OPTIMIZATION OF TUNED MASS DAMPER TO MINIMIZE THE DISPLACEMENT

Final Project Report
as a requirement to obtain Bachelor degree from
Universitas Atma Jaya Yogyakarta

by:
NATHAN YULEO FECAN
Student ID Number: 131315000

INTERNATIONAL CIVIL ENGINEERING PROGRAM
DEPARTMENT OF CIVIL ENGINEERING
FACULTY OF ENGINEERING
UNIVERSITAS ATMA JAYA YOGYAKARTA
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STATEMENT

I signed below stating that the final project with the title:

"OPTIMIZATION OF TUNED MASS DAMPER TO MINIMIZE THE DISPLACEMENT"

It is the result of my own work and not a result of plagiarism of other people's work. Ideas, research data, and quotes directly or directly derived from the writings or ideas of others expressly provided in this Final Project. If it is proven later that this Final Project is the result of plagiarism, the graduation certificate that I received will be canceled and returned to Universitas Atma Jaya Yogyakarta.

Yogyakarta, March 27 , 2017

Who made the remarks,

NATHAN YULEO FECAN

APPROVAL

Final Project Report

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has been approved by Supervisor

Yogyakarta, 27 March 2017

Supervisor,

Prof. Ir. Yoyong Arfiadi, M.Eng., Ph.D.,

Department of Civil Engineering

Chairman,

J. Januar Sudjati, ST, MT

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APPROVAL

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has been examined and approved by:

Name	Signaturre	Date
Chairman : Prof. Ir. Yoyong Arfiadi, M.Eng., Ph.D	.....	27/03/2017
Secretary : Dinar Gumilang Jati, S.T., M.Eng	.....	27/3 2017
Member : Dr. Ir. Ade Lisantono, M.Eng	.....	29/03/2017

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PREFACE

First of all, I would like to thanks to God for His blessing that had been given to the author, so that the author could prepare and finish this final project report. This report was completed as a requirement to obtain Bachelor degree from Universitas Atma Jaya Yogyakarta.

I would like to express my gratitude towards:

1. Prof. Ir. Yoyong Arfiadi, M.Eng., Ph.D., as my Supervisor during did my final project, for his support, advice and invaluable knowledges.
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I realize this report has many mistakes. Therefore, I accept any form of suggestion for further improvement. Finally, I hope this report can be useful for the readers.

Yogyakarta, March 27 , 2017

NATHAN YULEO FECAN

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NOTATIONS

m = mass of the main system

m_d = mass of the damper

μ = mass ratios between structure and damper

c = damping of the main system

c_d = damping of the damper

k = stiffness of the main system

k_d = stiffness of the damper

u = displacement

$\dot{u}$ = velocity

$\ddot{u}$ = acceleration

a_g = ground acceleration

y = relative displacement

$\dot{y}$ = relative velocity

$\ddot{y}$ = relative acceleration

P = external force of the main system

P_d = external force of the damper

ω = natural frequency of the main system

ω_d = natural frequency of the damper

t = time

ξ = damping ratio of the main system

ξ_d = damping ratio of the damper

α = frequency ratio

C_z = regulation matrix

E = modulus of elasticity

J = performance index

L = Lyapunov matrix

L_c = controllability Gramian

L_o = observability Gramian

z = regulated (controlled) output vector

Z = state vector

ABSTRACT

"OPTIMIZATION OF TUNED MASS DAMPER TO MINIMIZE THE DISPLACEMENT" *prepared by Nathan Yuleo Fecan, Stu. ID Number 131315000, 2017, Structural Engineering, International Civil Engineering Program Department, Faculty of Engineering, Universitas Atma Jaya Yogyakarta.*

Tuned mass dampers (TMDs) systems are one of the vibration controlled devices used to reduce the response of buildings subjected to lateral loadings such as wind and earthquake loadings. There has been many research of TMDs due to their simplicity. The optimization of properties of TMDs become one topic that will become the main topic in this research. The numerical optimization technique is used to compute the optimum values of TMD parameters that will minimize the maximum displacement of the structure. The concept of genetic algorithms is based on Charles Darwin's theory of survival of the fittest. Genetic algorithm simulates the survival of the fittest among individuals over consecutive generation for solving a problem.

The purpose of this research is to optimize the tuned mass damper parameter that are damping (k_d) and damping system (c_d). In this research a simple 20 stories building will be used for the simulations. The building is modeled as shear building. The TMDs will be added to the building in the top floor. In order to optimize the parameters of TMDs, Genetic algorithms (GAs) were used to help the optimization problems. For the comparison, different mass ratio with the range between 1% to 10% were used.

The result of simulation shows that when mass ratio increased, frequency ratio will be decreased. When mass ratio increased, damping ratio of TMD will be increased. Then the building will be simulating subject earthquake ground accelerations such as El Centro 1940, Kobe 1995, Hachinohe 1968 and Northridge 1994 ground accelerations. The displacement of the structure without TMD in El Centro 1940, Kobe 1995, Hachinohe 1968 and Northridge 1994 ground accelerations are 0.244 m, 0.317 m, 0.312 m and 0.693 m, respectively. The acceleration of the structure without TMD are 6.545 m, 1.567 m, 4.31 m and 1.59 m, respectively. When applied with the 10% TMD, the displacement reduced by 18.95% to 0.198 m, 7.6 % to 0.293 m, 31.75% to 0.213 m and 20.10% to 0.554 m. For the acceleration reduced by 90% to 0.655 m, 90% to 0.157 m, 90% to 0.431 m, 90% to 0.159 m. The simulation of the optimized TMDs subject to earthquake ground accelerations show that the TMDs can reduce the displacement and acceleration of the building effectively.

Keywords: *tuned mass dampers, genetic algorithm, optimization, earthquake.*