UNIVERSITI TEKNIKAL MALAYSIA MELAKA	**CENTRE FOR RESEARCH AND INNOVATION MANAGEMENT** **PROJECT COMPLETION REPORT**

PERHATIAN:

1. Laporan akhir projek hendaklah dihantar ke **CRIM dua (2)** bulan selepas projek tamat.

2. Sila lampirkan dokumen yang berkaitan seperti yang dinyatakan.

3. CRIM akan mengumpul dan membukukan Profil Penyelidikan mengikut jenis geran dan Bidang Fokus UTeM.

4. Penghantaran secara atas talian URIS akan dilaksanakan pada satu masa kelak.

5. Senarai semak:

No.	Perkara	Tandakan (√)
1.	Borang R&D010 lengkap	√
2.	Perakuan Dekan / Timbalan Dekan (P&I)	
3.	Sertakan Lampiran A: Profil Penyelidikan. Penulisan Profil Penyelidikan mesti berasaskan kepada kertas cadangan projek berkaitan yang diluluskan.	√
4.	Salinan hardcopy & softcopy (MS Word) borang R&D 010 (CD/DVD)	√
5.	Borang P3(R) - Laporan Akhir Skim Geran Penyelidikan Fundamental (FRGS) untuk FRGS	

A. PROJECT DETAILS

Project Leader : MOHD AZLI BIN SALIM

Faculty/Centre : FKM

Project Title : DYNAMIC ANALYSIS OF LAMINATED RUBBER-METAL SPRING **ON**

Project Ref. No.: PJP/2012/FKM (42A) S01046

Project Focus Area : a) **Green Technology** b) Emerging Technology
c) System Engineering d) Human Technology Interaction

Project Duration : Starts Date 1st June 2012 Final End Date: 30th June 2014

Budget Approved: RM 15,000.00 Amount Spent : RM 15,000.00

Project Members : Multidiciplinary ? _____ Multifaculty ?AMINURRASHID NOORDIN

B. PROJECT ACHIVEMENT AND PERFORMANCE

OVERALL	**0 – 50%**	**51 – 75%**	**76 – 100%**
Work completion (please state # %)			x
Financial Utilization (please state # %)			x
RESEARCH OUTPUT			
I. PUBLICATION (Recorded at UTeM eRepository)	UTeM Press	Index Scopus/ISI	Others
a. No. of Journal Publication (Please attach the first page of publication)		2	
b. No. of Conference Proceeding (Please attach the first page of publication)			
c. No. of Other type of publication eg. monograph, books, chapters in book			

II. PROTOTYPE DEVELOPMENT	National	International
a. No. of Intellectual Property Rights		
b. Attended product exhibition & competition		
c. No. of Industrial Collaboration MoU/NDA/MoA)		

III. HUMAN CAPITAL DEVELOPMENT

Number of Human Capital		On-Going		Graduated	
		Malaysian	Non-M	Malaysian	Non-M
1	PhD Student				
2	Master Student	1			
3	Undergraduate Student (PSM/SRA)				
Total		1			

IV. ASSETS AND INVENTORY PURCHASED (Cost more than RM 3000 per item)

1.

2.

3.

4.

5.

DECLARATION OF PROJECT LEADER

I acknowledged UTeM in providing the fund for this research work.

I certify that the information given in this final project report is true to the best of my knowledge.

Project Leader's Signature :

Official stamp :
Name :
Designation :
Date :

ENDORSEMENT BY DEAN or DEPUTY DEAN (RESEARCH), FACULTY/CENTRE
(Please state /comment on the performance of the project)

_____

_____

_____ _____
Signature & Official Stamp Date

Revised date : 4Mac2014

LAMPIRAN A

TEMPLATE
PROFIL PENYELIDIKAN

Picture related to the research project

DYNAMIC ANALYSIS OF LAMINATED RUBBER-METAL SPRING ON HIGH-RISE BUILDING

MOHD AZLI BIN SALIM
NUR RASHID BIN MAT NURI @ MD DIN
NAZRI HUZAIMI BIN ZAKARIA
AMINURRASHID BIN NOORDIN
HAIRUL BIN BAKRI
FACULTY OF MECHANICAL ENGINEERING
azli@utem.edu.my
NOISE AND VIBRATION

ABSTRACT (120 words)

This study is to gain an understanding and develop a test rig for high-rise building isolation for ground motion in vibration and noise phenomenon in Malaysia. In this study a 7-storey high rise building structure with actual scale will be developed. There are three types of simplify structure base such as a pure force, rigid body and short resonant beam. These bases will be connected to the ground structure of building via a single isolator. The outcome of this study is to express the frequency averaging energy transmission or the peak amplitude transmission to the ground structure motion in terms of approximate source and isolator mobility formulae. Theoretical predictions will be compared with experimental measurements. It is useful to predict an energy transmission from ground motion from building, more profound understanding and greater confidence on the approach will not be gained unless measurements can be made. The methods called frequency domain acceleration data and structural frequency response information will be used in this study. These methods are chosen because there is energy input to the structure at a single isolator, and then the energy will be transmitted through an isolator using acceleration at the top and bottom. The energy then will be absorbed by finite resonant structure using accelerations at one, two or four points. By right, after completing this study and experiment, the response on ground isolator of high-rise building can be understood in depth.

1. INTRODUCTION

Recently, the advantage technology in seismicity engineering is become more relevant. It is becoming more important to understand because much active seismicity ground motion is increased in Europe, America and Asia region. Vertical and horizontal swing called vibration can be pleasant and useful as in massaging and therapeutic applications but it also unpleasant and harmful because it can lead catastrophic failures of components (M.A.Salim et al., 2011), (Fujita, 1994). Many researchers around the world have conducted detail study on ground isolator for high-rise building because this type of structure has a big potential to collapse during the big seismicity activity.

Wang (2012) has studied the damage field happen at Wenchuan Earthquake. The high-rise building is occurred in terms of serious damage and many innocent people are died during the disaster (Maniatakis et al., 2012). According to that, high-rise building is more sensitive in seismic activity. Besides, a stiffness analysis is conducted by Eom in 2011. In this analysis, inelastic design forces and deformations of individual members in structure are determined by linear analysis and the magnitude of secant stiffness is calculated (Eom at al., 0212). In order to draw a conclusion, the researcher has used frequency domain acceleration data and structural frequency response information to analysis the ground isolator response during the miniature of ground motion with small scale earthquake.

Henry studied the building collapse from the Chrischurch earthquake in 2011 (Eom at al., 0212). Till-up precast concrete buildings in Chrischurch are studied in detail for a ground isolator. The researcher has found that the ground isolator is not operating during the disaster. The collapse is due to the plane loading direction, both load bearing and cladding panel was not enough response caused by huge ground motion of seismicity activity.

In ASEAN, a huge earthquake occurred in Padang Pariaman, Indonesia. This disaster kills 1200 people, thousands of houses are seriously damaged and many buildings were collapsed (Rosyidi et al., 2011). Rosyidi investigated this disaster, and the researcher found that the quality of construction which did not meet the building code and the standard of requirements (Rosyidi et al., 2011). Besides that, in this location, they do not install any ground isolator to counter back the seismicity activity and because of that many building is not enough strength to stabilize the structure.

In this research, the focus is mainly on studying and developing the test rig including the 7-storey high-rise building, ground isolator and miniature of seismicity motion in laboratory. Then, the frequency domain acceleration data and structural frequency response information method will be introduced to analysis the responses and finally will suppress the energy transmission from ground motion to structure.

2. RESEARCH METHODOLOGY

DESCRIPTION OF RESEARCH METHODOLOGY

i. Literature review on related field

a. To obtain an overview of high-rise building
b. To obtain an overview about the frictional-type sliding isolators
c. To obtain an overview about laminated rubber bearing isolators with and without lead-core

ii. Design and fabricate the 7 storey of building

a. The designs will be developed by referring the Suy's design (Suy et al., 2007).
b. The calculation of structural integrity will be calculated using conventional method.

iii. Design and development of laminated rubber metal spring

a. Analytical model which is mathematical modeling of laminated rubber metal spring will be developed using Koh-Kelly and Haring theory.
b. Numerical analysis using numerical software will be developed in order to verify the analytical model.
c. Experimental test rig of laminated rubber metal spring will be developed based on the verification made before.
d. The laminated rubber metal spring will apply to the 7 storey building.

iv. Data analysis and discussion

a. The analytical model data analysis will be collected using MatLab software and it is available at Studio Komputer Umum, Fakulti Kejuruteraan Mekanikal, Universiti Teknikal Malaysia Melaka.
b. The numerical model will be developed using Ansys software which is available at Pneumatics Laboratory, Fakulti Kejuruteraan Mekanikal, Universiti Teknikal Malaysia Melaka.
c. The test rig will be developed at Measurement and Instrumentation Laboratory, Fakulti Kejuruteraan Mekanikal, Universiti Teknikal Malaysia Melaka. The software will use is DeweSoft and it is applicable for vibration analysis.

3. LITERATURE REVIEW

Building isolation of ground structures such as multi-storey buildings, nuclear reactor, bridges, sensitive equipment, mechanical parts, sensor and many more are designed to preserve structural integrity and to prevent injury to the occupants and damage to the contents by reducing the earthquake or vertical ground vibration and deformations in the structure (R.A.Ibrahim, 2008). The performance of these systems depends on two characteristics which are:

i. The capacity if shifting the system fundamental frequency to a lower value, which is well remote from the frequency band of most common earthquake or vertical ground motion (R.A.Ibrahim, 2008).
ii. The energy dissipation of the isolator (R.A.Ibrahim, 2008).

Basically, all isolation systems can be classified into two main categories:

i. Laminated rubber bearing isolators with and without lead-core (R.A.Ibrahim, 2008).
ii. Frictional-type sliding isolators (R.A.Ibrahim, 2008).

The first category has several practical applications while the second is still in the early stage of development around the world (R.A.Ibrahim, 2008). The main purposes of friction-base isolator is based on decoupling a structure from the damaging components of ground motion by introducing flexibility and energy absorption capacity through a system placed between the structure and its foundation (Kelly, 1986). Besides, rubber

bearings have been entensively used in base-isolation systems because the stiffness of the rubber and protect the structure integrity during the earthquake motion.

The designation of rubber bearings involves the influence of nonlinear behavior during large deformation and the increase in stiffness due to aging (R.A.Ibrahim, 2008). A combination of laminated rubber bearings, viscous damper and friction elements is considered to seismically isolate a building of 7 levels (Suy et al., 2007). A smooth approximation of discontinuous characteristics friction was introduced in the analytical modeling of the structure (Suy et al., 2007). It was found that the dynamics of the superstructure largely influence the entire systems response.

A number of overviews of the applications and performance of seismic isolation to structural systems were presented in open literature. A numerical algorithm for distribution of friction devices along the height of different structural systems was presented by Dimova (Dimova et al., 1995). The response of a rigid structure with frictional-base isolation system to a random ground motion excitation was the focus on the study. It also provided a comparison of the rms displacement and velocity responses as predicted analytically with those estimated by Monte Carlo simulation (Dimova et al., 1995). In the final of the study, it concluded that the frictional-base isolators are highly reliable in reducing structural displacements and accelerations.

Multi-storey buildings constructed with a kiw-rise podium structure form a major shortcoming in view of seismic design. For example, Shahrooz and Moehle experimentally and numerically demonstrated that relatively large inter-storey drifts of the setback structure were localized at the level just above the podium structure (Shahrooz et al., 1990). It was found experimentally that unfavorable seismic response implication did occur in the building complex in the rigidly connected case. This was in contrast with the friction damper, which exhibited effectiveness in reducing absolute acceleration and inter-storey drift responses of both buildings if friction level was appropriately applied.

4. FINDINGS

At the end of the study, the potential of laminated rubber metal spring is developed and it is decreased the ground motion for high-rise building, mechanical parts, automotive parts, sensitive instruments and many more.

5. CONCLUSION

Static analysis of a laminated rubber-metal spring has been modelled using the Finite Element method. It was found that the deformation of the rubber due to load can be reduced by embedding layers of metal plates. However, this generates higher stress distributions compared to pure solid rubber and the stress concentrates mainly on steel plate layers. Strain distribution was observed to be high at the solid rubber isolator and it decreases on the laminated rubber-metal spring. For the latter, the critical parts of strain distribution still occur in the rubber layers.

Steady state dynamic analysis of the models of laminated rubber-metal spring suggests that addition of metal plate does increase the vibration performance of the seismic isolation system. However, even more quantity of metal shims contain in a rubber isolator, the natural frequency of the system remain the same. Only the internal resonance show improvement as more metal shims embedded inside it. After adding the metal plate up to five layers, the performance was dropping thus making laminated rubber-metal spring with 4 metal plate the most reliable design for this study of dynamic analysis.

Static and Steady state dynamic analysis done had done shows that laminated rubber-metal spring with 4 embedded metal layers were the most optimize designs for the dimensions studied. However, this result does not affected by the changing of mass on top of the isolator for steady state dynamic analysis. Thus study on effect of mass on laminated rubber-metal spring is needed to be pursued.

ACHIEVEMENT

i) Name of articles/ manuscripts/ books published

Two long papers are publish in journal and cited by ISI and SCOPUS. (Wulfenia Journal and Advanced Science Letters).

M.A.Salim, A. Noordin, M.A. Abdullah "*Modeling, Simulation and Validation of Tuned Mass Damper for High Rise Structure with Control Scheme to Suppress Dynamic Unbalance Force*", Wulfenia Journal, Vol. 19, No. 8, August 2012, pp 298-314, ISSN 1561-882X. {**Publisher**: Wulfenia Journal. **Indexed**: T**homson Reuters IF – 0.267**, BIOSIS Previews, Elsevier Bibliographic Database, DOAJ, EMBASE, ABMINFORM, Genamica, Ulrich, Compendex}.

M.A. Salim, A. Putra, M.A. Abdullah, A. Noordin, B.T. Tee, *"Peak Amplitude Transmission on High-Rise Structure by Implementing TMD Method"*, Advanced Science Letters, Volume 19, Number 1, January 2013, pp. 101-105, ISSN 1936-6612, EISSN 1936-7317, 2012. {**Publisher**: American Scientific Publisher. Indexed: **Thomson Reuters** IF – 1.253(Q2 – Multidisciplinary Sciences, Rank 15 over 59), Chemical Abstracts, Elsevier Bibliographic Database, Compendex, Scopus, Biological Science Abstracts, Biotechnology and BioEngineering Abstracts, Biotechnology Research Abstracts, Bacteriology Abstracts (Microbiology B), Neurosciences Abstracts, Engineering Reseach Database, Technology Research Database, Environmental Science and Pollution Management}. {**DOI**: http://dx.doi.org/10.1166/asl.2013.4690}

ii) Title of Paper presentations (international/ local)

iii) Human Capital Development

One MSc. Student

iv) Awards/ Others

v) Others

REFERENCES

B.M.Shahrooz, J.P.Moehle. 1990. “Seismic Response and Design Setback Buildings”. *ASCE Journal of Structural Engineering*. 16. 1423 – 1439.

Eom., T.S., Kim., J.Y., Park., H.G, 2012. “Building Analysis for Inelastic Earthquake Design of Regular Moment Frames and Dual Systems Addressing Moment Redistribution”. *Engineering Structures*. 34. 147 – 154.

Fujita, T, 1994. “Application of Hybrid Mass Damper with Convertible Active and Passive Modes using Hydraulic Actuator to High Rise Building”. *IEEE Proceeding of the 1994 America Control Conference*. 1067 – 1072.

H.M.R. Suy, R.H.B. Fey, F.M.B.Galanti, H.Nimeijer. 2007. “Nonlinear Dynamic Analysis of a Structure with a Friction-Based Seismic Base Isolation System”. *Nonlinear Dynamics*. 50. 523 – 538.

J.M.Kelly. 1986. “A Seismic Base Isolation; Review and Bibliography”. *Soil Dynamics and Earthquake Engineering*. 5. 202 – 216.

M.A.Salim, A.Noordin, J.Karjanto, M.Z.M.Rody, 2011. “The New Generation of Building Concept to Suppress the Horizontal Vibration During the Earthquake. *Australian Journal of Basic and Applied Sciences*. 5 (4). 16 – 25. ISSN 1991 – 8178.

Maniatakis, C, Spyrakos, C.C, 2012. “A New Methodology to Determine Elastic Displacement Spectra in the Near-Fault Region”. *Soil Dynamics and Earthquake Engineering*. 35. 41 – 58.

R.A.Ibrahim, 2008. “Recent Advances in Nonlinear Passive Vibration Isolator”. *Journal of Sound and Vibration*. 314. 371 – 452.

Rosyidi, A.P., Jamaluddin, T.A., Sian, L.C., Taha, M., R, 2011. “Earthquake Impacts of the Mw 7.6, Padang, Indonesia, 30 September 2009”. *Sains Malaysiana*. 40 (12). 1393 – 1405.

S.L.Dimova, K.Meskouris, W.B.Kratzig. 1995. “Numerical Technique for Dynamic Analysis of Structures with Friction Devices”. *Earthquake Engineering and Structural Dynamics*. 24. 881 – 891

APPENDIXES