

NONLINEAR FINITE ELEMENT MODELING FOR STEEL BEAM-COLUMN  
CONNECTION ATTACHED WITH TOP AND SEAT ANGLE

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*To my beloved mother and father*

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## ABSTRACT

Two types of connection are generally considered in the design of steel structures in practice. These are classified as completely rigid (fixed) and simple (pin) connections. In theory, completely rigid connections cannot undergo rotation and simple connections cannot transfer moment. Nevertheless, in reality, rigid connections have a relative flexibility which makes them to rotate and simple connections have some reserve capacity to transfer moments. However, in an effort to increase the amount of data on the rotational stiffness of top and seat angle available to researchers, this thesis presents the modeled and non linear analysis of different theoretical top and seat angle connections. The finite element modeling software, ABAQUS, is used to create moment-rotation curves for these theoretical connections such as top and seat angle connection with bracket and top and seat angle connection with gusset plate. To demonstrate finite element modeling's ability to accurately predict the response of the theoretical connections, the results of several experiments performed on top and seat connections are reproduced in ABAQUS. The result of this study shows that initial stiffness of top and seat angle connection increased when attached bracket or gusset plate in connection zone. It is also found that this type of connection can be classified as rigid connection.

## ABSTRAK

Secara umumnya dua jenis sambungan selalu dianggap dalam rekabentuk struktur keluli, iaitu sambungan sepenuh tegar dan sambungan mudah. Secara teori, sambungan tegar sepenuhnya tidak boleh mengalami putaran dan sambungan mudah tidak boleh memindahkan momen. Walau bagaimanapun, dalam keadaan sebenar, sambungan tegar mempunyai kebolehlenturan bandingan yang membuatkan ia boleh berputar dan sambungan mudah berkemampuan untuk memindahkan momen. Dalam usaha untuk meningkatkan penghasilan data bagi kekukuhan putaran sesiku atas dan pelapek oleh penyelidik, tesis ini membentangkan permodelan dan analisis bukan linear terhadap pelbagai jenis sambungan sesiku atas dan pelapek. Model perisian unsur terhingga ABAQUS digunakan bagi mewujudkan lengkung momen-putaran untuk sambungan ini secara teori, khususnya untuk sambungan sesiku atas dan pelapek dengan braket dan sesiku atas dan pelapek bersama plat gaset. Bagi menunjukkan keupayaan permodelan kaedah unsur terhingga dapat meramal dengan tepat ke atas sambungan, hasil daripada beberapa ujikaji yang dijalankan ke atas sambungan sesiku atas dan pelapek sedia ada dihasilkan dan diramal semula menggunakan perisian ABAQUS. Hasil penyelidikan ini menunjukkan kekukuhan permulaan bagi sesiku pelapek dan atas dapat ditingkatkan dengan menggunakan braket atau plat gaset sebagai alat tambahan kepada sesiku pelapek dan atas sedia ada. Jenis sambungan ini juga didapati boleh dikelaskan sebagai sambungan tegar.

## TABLE OF CONTENTS

Chapter	Title	Page
	<b>DECLARATION</b>	ii
	<b>DEDICATION</b>	iii
	<b>ACKNOWLEDGEMENT</b>	iv
	<b>ABSTRACT</b>	v
	<b>TABLE OF CONTENTS</b>	vii
	<b>LIST OF TABLE</b>	x
	<b>LIST OF FIGURE</b>	xi
	<b>LIST OF SYMBOLS</b>	xvi
1	<b>Introduction</b>	
	1.1 Introduction	1
	1.2problem statement	1
	1.3Research objective	2
	1.4. Research scope	3
	1.5 Significant of study	4
	1.1 Introduction	4
	1.2problem statement	1
2	<b>Literature review</b>	6
	2.1 connection	6
	2.2 connection classification	6
	2.2.1 Strength	7
	2.2.2 Ductility	7
	2.2.3 Stiffness	8
	2.3Fullrestraintconnection	9
	2.4Partialrestraiconnection	10
	2.5 Simple connection	10

2.6	Types partially restraint	11
2.6.1	Single Web-Angle and single	11
2.6.2	Double Web-Angle	12
2.6.3	top and seat angle connection	12
2.6.4	Top and seat angle with double web	13
2.6.5	Top and seat angle connection with stiffener	14
2.7	M- curve	16
2.7.1	Initial stiffness	19
2.7.2	The initial stiffness of the top and seat angle connections	28
2.8	Benefit of semi rigid connection	29
2.9	Finite element method	30
2.10	Nonlinear Finite Element Analysis	35
2.10.1	Geometry Nonlinearity	35
2.10.2	Boundary Nonlinearity	36
2.10.3	Material Nonlinearity	37
2.11	Advantages and Limitations of Finite Element	37
2.12	conclusion of literature review	38
3	<b>Methodology</b>	39
3.2	Experimental test	40
3.2.1	Experimental procedure	41
3.3	Specimens description	45
3.4	Material properties	48
3.5	Finite Element Method	51
3.5.1	modeled	52
3.5.1.1	beam	53
3.5.1.2	column	54
3.5.1.3	Angle section	55
3.5.1.4	Bracket	56
3.5.1.5	Gusset plate	57
3.5.2	Assembly	58

	3.5.3 Interaction	60
	3.5.4 Mesh	63
	3.5.5 Boundary condition	65
	3.5.6 Loading and Analysis	66
	3.5.7 classification between connections	67
	3.5.7.1 Beam line	67
	3.5.7.2 stiffness	71
4	<b>Result and Analysis</b>	72
	4.1 introduction	72
	4.2 Finite Element Analysis Result	72
	4.2.1 Moment-Rotation curve	73
	4.2.1.1 Rotation	73
	4.2.1.2 Moment	74
	4.2.2 Rigidity coefficient	75
	4.2.3 Stiffness	89
	4.2.4 Displacement in Mid Span	94
	4.3 Comparison between Laboratory Results and Abaqus Result	95
	4.3.1 Comparison M- Curve	95
5	<b>Conclusion And Recombination</b>	97
	5.1 Conclusions	97
	5.2 Recommendations	98
6	<b>References</b>	100



**LIST OF TABLES**

<b>Table NO</b>	<b>Title</b>	<b>Page</b>
Table 2.1	curve-fitting constants and standardization constants for polynomial	21
Table 3.1	detail of experimental test	40
Table 3.2	detail of specimens	45
Table 3.3	detail of specimens	46
Table 3.4	Stress strain	50
Table 3.5	Detail of gusset plates	57
Table 3.6	Beam properties	66
Table 4.1	Horizontal displacement for top and bottom of beam	74
Table 4.2	Moment value obtain equation	75
Table 4.3	Connection classification AISC	88

## LIST OF FIGURES

<b>Figure No</b>	<b>Title</b>	<b>Page</b>
Figure 1.1	top and seat angle	2
Figure 1.2	top and seat angle with stiffener	3
Figure 1.3	top and seat angle with plate	3
Figure 2-1	Rotation Characteristic of a Typical Semi-Rigid	9
Figure 2.2.1	connection with top and seat plate	9
Figure 2.2.2	rigid connection with stiffener	9
Figure2.3	semi rigid connection between rigid and simple connection	10
Figure 2-4-a	web angle connection	11
figure 2-4-b	web angle connection	11
Figure 2-4-c	double web angle connection	12
Figure 2-4-d	top and seat angle connection	13
Figure 2-4-e	Top and Seat Angle with Double Web-Angle Connections	14
Figure 2-4-c	top and seat angle with stiffener	15
Figure 2-5		15
Figure 2.6.a	Moment and rotation (M- ) relationship	17
Figure 2.6.b	The M – curve of semi-rigid connections	17

Figure 2.6.c	semi rigid beam to column connection	18
Figure 2.6.d	various linear model for semi rigid connection	20
Figure 2.6.e	three parameter power model of semi rigid connection	24
Figure 2.7.a	typical top-and-seat angle connection	28
Figure 2.7.b	Deflected configuration at elastic condition	29
Figure 2.8	portion of Flange Angle used in Azizinamini Finite Element analysis	33
Figure 2.9	example of geometric nonlinearity behaviour	35
Figure 2.10	example boundary nonlinear	36
Figure 3.1.a	Typical Test Setup and Instrumentation	41
Figure 3.1.b	Typical Test Setup and Instrumentation	42
Figure 3.2	specimen A1 modeled by ABAQUS	42
Figure 3.3	specimen A1 modeled by ABAQUS page	43
Graph 3.1	Comparison of M– r curves among FE analysis, power model and experiment	44
Graph3. 2	Comparison of M– r curves among FE analysis (ABAQUS), and experiment A1	44
Figure 3.4.a	top and seat angle page	46
Figure 3.5.a	top and seat angle with bracket	47
Figure 3.6.a	top and seat angle with gusset plate welded to beam and column	47
Figure 3.6.b	top and seat angle with gusset plate	47
Figure 3.4.b	top and seat angle	48
Figure 3.5.b	top and seat angle with bracket	48
Graph 3.3	stress strain curve of steel	50
Figure 3.7.a	C3D20 Element	52
Figure 3.7.b	C3D8 Element	52

Figure 3.8	IPE300	53
Figure3.9	column shape	54
Figure 3.10	solid modeled angle sections	55
Figure 3.11	modeled bracket	56
Figure 3.12	modeled gusset plate	57
Figure 3.13.a	assembly of specimen 4	58
Figure 3.13.b	assembly of specimen7	59
Figure 3.13.c	assembly of specimen 8	59
Figure 3.13.d	assembly of specimen 13	60
Figure 3.15.a	top angle	61
Figure3.15. b	seat angle	61
Figure 3.16	Gap Element Used in the Simulations	62
Figure3.17.a	beam mesh	64
Figure 3.1 7.b	column mesh	64
Figure 3.17.c.	angle meshes	64
Figure .3.18	Boundary condition	65
Figure 3.19	apply loading	67
Figure 3.20	Moments and rotation for slope _deflection equation	68
Figure 3.21	moment- rotation characteristics of AISC connection types	70
Figure 3.22	AISC Moment-Rotation Curve(AISC, 2005a)	72
Figure 4.1	obtain rotation	73
Figure 4.2	Moments and rotation for slope _deflection equation	75
Graph 4.2.a	moment rotation for specimen 2	77
Graph 4.2.b	moment rotation for specimen 2 and 1	77
Figure 4.3	von Mises' stresses specimen 2	78

Graph 4.3.a	moment rotation for specimen 3	78
Graph 4.4	moment rotation for specimen 4	79
Graph 4.5	moment rotation for specimen 5	80
Graph 4.5	moment rotation for specimen 5, 4	81
Graph 4.6	moment rotation for specimen 6	81
Graph 4.7	moment rotation for specimen 7	82
Graph 4.8	comparison moment rotations between specimen 4 to7	83
Graph 4.9	comparison moment rotation specimen 8 to 4	84
Graph 4.10	comparison moment rotation specimen 10 and 4	85
Graph 4.11	comparison moment rotation specimen 10, 8 and 4	85
Graph 4.12	comparison moment rotation specimen 10, 8 and 4	86
Graph 4.13	moment rotation specimen 12	86
Graph 4.14	comparison moment rotation specimen 12, 13,14and 4	87
Graph 4.15.a	I Initial Stiffness specimens 1	89
Graph 4.15.b	compares I Initial Stiffness specimens 1 and 2	90
Graph 4.16	Initial Stiffness specimens 4	90
Graph 4.17	Initial Stiffness specimens 8	91
Graph 4.18	Initial Stiffness specimens 8 and 10	91
Graph 4.19	Initial Stiffness specimen 12	92
Graph 4.20	comparison I Initial Stiffness specimen 12 and 13	93
Graph 4.21	comparison I Initial Stiffness specimen 12, 13 and 14	93
Graph 4.22	displacements in middle of beam	94
Graph 4.23	experimental moment rotation curve	95
Graph 4.24	FEM moment rotation curve	96

Figure 4.25 comparison FEM and experimental moment rotation curve 96

**LIST OF SYMBOLS**

$A$ = Cross sectional area of the beam

$b_f$ = Width of flange

$CoF$ = Coefficient of friction

$d$ = Depth of the beam section

$DoF$ = Degree of freedom

$FEM$ = Finite element modeling

$h$ = Height of the beam web

$I_x$ = Moment of inertia about the x-axis

$L$ = Length of the beam

$M_p$ = Plastic moment of the beam

$PR$ = Partially restrained

$r_x$ = Radius of gyration about x-axis

$R_y$ = Ratio of expected yield stress to specified minimum yield stress

$S_x$ = Elastic section modulus about the x-axis

$t_f$ = Thickness of flange

$t_w$ = Thickness of web

$Z_x$ = Plastic section modulus about the x-axis

= Rotation

$t$ = thickness

$e$ =load distance in seat angle

## CHAPTER 1

### INTRODUCTION

#### 1.1 Introduction

In the structural analyses, some assumptions are supposed for process facility in the design phase. One of those is semi-rigid connections (partially fixity or restrained) which are assumed rigid or pinned connections in peculiar to structure. Actually, rigid and pinned connections may be evaluated as a specific case of semi-rigid connections. Frame system supports are assumed to be fixed, but if those are constructed on elastic foundations, they should consider as semi-rigid. In addition to this, beam to-column connections in prefabricated structure are taken for granted as pinned connection though they are actually semi-rigid. Furthermore, steel brace connection to reinforced concrete (RC) frames in steel braced RC buildings and truss element connection to joints in truss systems are assumed pinned connection. These connections, which are stated above, are actually semi-rigid and their existence in structural analysis provides more realistic and reliable results.

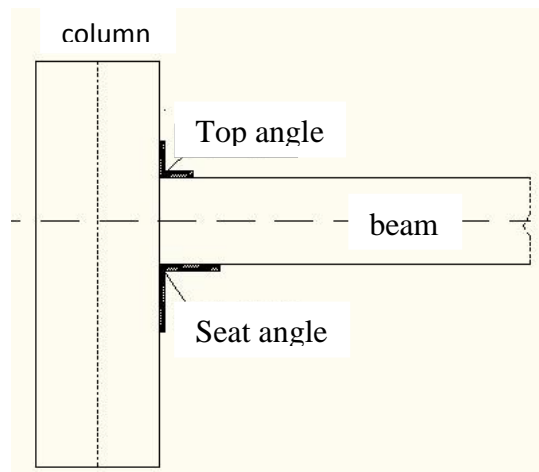
The advantages of semi rigid connection are more than rigid or pinned connection. However, this type of connection does not generally used because of the difficulties to analyze and model. The advantages are listed as providing adequate lateral bracing for wind loads in low rise building, making bracing element unnecessary; optimizing the bending moment due



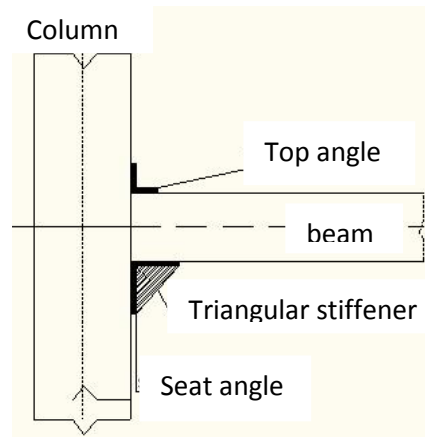
to connection's restraint and minimizing steel weight and overall cost saving (Md Tahir, 1997).

## 1.2 Problem statement

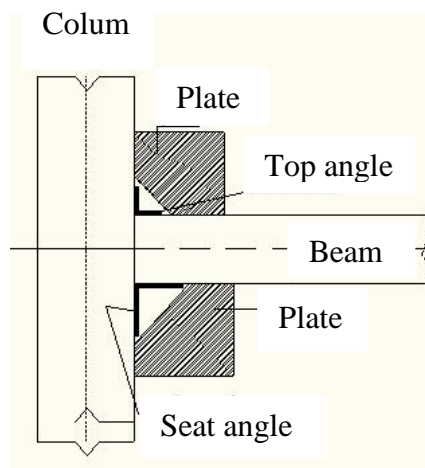
In the some of the country connection of steel beam to steel column using top and seat angle connection is common. Also in the some cases when shear force increased using stiffener under the seat angle for resistant in front of shear forces. However this type of connections assuming pinned connection and using in frame with simple support with brace. In this especial case there are to plates that connected braces to beam and column one of them is top of the beam and the other one is under of the beam. Plates welded to both of the beam and column (figure 1.1 to 1.3) then the behaviour of connection could be changed.



**Figure 1.1:** top and seat angle



**Figure 1.2:** top and seat angle with stiffener



**Figure 1.3:** top and seat angle with plate

### 1.3. Research objective

The specific objectives of this study are as follows:

- To determine the moment-rotation curve characteristic of the top and seat angle steel beam to steel column connection obtained from ABAQUS analysis.

- To determine the moment - rotation curve characteristic of the top and seat angle connection while gusset plate of the braces welded to beam and column obtained from ABAQUS analysis.
- To determine different of specimens between moment-rotation curves that obtained from ABAQUS analysis.
- To determine the accuracy of the analysis result from ABAQUS by comparing them with result obtain from full scale laboratory test.

#### **1.4. Research scope**

The connection of steel beam to column is modelled using finite element software, ABAQUS. The research is focused on the top and seat angle connection with gusset plate in connection zone and also top and seat angle connection attached with bracket in sea angle. The results that obtain from ABAQUS for different specimens are compared together and also top and also with result obtained from laboratory test.

#### **1.5 Significant of study**

Typically, the behaviour of semi-rigid connections relates to the performance on sub-assembly frame of beam-to-column connection. In semi-continuous construction design, semi-rigid connection developed an end restrain leading to reduction on beam moment which resulted to lighter beam in many cases (Md Tahir, 1997). The amount of restrain developed from the semi-rigid connections depends on the stiffness of the connection. The term stiffness in each connection nodes can be either modelled as pinned, rigid or semi-rigid case. This leads to the simplicity and effectiveness of the structural analysis. For example, if the stiffness of the connection is equal to zero, the analysis is modelled as pinned joint.

However, if the connection stiffness is too stiff and approaches infinity, the connection can be modelled as rigid connection.

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