column location and at the sides for Connection 1 .....	51
Figure 6.8 Axial Column Force versus Time for Connection 1 .....	51
Figure 6.9 Beam Deflection and Rotation for connection 1(FSM-WS).....	52
Figure 6.10 Side Column Rotation and Beam Internal Axial Force for Connection 1(FSM-WS) .....	53
Figure 6.11 Normal stresses in Top Reinforcement at the middle and the side connections for Connection 1(FSM-WS)(Cont.).....	54
Figure 6.12 Normal Stresses in Dowels at removed column location and at the sides for Connection 1(FSM-WS).....	54
Figure 6.13 Axial Column Force versus Time for Connection 1 (FSM-WS).....	55
Figure 6.14 Connection Enhancement Detailing.....	55
Figure 6.15 Additional Reinforcement for the Suggested Enhancement .....	56
Figure 6.16 Beam Deflection and Rotation for connection 1(Enhanced MC) .....	57
Figure 6.17 Side Column Rotation and Beam Internal Axial Force for Connection 1(Enhanced MC) .....	58
Figure 6.18 Normal stresses in Top Reinforcement at the middle and the side connections for Connection 1(Enhanced MC) (Cont.).....	59
Figure 6.19 Normal Stresses in Dowels at removed column location and at the sides for Connection 1(Enhanced MC) .....	59
Figure 6.20 Axial Column Force versus Time for Connection 1 (Enhanced MC) .....	60
Figure 6.21 Illustration of the change in Beam Behaviour .....	60
Figure 6.22 Major Principal Strain Contours of Connection (1) without and with Enhancement .....	60
Figure 6.23 Beam Deflection and Rotation for Connection 2 (OMC).....	61
Figure 6.24 Side Column Rotation and Beam Internal Axial Force for Connection 2 (OMC) .....	62
Figure 6.25 Normal stresses in Top Reinforcement at the middle and the side connection for Connection 2(OMC)(Cont.).....	63
Figure 6.26 Normal Stresses in Dowels at removed column location and at the sides for Connection 2(OMC) .....	63
Figure 6.27 Axial Column Force versus Time for Connection 2(OMC) .....	64
Figure 6.28 Beam Deflection and Rotation for Connection 2 (FSM- WS).....	64
Figure 6.29 Beam Deflection and Rotation for Connection 2 (FSM- WS) (Cont.) .....	65
Figure 6.30 Side Column Rotation and Beam Internal Axial Force for Connection 2(FSM-WS) .....	65



Figure 6.31 Normal stresses in Top Reinforcement at the middle and the side connection for Connection 2(FSM-WS) .....	66
Figure 6.32 Normal Stresses in Dowels at removed column location and at the sides for Connection 2(FSM-WS) .....	66
Figure 6.33 Normal Stresses in Dowels at removed column location and at the sides for Connection 2(FSM-WS) .....	67
Figure 6.34 Axial Column Force versus Time for Connection 2(FSM-WS) .....	67
Figure 6.35 Additional Reinforcement for the Suggested Enhancement .....	68
Figure 6.36 Connection Enhancement Detailing.....	68
Figure 6.37 Beam Deflection and Rotation for Connection 2 (MC Enhanced) .....	69
Figure 6.38 Side Column Rotation and Beam Internal Axial Force for Connection 2(MC Enhanced) .....	70
Figure 6.39 Normal stresses in Top Reinforcement at the middle and the side connection for Connection 2(MC Enhanced) (Cont.) .....	71
Figure 6.40 Normal Stresses in Dowels at removed column location and at the sides for Connection 2(MC Enhanced) .....	71
Figure 6.41 Axial Column Force versus Time for Connection 2(MC Enhanced) .....	72
Figure 6.42 Major Principal Strain Contours of Connection (2) without and with Enhancement .....	72
Figure 6.43 Deflection at the Removed Column Location for connection 3 (OMC)...	73
Figure 6.44 Beam Rotation of 6m Span for connection 3(OMC) .....	74
Figure 6.45 Column Rotation Connected to the Two Beams for connection 3(OMC)	74
Figure 6.46 Beam Axial Force for connection 3(OMC) .....	75
Figure 6.47 Normal Stresses in Dowels for connection 3(OMC) .....	75
Figure 6.48 Normal Stresses in Top Reinforcement for connection 3(OMC) .....	76
Figure 6.49 Column Axial Force for connection 3(OMC).....	76
Figure 6.50 Deflection at the Removed Column Location for connection 3 (FSM-WS) .....	77
Figure 6.51 Beam Rotation of 6m Span for connection 3(FSM-WS).....	78
Figure 6.52 Column Rotation Connected to the Two Beams for connection 3(FSM-WS) .....	78
Figure 6.53 Beam Axial Force for connection 3(FSM-WS) .....	78
Figure 6.54 Normal Stresses in Dowels for connection 3(FSM-WS) .....	79
Figure 6.55 Normal Stresses in Top Reinforcement for connection 3(FSM-WS) (Cont.) .....	80
Figure 6.56 Column Axial Force for connection 3(FSM-WS).....	80
Figure 6.57 Connection Deflection at the Removed Column Location for connection 4(OMC) .....	81
Figure 6.58 The Beam Rotation for connection 4 for the beams of different spans (OMC) .....	82
Figure 6.59 The Column Rotation of The Connected Three Beams for connection 4 (OMC) .....	82
Figure 6.60 Beam Axial Force for connection 4 for the beams of different spans (OMC) .....	82
Figure 6.61 Normal Stresses in Dowels at the sides of the Removed Column for connection 4(OMC).....	83
Figure 6.62 Normal Stresses in Dowels at the Removed Column Location for connection 4(OMC).....	83
Figure 6.63 Normal Stresses in Top Reinforcement at the removed column location and the sides for connection 4(OMC) .....	84

Figure 6.64 Column Axial Force (OMC) .....	85
Figure 6.65 Connection Deflection at the Removed Column Location for connection 4(FSM-WS) .....	86
Figure 6.66 The Beam Rotation for the three beams of different spans for connection 4(FSM-WS) .....	86
Figure 6.67 The Column Rotation of The Connected Three Beams for connection 4(FSM-WS) .....	87
Figure 6.68 Beam Axial Force for connection 4(FSM-WS) .....	87
Figure 6.69 Normal Stresses in Dowels at the sides of the Removed Column for connection 4(FSM-WS) .....	87
Figure 6.70 Normal Stresses in Dowels at the Removed Column Location for connection 4(FSM-WS) .....	88
Figure 6.71 Normal Stresses in Top Reinforcement at the removed column location and the sides for connection (FSM-WS) .....	88
Figure 6.72 Column Axial Force (FSM-WS) .....	89
Figure 6.73 FSM-WS Major Principal strain contours of the first floor at t= 0.75 seconds .....	89
Figure 6.74 The New Structural System After the Column loss for the FSM-WS Case Study .....	90
Figure 6.75 Connection Deflection at the Removed Column Location for connection 4(FSM-S) .....	91
Figure 6.76 The Beam Rotation for connection 4(FSM-S) .....	92
Figure 6.77 The Column Rotation of The Connected Three Beams for connection 4 (FSM-S) .....	92
Figure 6.78 Beam Axial Force for connection 4(FSM-S) .....	92
Figure 6.79 Normal Stresses in Dowels at the sides of the Removed Column for connection 4(FSM-S) .....	93
Figure 6.80 Normal Stresses in Dowels at the Removed Column Location for connection 4(FSM-S) .....	93
Figure 6.81 Normal Stresses in Top Reinforcement at the removed column location and the sides for connection 4(FSM-S) .....	93
Figure 6.82 Normal Stresses in Top Reinforcement at the removed column location and the sides for connection 4(FSM-S)(Cont.) .....	94
Figure 6.83 Column Axial Force (FSM-S) .....	94
Figure 6.84 (a) FSM-S Structural Plan .....	95
Figure 6.85 FSM-S Case Study Major Principal strain contours of the first floor at t= 0.75 seconds .....	95
Figure 6.86 Beam Deflection and Rotation for connection 5(OMC) .....	97
Figure 6.87 Column Rotation Versus Time for connection 5(OMC) .....	97
Figure 6.88 Beam Internal Axial Force Versus Time for connection 5(OMC) .....	98
Figure 6.89 Normal Stresses in Dowels for connection 5(OMC)(Cont.) .....	99
Figure 6.90 Normal Stresses in Top Reinforcement for connection 5(OMC) .....	99
Figure 6.91 Normal Stresses in Top Reinforcement for connection 5(OMC)(Cont.) .....	100
Figure 6.92 Internal Axial Force in Column for connection 5(OMC) .....	100
Figure 6.93 Beam Deflection and Rotation for connection 5(FSM-WS) .....	101
Figure 6.94 Column Rotation Versus Time for connection 5(FSM-WS) .....	102
Figure 6.95 Beam Internal Axial Force Versus Time for connection 5(FSM-WS) .....	102
Figure 6.96 Normal Stresses in Dowels for connection 5(FSM-WS)(Cont.) .....	103
Figure 6.97 Normal Stresses in Top Reinforcement for connection 5(FSM-WS) .....	103
Figure 6.98 Internal Axial Force in Column for connection 5(FSM-WS) .....	104

Figure 6.99 Additional Reinforcement used for the Enhancement .....	105
Figure 6.100 Localized Local Failure with connection Enhancement (Strain Contours) .....	105
Figure 6.101 Beam Deflection and Rotation for connection 5(MC Enhanced) .....	106
Figure 6.102 Column Rotation Versus Time for connection 5(MC Enhanced).....	107
Figure 6.103 Beam Internal Axial Force Versus Time for connection 5(MC Enhanced) .....	107
Figure 6.104 Normal Stresses in Dowels for connection 5(MC Enhanced) .....	108
Figure 6.105 Normal Stresses in Top Reinforcement for connection 5(MC Enhanced) .....	109
Figure 6.106 Internal Axial Force in Column for connection 5(MC Enhanced) .....	109
Figure 6.107 Local Failure in the system after Enhancement for connection 6.....	112
Figure 6.108 Deflection at the Removed Column Location versus Time for connection 6 .....	113
Figure 6.109 Beam Rotations Versus Time for connection 6(Cont.).....	114
Figure 6.110 Column Rotations Versus Time for connection 6.....	114
Figure 6.111 Column Rotations Versus Time for connection 6(Cont.) .....	115
Figure 6.112 Axial Beam Force Versus Time for connection 6.....	115
Figure 6.113 Axial Beam Force Versus Time for connection 6(Cont.).....	116
Figure 6.114 Normal Stresses in dowels of different locations versus Time for connection 6(Cont.) .....	117
Figure 6.115 Normal Stresses in dowels of different locations versus Time for connection 6.....	117
Figure 6.116 Normal Stresses in dowels of different locations versus Time for connection 6(Cont.) .....	118
Figure 6.117 Normal Stresses in Top Reinforcement in different locations versus Time for connection 6.....	118
Figure 6.118 Normal Stresses in Top Reinforcement in different locations versus Time for connection 6(Cont.).....	119
Figure 6.119 Normal Stresses in Top Reinforcement in different locations versus Time for connection 6(Cont.).....	120
Figure 6.120 Internal Axial Force in Column for connection 6.....	120
Figure 7.1 The Enhancement detailing for both middle and side connection for connection 1.....	123
Figure 7.2 Additional reinforcement for the suggested enhancement.....	123
Figure 7.3 Deflection at removed column location versus time for connection 1 .....	124
Figure 7.4 Beam rotation versus time for connection 1 .....	124
Figure 7.5 Column rotation versus time for connection 1 .....	125
Figure 7.6 Beam axial force versus time for connection 1 .....	125
Figure 7.7 Normal stresses in dowels in different locations versus time for connection 1(Cont.).....	126
Figure 7.8 Normal stresses in top reinforcement in different locations versus time for connection 1.....	126
Figure 7.9 Axial force in column versus time for connection 1 .....	127
Figure 7.10 Column rotation and structure side sway without and with enhancement at t= 0.5 seconds for connection 1 .....	128
Figure 7.11 Major principal strain contours at t= 0.12 seconds before and after enhancement for case studies of connection 1.....	129
Figure 7.12 Plan view for the Slab restrains for connection 2 .....	130

Figure 7.13 The Enhancement detailing for both middle and side connection for connection 2.....	131
Figure 7.14 Additional reinforcement for the suggested enhancement.....	131
Figure 7.15 Deflection at the Removed Column Location Versus Time for Connection 2.....	132
Figure 7.16 Beam Rotation Versus Time for Connection 2.....	132
Figure 7.17 Column Rotation Versus Time for Connection 2.....	133
Figure 7.18 Internal Beam Force Versus Time for Connection 2.....	133
Figure 7.19 Normal Stresses in Dowels in different locations versus Time for Connection 2.....	134
Figure 7.20 Normal Stresses in Top Reinforcement in different locations versus Time for Connection 2.....	135
Figure 7.21 Internal Axial Force in Column versus Time for Connection 2.....	135
Figure 7.22 Additional Reinforcement for the Suggested Enhancement.....	137
Figure 7.23 Deflection at the Removed Column Location Versus Time for connection 3.....	137
Figure 7.24 Beam Rotation versus Time for connection 3.....	138
Figure 7.25 Column Rotation versus Time for connection 3.....	138
Figure 7.26 Internal Axial Beam force versus Time for connection 3.....	138
Figure 7.27 Dowels Normal Stresses for different Locations versus Time for connection 3.....	139
Figure 7.28 Top Reinforcement Normal Stresses for different Locations versus Time for connection 3.....	139
Figure 7.29 Top Reinforcement Normal Stresses for different Locations versus Time for connection 3.....	140
Figure 7.30 Column Internal Force Versus Time for connection 3.....	140
Figure 7.31 Strain Contours at $t = 0.6$ for the two case studies of connection 3 (Cont.).....	142
Figure 7.32 Plan of FSM-S with Slab's lateral Restrain for connection 5.....	143
Figure 7.33 Deflection at the Removed Column Location Versus Time for connection 5.....	144
Figure 7.34 Beam Rotation versus Time for connection 5.....	144
Figure 7.35 Column Rotation versus Time for connection 5.....	145
Figure 7.36 Internal Beam Force Versus Time for connection 5.....	145
Figure 7.37 Normal Stresses in Dowels of different Locations Versus Time for connection 5.....	145
Figure 7.38 Normal Stresses in Dowels of different Locations Versus Time for connection 5(Cont.).....	146
Figure 7.39 Normal Stresses in Top Reinforcement of different Locations Versus Time for connection 5.....	146
Figure 7.40 Column Internal Force Versus Time for connection 5.....	147
Figure 7.41 Strain Contours For Before and After Enhancement Case Studies at $t = 1$ seconds for Connection 5.....	148
Figure 7.42 Plan of FSM-S with Slab's and beam lateral Restrain for connection 6.....	149
Figure 7.43 Deflection at the Removed Column Location Versus Time for connection 6(Cont.).....	150
Figure 7.44 Beam Rotation Versus Time.....	151
Figure 7.45 Column Rotation Versus Time for connection 6.....	152
Figure 7.46 Internal Beam Force Versus Time for connection 6.....	153

Figure 7.47 Normal Stresses in Dowels of different Locations Versus Time for the three beams for connection 6.....	154
Figure 7.48 Normal Stresses in Dowels of different Locations Versus Time for the three beams for connection 6(cont.) .....	155
Figure 7.49 Normal Stresses in Top Reinforcement of different Locations Versus Time for the three beams for connection 6 .....	156
Figure 7.50 Normal Stresses in Top Reinforcement of different Locations Versus Time for the three beams for connection 6(Cont.).....	157
Figure 7.51 Column Internal Force Versus Time for connection 6 .....	158
Figure 8.1 Structural System of Connection 4 .....	160
Figure 9.1 Beam arrangement and its effect on the connection failure.....	167

# Abstract

Precast concrete structures become widely used recently due to high quality of manufacturing as well as its good behaviour under gravity. The most critical part in the precast structures is beam to column connections in precast frame system due to the different variables involved in the assemblages.

Many code regulations scoped on the design of the whole structure to resist different column loss scenarios regardless of beam connection joint behaviour. Also, many researches are conducted to study the overall behavior of the structure due to different column loss scenarios as well as studying different types of monolithic column beam connections and its behavior under column loss scenario. Many approaches are developed to strengthen the main structural elements as well as enhancing the overall behavior of the structure to resist the progressive collapse. However, few researches scoped on studying precast beam-column connection behavior under column loss scenario. This can be explained due to the limitations of the experimental and numerical testing of the connection to simulate the actual behavior under the column loss.

Many limitations and difficulties could take place during experimental testing such as:

- 1- Constructing the connection with its actual size
- 2- Simulating the column removal scenario
- 3- Testing the effect of different column loss scenarios on the whole structure

In this thesis, a detailed study is carried out on a prototype precast concrete structure to study the behaviour of the precast beam-column connections under column loss scenarios. One type of connections is used, gravity moment connections. The choice of the structure is based on different column removal scenarios as well as different frame arrangements. The structure is designed according to the American Concrete Institute and Precast/Prestressed Concrete Institute Design Hand book.

The study is divided into three main phases; the first phase is to study the local beam-column connection and its behaviour under column loss. The second phase is to study the connection behaviour under the column loss by modeling the full structural without slab contribution. The third phase is to study the connection behaviour under column loss by modeling the full structure model with slab contribution.

The Applied Element Method is implemented in the study to construct a 3D detailed model of the studied connections by using Extreme Loading of Structures Software. The performance of the connections is presented in terms beam, column and joint behaviour. Maximum beam deflection, rotation and internal axial force are calculated. Connection reinforcement normal and shear stresses are obtained as well as column behaviour in terms of rotation and internal axial forces are discussed. From the results obtained an enhancement design is suggested for the failed connections and studied its effect in resisting the local failure due to column removal.

The outcomes of the current research can be stated as follows:

- 1- Observing the different connection behavior that took place due to column loss for local and full structure model.
- 2- Observing the actual failure pattern
- 3- Suggesting an enhancement technique to prevent the local connection failure.
- 4- Considering the slab and its effect on the structural behavior with and without connection enhancement.

- 5- Calculating rotations of the elements connected to the concerned connection (Beams and columns) and compare their values with the UFC code requirements.

The results emphasized that the enhancement technique suggested for the different cases can work effectively in strengthening the precast beam-column connection as well as preventing local and global system failure due to column loss. Slabs played an important role in increasing the system strength against failure due to column loss and cannot be neglected in future research. finally, the enhancement technique succeeded in meeting the Unified Facilities criteria limitations as a result of no need for extra design consideration to prevent progressive collapse due to column loss.