

**TRUSS BRIDGE MOVEMENT AND  
DISPLACEMENT ANALYSIS FOR DIFFERENT  
TYPES OF EARTHQUAKE LOADINGS**

**FATIN NABIHAH BINTI SUHAIME**

**B. ENG (HONS.) CIVIL ENGINEERING**

**UNIVERSITI MALAYSIA PAHANG**

TRUSS BRIDGE MOVEMENT AND DISPLACEMENT ANALYSIS FOR  
DIFFERENT TYPES OF EARTHQUAKE LOADINGS

FATIN NABIHAH BINTI SUHAIME

Thesis submitted in fulfillment of the requirements  
for the award of the  
Bachelor Degree in Civil Engineering

Faculty of Civil Engineering and Earth Resources

UNIVERSITI MALAYSIA PAHANG

JUNE 2017



## **SUPERVISOR'S DECLARATION**

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Bachelor of Civil Engineering

---

(Supervisor's Signature)

Full Name : IR. DR. SAFFUAN BIN WAN AHMAD

Position : SENIOR LECTURER

Date : 10 JUNE 2017



## **STUDENT'S DECLARATION**

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

---

(Student's Signature)

Full Name : FATIN NABIHAH BINTI SUHAIME

ID Number : AA13289

Date : 10 JUNE 2017

**This thesis is proudly dedicated to:**

**All my beloved family (my mother, my father, my brother and all my friends)**

**Thanks for your endless love, sacrifices, prayers, supports and advices**

## ACKNOWLEDGEMENT

Above all I would like to thank “ALMIGHTY ALLAH” who’s guidance and let me courageous at every moment to finish my thesis. I believe that he is the only sovereign authority who has control everything.

I extend my humble and deepest appreciation to all that help me in writing this thesis. My first appreciation goes to my Supervisor Ir. Dr. Saffuan Bin Wan Ahmad who has given precious advice, instructions and knowledge during completing my thesis. Besides that, I would like to thanks the respected panel, En. Mohammad Amirulkhairi and Dr. Khairunisa for their comments and suggestion to improve my thesis.

To my family, especially to my beloved father, Suhaim Bin Talib and my beloved mother Norhamizan Binti Ahmad Lathin for their continuous prayers and support. Not forget to my dearest friend Dinie Amni Binti Mahamud, Nurnajat Nadira Binti Abdul Rahman and Muhammad Zul Hazmi Bin Mansor who always give continuous help and support.

## TABLE OF CONTENT

	<b>Page</b>
<b>TITLE PAGE</b>	i
<b>SUPERVISOR’S DECLARATION</b>	ii
<b>STUDENT’S DECLARATION</b>	iii
<b>DEDICATION</b>	iv
<b>ACKNOWLEDGEMENT</b>	v
<b>ABSTRACT</b>	vi
<b>ABSTRAK</b>	vii
<b>TABLE OF CONTENTS</b>	viii
<b>LIST OF TABLES</b>	xi
<b>LIST OF FIGURES</b>	xii
<b>LIST OF SYMBOLS</b>	xv
<b>LIST OF ABBREVIATIONS</b>	xvi
<b>CHAPTER 1            INTRODUCTION</b>	
1.1    Background of Study	1
1.2    Problem Statement	3
1.3    Research Objective	4
1.4    Scope of Study	4
1.5    Significant of Study	5
<b>CHAPTER 2            LITERATURE REVIEW</b>	
2.1    Introduction	6
2.2    Causes of Earthquake	7
2.2.1    Tectonic Plate	7
2.2.2    Types of Earthquake and Faults	8
2.3    Seismic Wave	11
2.4    Measuring Instrument	14

2.5	Earth Magnitude and Intensity	16
2.5.1	Earthquake Magnitude	16
2.5.2	Intensity	17
2.6	Trusses Bridge Structure	18

### **CHAPTER 3            METHODODLOGY**

3.1	Introduction	21
3.2	Literature Review	23
3.3	Gather Information and Data	23
3.4	SAP2000 Program	23
3.4.1	SAP2000 Software Flowchart	24
3.4.2	Steps in SAP2000 Software	25

### **CHAPTER 4            RESULTS AND DISCUSSION**

4.1	Introduction	32
4.2	Characteristic of Trusses Bridge	32
4.3	Analysis of Trusses Bridge	32
4.3.1	Modal Analysis	33
4.4	Virtual Work Diagram	37
4.5	Time History Analysis	39
4.6	Shear and Moment Resistances	43
4.6.1	Dead Load + Live Load (DL+LL)	43
4.6.2	Dead Load +Live Load +Wind Load +Acheh (DL+LL+WL+Acheh)	43
4.6.3	Dead Load +Live Load +Wind Load + El-Centro (DL+LL+WL+El-Centro)	44
4.6.4	Shear and Moment Capacity	45
4.7	Response Spectrum Analysis	46
4.7.1	Acheh Earthquake	46
4.7.2	El-Centro Earthquake	49
4.7.3	Acheh Earthquake	51
4.7.4	El-Centro Earthquake	54
4.8	Summary of Analysis	56
4.8.1	Time Period and Frequency	57
4.8.2	Maximum Shear and Moment	58
4.8.3	Time History	58



4.8.4	Response Spectrum Analysis	59
-------	----------------------------	----

## **CHAPTER 5            CONCLUSION AND RECOMMENDATIONS**

5.1	Conclusion	60
5.1.1	The resistance of the existing bridge structure using the vulnerability assessment	60
5.1.2	The performance of the bridge structure under different types of loadings	60
5.1.3	The acceleration and displacement in x and y direction	60
5.2	Recommendation	61

<b>REFERENCES</b>	62
-------------------	----

<b>APPENDIX</b>	63
-----------------	----

A1	Design Moment Resistance of floor beam	63
----	--	----

A2	Design Shear Resistance of floor beam	64
----	---------------------------------------	----

## LIST OF TABLES

<b>Table No.</b>	<b>Title</b>	<b>Page</b>
2.1	The earthquake magnitude and effects	17
4.1	Maximum Joint Displacement vs. U1	42
4.2	Maximum Joint Displacement vs. U2	42
4.3	Maximum Joint Acceleration vs. U1	42
4.4	Maximum Joint Acceleration vs. U2	42
4.5	Ratio of resistance to capacity for floor beam 63	45
4.6	Peak Response Spectrum for Aceh Earthquake in x direction (Frequency)	48
4.7	Peak Response Spectrum for Aceh Earthquake in y direction (Frequency)	48
4.8	Peak Respon Spectrum for El-Centro Earthquake in x direction (Frequency)	50
4.9	Peak Respon Spectrum for El-Centro Earthquake in y direction (Frequency)	51
4.10	Peak Respon Spectrum for Aceh Earthquake in x direction (time period)	53
4.11	Peak Respon Spectrum for Aceh Earthquake in y direction (time period)	53
4.12	Peak Respon Spectrum for El-Centro Earthquake in x direction (time period)	56
4.13	Peak Respon Spectrum for El-Centro Earthquake in x direction (time period)	56
4.14	Rigidity of shape according to their time period	57
4.15	Maximum shear and moment under different type of load combination	
4.16	Maximum displacement and acceleration under different type of earthquake	58
4.17	Maximum displacement and acceleration of 0% damping under different types of earthquake	59
5.1	Displacement and acceleration for Time History Analysis and RSA for El-Centro earthquake	61

## LIST OF FIGURES

Figure No.	Title	Page
1.1	Steel Arch Road Bridge ,Sultan Iskandar Bridge, Kuala Kangsar (1932)	2
1.2	Concrete Bridge, Sultan Abdullah Bridge, Jerantut Pahang	2
1.3	Sultan Ibrahim Suspension Bridge, Kuala Krai (1945)	3
1.4	Cable Stayed Bridge, Sri Saujana Bridge, Putrajaya (2002)	3
2.1	Major Tectonic Plates	8
2.2	Types of Inter-Plate Boundaries	8
2.3	Normal fault diagram	9
2.4	Reverse fault diagram	10
2.5	Strike-slip fault diagram	10
2.6	P-waves	12
2.7	S-wave	12
2.8	Loves Waves	13
2.9	Rayleigh Waves	14
2.10	Oscillating Pendulum Bob	15
2.11	Basic Principle of Seismometer	15
2.12	Seismogram and type of waves	16
2.13	Modified Mercalli Intensity Scale	18
2.14	Warren Truss Bridge	19
2.15	Pratt Truss	19
2.16	Howe Truss	20
2.17	K Truss	20
3.1	Flow chart to carry out the project	22
3.2	Structure Design in SAP 2000 Software	24
3.3	Choose the unit for the project	25
3.4	Template selected 'Grid'	26
3.5	Define grid line and grid spacing	26
3.6	Define material	27
3.7	Assign the structure properties	27
3.8	Model structure of truss bridge in SAP2000 (3D)	28
3.9	Define the load cases	28
3.10	Time history function (Acheh earthquake)	29
3.11	Time history function (El-Centro earthquake)	29
3.12	Add restraint at the base condition	30
3.13	Run analysis	31
3.14	Complete run analysis	31
4.1	Mode shape 1 with period of 0.71765	33
4.2	Mode shape 2 with period of 0.71707	33
4.3	Mode shape 3 with period of 0.55374	34
4.4	Mode shape 4 with period of 0.54548	34
4.5	Mode shape 5 with period of 0.45376	34
4.6	Mode shape 6 with period of 0.43866	34
4.7	Mode shape 7 with period of 0.39572	34
4.8	Mode shape 8 with period of 0.38925	34

4.9	Mode shape 9 with period of 0.24634	35
4.10	Mode shape 10 with period of 0.20925	35
4.11	Mode shape 11 with period of 0.18444	35
4.12	Mode shape 12 with period of 0.18430	35
4.13	Modal period and frequency	36
4.14	Forces: Dead, Displacement: Dead	37
4.15	Forces: Dead, Displacement: Wind	37
4.16	Forces: Dead, Displacement: Live	38
4.17	Forces: Live, Displacement: Live	38
4.18	Forces: Wind, Displacement: Live	38
4.19	Forces: Wind, Displacement: Wind	39
4.20	Joint Displacement vs. U1 for Acheh and Elcentro Loading	40
4.21	Join Acceleration vs U2 for Acheh and El-Centro loading	40
4.22	Joint Acceleration vs U1 for Acheh and El- Centro loading	41
4.23	Join Acceleration vs U2 for Acheh and El-Centro loading	41
4.24	Result of the maximum shear force for DL + LL	43
4.25	Result of the maximum momente for DL + LL	43
4.26	Result of the maximum shear for DL+LL+WL+ACHEH	44
4.27	Result of the maximum moment for DL+LL+WL+ACHEH	44
4.28	Result of the maximum shear for DL+LL+WL+EL-CENTRO	44
4.29	Result of the maximum moment for DL+LL+WL+EL-CENTRO	44
4.30	Spectra Displacement in X direction	46
4.31	Spectra Displacement in Y direction	46
4.32	Spectral Velocities in X direction	47
4.33	Spectral Velocities in Y direction	47
4.34	Pseudo Spectral Velocities in X direction	47
4.35	Pseudo Spectral Velocities in Y direction	47
4.36	Spectral Accelerations in X direction	47
4.37	Spectral Accelerations in Y direction	47
4.38	Pseudo Spectral Acceleration in X direction	48
4.39	Pseudo Spectral Acceleration in Y direction	48
4.40	Spectra Displacement in X direction	49
4.41	Spectra Displacement in Y direction	49
4.42	Spectral Velocities in X direction	49
4.43	Spectral Velocities in Y direction	49
4.44	Pseudo Spectral Velocities in X direction	49
4.45	Pseudo Spectral Velocities in Y direction	49
4.46	Spectral Accelerations in X direction	50
4.47	Spectral Accelerations in Y direction	50
4.48	Pseudo Spectral Acceleration in X direction	50
4.49	Pseudo Spectral Acceleration in Y direction	50
4.50	Spectra Displacement in X direction	51
4.51	Spectra Displacement in Y direction	51
4.52	Spectra Displacement in X direction	52
4.53	Spectra Displacement in Y direction	52
4.54	Spectral Velocities in X direction	52
4.55	Spectral Velocities in Y direction	52
4.56	Pseudo Spectral Velocities in X direction	52
4.57	Pseudo Spectral Velocities in Y direction	52
4.58	Spectral Accelerations in X direction	52

4.59	Spectral Accelerations in Y direction	52
4.60	Pseudo Spectral Acceleration in X direction	53
4.61	Pseudo Spectral Acceleration in Y direction	53
4.62	Spectra Displacement in X direction	54
4.63	Spectra Displacement in Y direction	54
4.64	Spectral Velocities in X direction	54
4.65	Spectral Velocities in Y direction	54
4.66	Pseudo Spectral Velocities in X direction	55
4.67	Pseudo Spectral Velocities in Y direction	55
4.68	Spectral Accelerations in X direction	55
4.69	Spectral Accelerations in Y direction	55
4.70	Pseudo Spectral Acceleration in X direction	55
4.71	Pseudo Spectral Acceleration in Y direction	55

**LIST OF SYMBOLS**

$\gamma_{M0}$	Partial factor for building
A	Cross sectional area
$f_y$	Yield strength
b	Overall breadth
h	Overall depth
$h_w$	Depth of web
$t_f$	Flange thickness
$t_w$	Web thickness
$\eta$	Member verification

**LIST OF ABBREVIATIONS**

3D	Three dimensional
DL	Dead load
LL	Live load
RSA	Response Spectrum Analysis
SAP	Structural Analysis & Design Program
WL	Wind load