EFFECT ON VIBRATION AMPLITUDE IN ALUMINIUM RECTANGULAR PLATE USING SIMULATION APPROACH

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DECLARATION

I declare that this project report entitled "Effect On Vibration Amplitude In Aluminium Rectangular Plate Using Simulation Approach" is the result of my own work except as cited in the references.

Signature	: ....
Name	: ....
Date	: ....

APPROVAL

I hereby declare that I have read this project report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Design & Innovation).

Signature : ....

Name of Supervisor : ....

Date : ....

DEDICATION

To my beloved mother and father.

ABSTRACT

This study is about the effect on vibration amplitude in aluminium rectangular plate using simulation approach. The purpose of this study is to study the vibration effect of aluminium plate using simulation technique. From the analysis that has been made, the frequency value is obtained from CATIA software. The result shows that the plate have the same frequency response when load is being applied at each point on the plate which means the model is in homogeneous condition. However, this study is conducted with three conditions of model. The analysis shows that the third condition which consist of the plates with springs, rubber between the second condition’s plates and base have the best result. This is proven as the percentage error is calculated from the frequency value obtained.

ABSTRAK

Kajian ini adalah mengenai kesan ke atas getaran amplitud pada plat aluminium segi empat menggunakan pendekatan secara simulasi. Tujuan kajian ini adalah untuk mengkaji kesan getaran plat aluminium menggunakan teknik simulasi. Berdasarkan analisis yang dilakukan, nilai frekuensi telah diperoleh daripada perisian CATIA. Hasilnya menunjukkan bahawa plat mempunyai tindak balas frekuensi yang sama apabila beban dikenakan pada setiap titik di atas plat yang bermaksud model berada dalam keadaan sekata. Walau bagaimanapun, kajian ini dijalankan berdasarkan model yang terbahagi kepada tiga keadaan. Analisis menunjukkan bahawa keadaan ketiga yang terdiri daripada plat berserta spring, getah antara plat dan tapak mempunyai hasil yang terbaik. Ini terbukti apabila ralat peratusan dikira dari nilai frekuensi yang diperoleh.

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f	=	Frequency
A	=	Area
CL	=	Velocity of propogation
D	=	Longitudinal stiffness
dx	=	Displacement
E	=	Modulus of elasticity
K	=	Wave number
P	=	Pressure
ε	=	Strain
μ	=	Wave length
ρ	=	Density
σ	=	Stress
ω	=	Operating frequency

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION OF STUDY

The application of plate plays a big role which is the most commonly used structures in the industrial world. In the structured design, plate is stated only to withstand applied static loads which are inadequate for the application. Possibility of large cyclic displacement and stresses should be considered due to periodic or random time changing the forces acting on the plate's lateral surface.

Some examples for the issue are the aircraft components or stationary structures exposed to high wind velocities which random forces are expected on the plate surface, tangential fluid force on plate surface used in ship hulls, submarines or offshore structures and regular or periodic excitation forces on plates used as structural housing on rotating or reciprocating machinery like compressors and reciprocating engines.

There exist a large number of isolated frequencies at which rectangular plate will go through a large-amplitude vibration by constant time changing the forces of matching frequencies as shown in Figure 1.1 below. The sensitivity of the plate vibration to the variation of weight limitations can be moderately different from the case of a single traveling load (A. Nikkhoo et al., 2014). The related elements with each plate's natural frequency is a characteristic or mode shape.

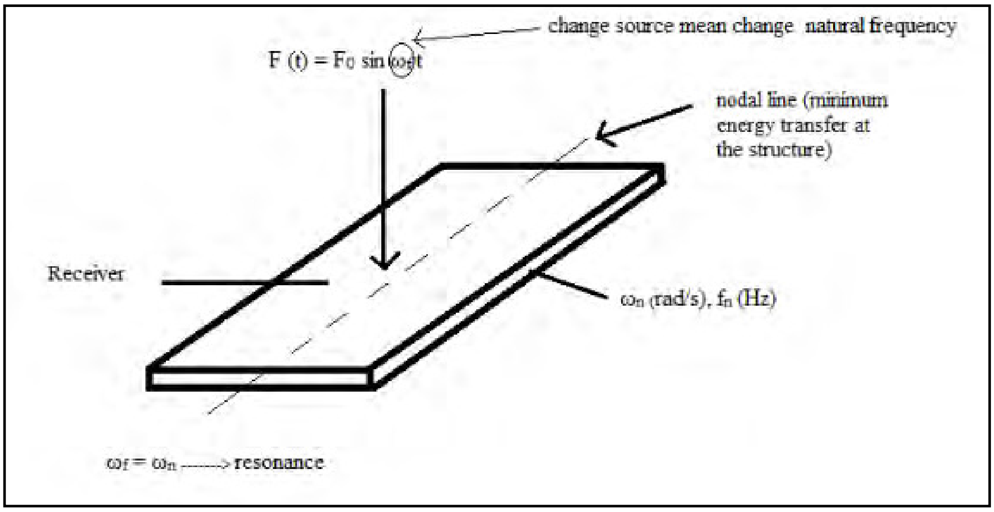

Figure 1.1: The schematic diagram of rectangular plate.

There are several steps to analyze the forced vibration. Before solving the problem, the value of natural frequency and mode shape need to be determined. Then, it can assist to analyze free vibration or forced vibration where the focus are known as amplitude of vibration.

From the previous study, a mixed method is used for the solution of free and forced vibration of rectangular plate which are Ritz method and differential quadrature method. The formulation of the problem is stated in matrix form and therefore programming is not hard. A good rate of convergence is demonstrated and the results are in good agreement with the available results even with a few numbers of Ritz terms and DQ sample points in the numerical examples presented (S.A. Eftekhari, 2011).

1.2 PROBLEM STATEMENT

The vibration analysis is a significant step for obtaining the result of frequency on the aluminium rectangular plate. The problem of the structured design is when there is matching between driving forces and the plate's natural frequencies which is known as resonance. The analysis is needed to avoid the possible resonance from occur in the application.

1.3 OBJECTIVE

The objective of this study is to study the vibration effect of aluminium plate using simulation technique.

1.4 SCOPE OF PROJECT

The scopes of this study are:

1. Conduct the simulation by using CATIA software.
2. Analyze the vibration occur on the aluminium plate.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Literature review is the information gathering which already exists in the previous research or project. The purpose of literature review is to define the research topic and it consists of several information of the previous research. The information can be obtained from referring to journal, article or information from website. Relevant sources from online articles and websites are compiled and cited to complete this literature review. Hence, by review the related information, it will help to understand the objective of the research.

2.2 THEORY OF PLATE

As stated in the background of study, the application of plate is widely used in the industrial world. The plate consists of two basic theories which are Kirchhoff plate theory and Mindlin plate theory. However, the plate properties such as the Young's Modulus, density and poisson's ratio is important for the different used of plate in any application. The previous research have found that different plate properties provide a different bending stiffness (Lu et al., 2006). This means that the plate properties lead the bending wave of the plate.

2.3 FREE VIBRATION OF PLATE

Basically there are three boundary conditions of plate that will affect the amplitude vibration occur on it which are simply supported, clamped and free. The boundary condition can be mixed with each other or just the same condition. It is important to prevent from the resonance which will happen when there is matching between driving forces and the plate natural frequencies. Free vibration analysis is significant to avoid resonance between the plate and driving force system.

From the previous research, the study is about free vibration analysis with three different boundary conditions by using Bessel functions. The conditions chosen are fully simply supported, fully clamped and the last one is the mixed condition which is two opposite boundaries with simply supported and another two boundary with clamped. The result of the analysis is appeared to be the natural frequency obtained is different for each boundary condition (Wu et al., 2007).

Another research had been made about the analysis of free vibration by using characteristic orthogonal polynomials in assumed mode method. The analysis is done by comparing the different thickness of the plate. As a result, higher thickness increased the natural frequency of the plate as shown in the graph analysis in Figure 2.1 below (Kim et al., 2012).

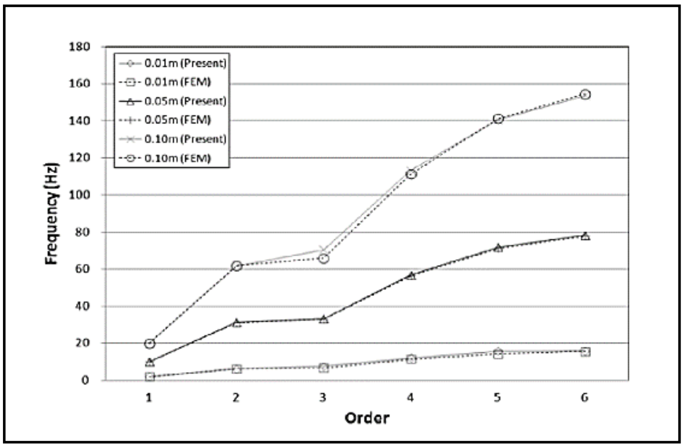

Figure 2.1: Natural frequencies in Hz of 4m × 3m rectangular plate with various thickness (Kim et al., 2012).

2.4 FLEXURAL WAVE

The previous research had done the flexural vibration analysis of a rectangular plate for the lower normal modes. The results show that different mode number produce different frequency. The frequency increased as the mode number is bigger as shown in Figure 2.2.

Table 5
Frequencies of a rectangular plate of 203 mm × 355 mm and thickness $h = 6.12$ mm.

Mode number N	Classification	Experimental frequency f_N (Hz)	Theoretical frequency f_N (Hz)
1	(2, 0)	255.5	253.3
2	(1, 1)	266.8	272.4
3	(2, 1)	602.9	613.2
4	(3, 0)	705.3	701.0
5	(0, 2)	815.9	803.2
6	(1, 2)	989.3	988.5
7	(3, 1)	1083.6	1098.9
8	A	1350.8	1361.6
9	B	1470.4	1471.5
10	(4, 1)	1758.0	1778.8
11	(3, 2)	1981.0	2022.1

The pairs (n,m) represent the number of nodal lines in the long (n) and short (m) sides, respectively. For modes labelled "A" and "B" this classification does not apply.

Figure 2.2: The frequency of different mode number. (Manzanares-Martnez et al., 2010)

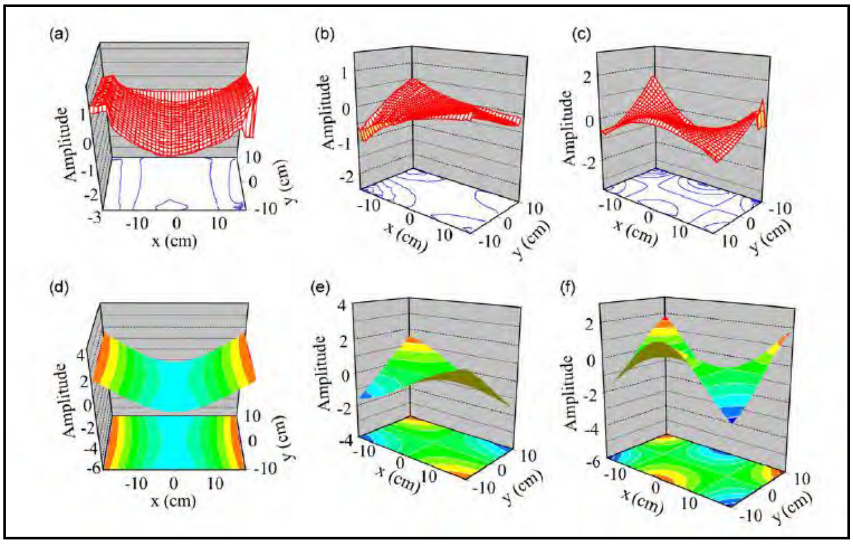

Figure 2.3: Normal-mode amplitudes for flexural waves of the rectangular plate. (Manzanares-Martnez et al., 2010)

The Figure 2.3 represent the result which the upper parts, (a), (b), and (c), are experimental results. The lower part, (d), (e), and (f), corresponds to theoretical amplitudes. The modes from left to right correspond to the (2, 0), (1, 1) and (2, 1) modes of Table 5.

2.5 SEISMIC ISOLATION SYSTEM

Currently, the further research from Korea Atomic Energy Research Institute found that the response of seismic isolation system is affected on the variability of the mechanical properties of lead rubber bearings, the response depends on the movement for different ground motions. The researcher states that the variation in the mechanical properties of base isolator will result significant influence on the shear resistance and the acceleration response of the structure.

It was discovered that the response of the isolation system is increased by the lower limit in variations, while the response of the superstructure is increased by the upper limit in variations. The upper limit in the stiffness variation of the isolators can reduce the decoupling performance of the isolation system (Choun, Park, & Choi, 2014). In the application of seismic isolation system, the building structures need to be related with safety, the different type in the materials and mechanical properties of the isolation system must be carefully controlled, furthermore to minimize the accidental torsion caused by the different similarity stiffness of variation isolators.

The factor of aging, environmental effects, and temperature in mechanical properties will contributes the stiffness and characteristic of isolation rubber metal, those the stiffness and damping values of the metal plate used for construction should be contrasts from other values used for design. Basically, the stiffness distribution of based isolated system and the mass distribution of structures at the ground level can be unbalance. A low natural frequency response of structure, such as seismically isolated structures is highly sensitive to the frequency input ground motion.

2.6 LAMINATED RUBBER-METAL SPRING (LR-MS) MODEL

Laminated rubber-metal spring is the multiple layer of rubber layer and metal plates were arranged alternating. The number of layer is determine based on the frequency vibration condition. A research had been done by the Centre for advanced Research on Energy, Universiti Teknikal Malaysia Melaka. By using dynamic analysis of finite element method, the performance of vibration transmissibility of LRMS can be determined. The laminated rubber-metal spring model is shown in Figure 2.4 below.

Figure 2.4: LR-MS Model

The FEA method has good accuracy for analyzing cylindrical solid rubber and LR-MS isolators and more interlayer metal plate inside LR-MS has better transmissibility performance at higher frequency, (M. A. Salim et al., 2013). There are many applications that use the LR-MS as their vibration absorption on superstructure to avoid for collapsing and disaster because of resonance frequency itself onto the superstructure. Penang second bridge is one of the examples which are designed to transfer the resonance frequency of the structure away from ground earthquake vibration frequency. Figure 2.5 shows the Penang Second Bridge and the rubber bearing used under the bridge is shown in Figure 2.6.