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Report on Plate Modal Analysis Investigating Cantilevered Rectangular Plates.

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ABSTRACT:

The research aims to determine the natural frequencies and mode shapes of an isotropic thin plate using Finite element method. The frequencies values for the isotropic cantilever thin plate have been obtained by finite element method using modelling Ansys software. The dimensions of the plate are considered for the geometry of a thin plate theory. Based on this Kirchhoff plate theory also one can determining the frequencies and mode shapes of a cantilever plate, the stiffness and mass matrices are calculated using Finite Element Method. This Finite Element methodology is useful for obtaining the natural frequencies of the considered rectangular cantilever plate. Numerical results obtained from FEM of the rectangular isotropic cantilever thin plate are giving close agreement with the exact solutions results. The results of project explain about how the frequency values are changing related to the mode deformation shape of plate for four different thickness of the plates (0.00625m,0.0125m,0.025m,0.05m).

Keywords: Ansys software, FEM, Isotropic cantilever thin plate, Finite element method

Introduction:

A brief introduction structure analysis of a plates, FEM, Ansys, and finally the objectives at present study.

General

For the study of plate-like structures, many techniques have been developed for both static and dynamic analysis. In case of complicated shapes generally it is difficult to obtain an accurate analytical solution for structures with different sizes, various loads, and different material properties. As a result, one must use approximate numerical approaches to get the right answers to static and dynamic issues. widely-used and effective numerical approximation approach known as the finite element method. The finite element method involves modelling the structure using small inter connected elements called finite elements. Each finite element maintains a displacement function. Through common interfaces like nodes or boundary lines, every element in an interconnected system is connected to every other element either directly or indirectly. The behavior of a particular node by terms of the attributes of every element with in model may be predicted from the stress/strain characteristics of the material constituting. Figure 1.1 below is an isotropic thin plate with length(l), breadth(b), and height(h).

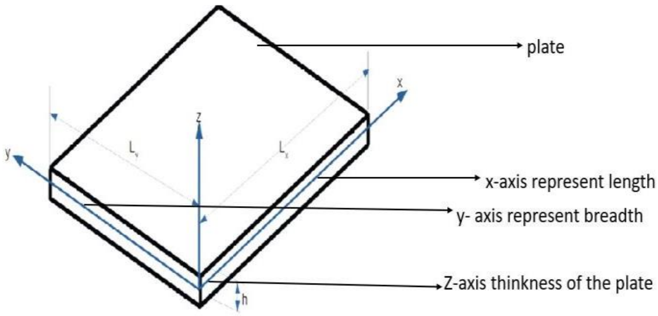

Figure 1.1 Isotropic thin plate [1]

The whole equations explaining the behavior or each node output in a series of algebraic equations that best expressed in the form of matrix notation. The finite element method of structural analysis enables the designer to found stress, vibration, thermal effects during the design process and to evaluate design changes before the construction of a possible prototype. As a result, there is increase in confidence in the prototype's acceptance.

Finite Element Method

The finite method employs a numerical approach for resolving issues that may be expressed as functional minimization or that can be characterized by partial differential equations. An assemblage of finite components serves as a representation of a domain of interest. Determined in terms of the nodal values of a sought-after physical field are approximating functions in finite elements. Discrete finite element problems with unknown nodal values are created from continuous physical problems. A system of algebraic equations in linear form should be solved for a linear issue. Nodal values can be used to retrieve values from within finite elements.

Analytical techniques, experimental methods, and numerical methods are the three main approaches to solving difficult engineering issues. Analytical approaches are accurate, but they can only handle simple geometries. Experimental methods can give accurate results, but they are costly, and in most cases not feasible financially. Engineering issues may be solved numerically using finite element analysis, which offers trustworthy engineering solutions. Finite element analysis is a very flexible and extensive numerical methodology.

The discretization of a specific domain into a collection of straightforward subdomains known as finite elements is the key component of FEA. The more of these finite elements there are, the more precise the modelling and analysis will be. The best- possible solution of differential equations is the foundation of the finite element method, a mathematical technique. Any equation with derivatives, whether ordinary or partial, is referred to as a differential equation. They might be linear, partial, or regular. Differential equations are significant from an engineering standpoint because they serve as the language through which physical laws are articulated. The aim of FEA is to transform the differential equations of a system into a set of linear equations, which can then be solved by computer software. Figure 1.2 shows the deformation of a car in finite element method.

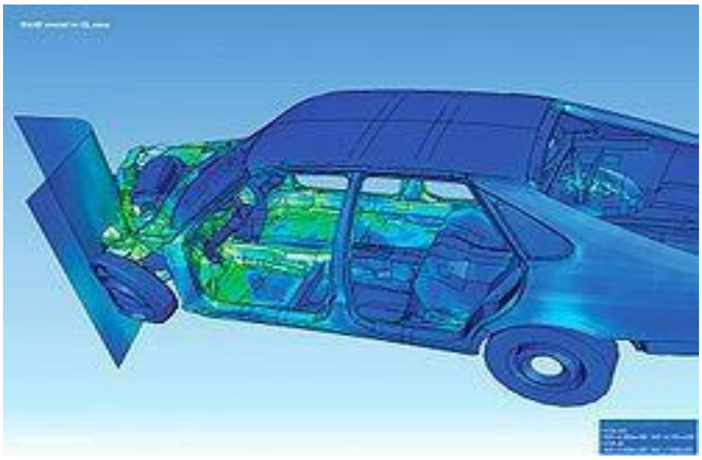

Figure 1.2 Visualization of a car deforms using finite element analysis [2]

Ansys software

Ansys was established in 1970 and became a legal entity in 1994. Software for engineering simulation and related services are mostly provided by Ansys. Aerospace, defence, automotive, biomedical, and other industrial sectors are just a few of the sectors that employ the company's products. Ansys offers a unified platform for product development, from design idea through final-stage testing and validation, by leveraging the power of today's desktop. The product line of the firm includes of simulation platform offers that are applied in several multi-physics domains, including heat transfer, statics, fluid mechanics, solid mechanics, etc.

Methodology:

MATERIAL USED:

Aluminium thin plate of dimensions

Length of the plate in X- axis = 0.6m

Width of the pate in Y – axis = 0.4m

PROPERTIES OF ALUMINIUM:

Density = 2700kg/m^3

Young's modulus = 68*10^9 N/m^2

Poisson's Ratio = 0.33

Corrosion Resistant

CONDITIONS:

- One end side of the plate is with fixed condition.

Dimensions of meshing model:

- No. of nodes in x axis 60.
- No. of nodes in y axis 40.
- Total elements 60 X 40 = 2400.
- Number of nodes on the plate, in both x and y axis is 2501.
- Number of elements on the plate, in both x and y axis is 2400.

Table 3.1: Material and thickness of the rectangular plate

S.no	Material Used	Thickness of the plate
1.	Aluminium	0.00625m
2.	Aluminium	0.0125m
3.	Aluminum	0.025m
4.	Aluminum	0.05m

3.1. Kirchhoff's plate theory:

The Kirchhoff-law theory of plates is a two-dimensional mathematical model that is used to determine the stresses and deformations in thin plates subjected to forces and moments. This theory is an extension of Euler-Bernoulli beam theory and developed in 1888 by love using assumptions proposed by Kirchhoff.

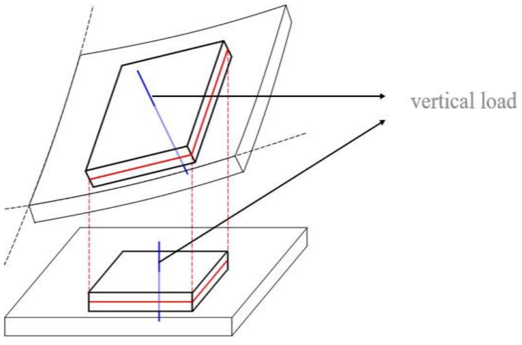

Figure 3.1 Vertical load is applying on plate [6]

Assumptions:

1. *The x–y plane coincides with the middle plane of the plate in the undeformed geometry.*
2. *The lateral dimension of the plate is at least 10 times its thickness.*
3. *The vertical displacement of any point of the plate can be taken equal to that of the point (below or above it) in the middle plane.*
4. *A vertical element of the plate before bending remains perpendicular to the middle surface of the plate after bending.*
5. *Strains are small: deflections are less than the order of (1/100) of the span length.*
6. *The strain of the middle surface is zero or negligible.*
7. The plate can be considered by planes perpendicular to the x axis as shown in the Fig. 3.2, to drive the governing equation.

Based on Kirchhoff assumptions, at any point P, due to a small rotation the stress and shear bending was determined.

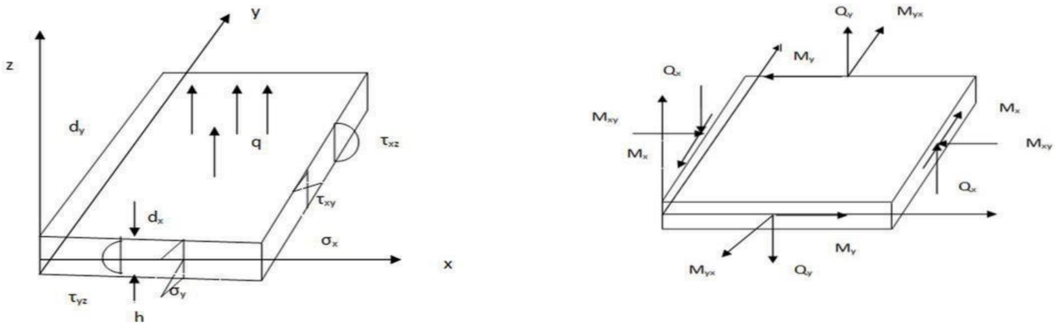

Figure 3.2 Shear and bending stress I plane normal [7]

Displacement in the x direction

$U = -Z * \alpha X = -Z * (\frac{\partial W}{\partial X})$ 2.1(a) ∂X

Displacement in the y direction

$U = -Z * \alpha Y = -Z * (\frac{\partial W}{\partial y})$ 2.2

The curvatures (rate of change of the angular displacements) of the plate are shown below with there respective equations 2.3(a), 2.3(b), 2.3(c):

$KX = -\frac{\partial^2 W}{\partial X^2}$ ….. 2.3(a)

$KY = -\frac{\partial^2 W}{\partial y^2}$ ….. 2.3(b)

$KZ = -2\,(\frac{\partial^2 W}{\partial x\,\partial y})$ …. 2.3(c)

By using the definitions of in-plane strains we can say, the in-plane strain displacement equations are shown below 2.4(a), 2.4(b), 2.4(c):

$\varepsilon X = -\frac{\partial^2 W}{\partial X^2}$ 2.4(a)

$\varepsilon Y = -\frac{\partial^2 W}{\partial y^2}$ 2.4(b)

$\varepsilon Z = -2\,(\frac{\partial^2 W}{\partial x\,\partial y})$ 2.4(c)

According to Kirchhoff theory, the plane stress equations for an isotropic material are shown below in equations 2.5(a), 2.5(b), 2.5(c):

Results

RESULTS AND DISCUSSION

This chapter includes the results that are performed in the numerical simulation and discussing some of the points that are observed from results.

Table 5.1 Ten Natural Frequency values (Hz) of different thicknesses of plate.

Mode shape	**Thickness of plate 0.00625m**	**Thickness of a plate 0.0125m**	**Thickness of a plate 0.025m**	**Thickness of a plate 0.05m**
	Frequency values (HZ)	**Frequency values (HZ)**	**Frequency values (HZ)**	**Frequency values (HZ)**
1	14.699	29.376	58.626	116.49
2	49.488	98.392	193.93	373.42
3	91.375	182.33	361.69	702.08
4	166.97	331.53	649.93	714.94
5	227.75	453.63	714.85	1227.9
6	262.35	522.09	829.69	1695.5
7	340.76	675.29	1025.2	1923.7
8	362.03	714.83	1312.7	2132.3
9	509.54	716.76	1391.1	2359.7
10	567.67	1010	1954.5	2401

Table 5.1 shown is the frequency values of different plate thicknesses of 0.00615m, 0.0125m, 0.025m and 0.05m related to 10 mode shapes of plate.

Visual charts

The Figure 5.1 represents change of frequencies with respect to the mode deformation shape of plate. Mode shapes vs Frequencies for the thickness of plate thickness of 0.00625m.

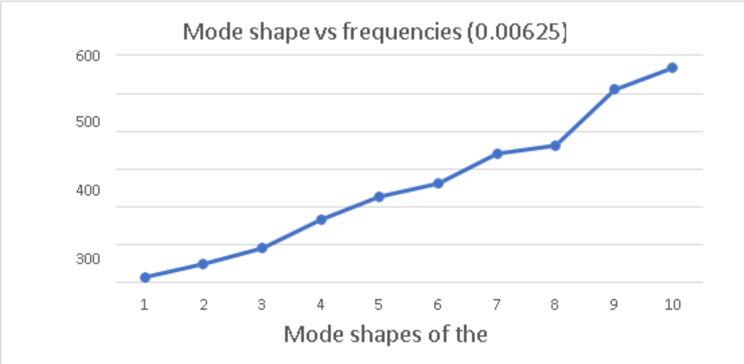

Figure 5.1 Visualization of plate thickness of 0.00625m

The Figure 5.2 represents the Mode shapes vs Frequencies for the thickness of plate of 0.0125m.

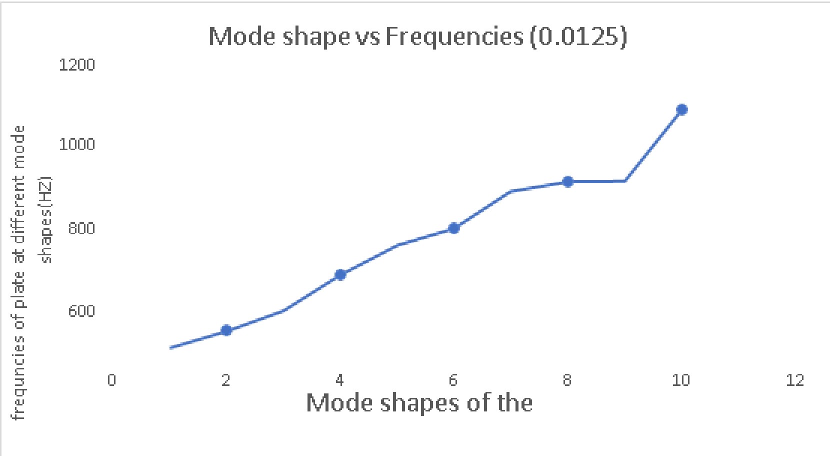

Figure 5.2 Visualization of plate thickness of 0.0125m

The Figure 5.3 represents the Mode shapes vs Frequencies for the thickness of plate of 0.025m.

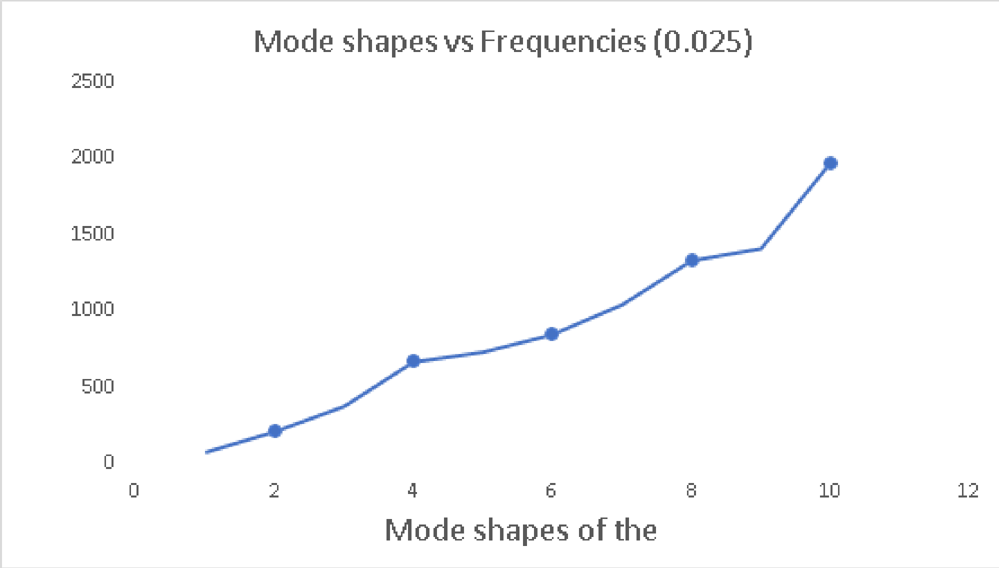

Figure 5.3 Visualization of plate thickness of 0.025m

The Figure 5.4 represents the Mode shapes vs Frequencies for the thickness of plate of 0.05m.

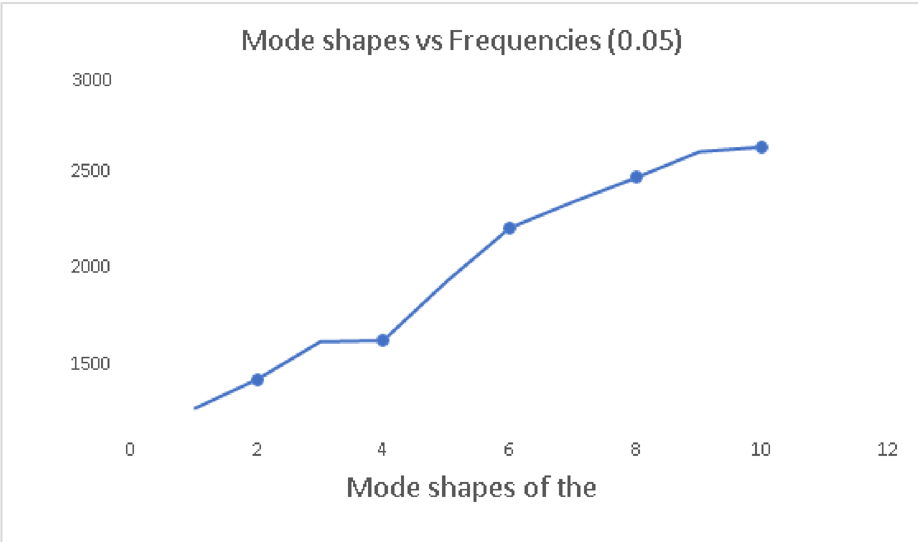

Figure 5.4 Visualization of plate thickness of 0.05m

Conclusion

- The approximate technique finite element method is used for analyzing a rectangular isotropic cantilever thin plate based on the classical plate theory.
- For thickness of plate 0.0125 and 0.025 the frequency values increase more for mode 9 and mode 10.
- Results showed the frequencies of four different thicknesses of plate. Increasing thickness of plate frequency values are increased.
- At mode shape 10 of four different thicknesses of plate frequencies are 567.67, 1010, 1954.4 and 2401, and Values are increasing.
- Values obtained in numerical experimental analysis are observed to be approximately equal to the theoretical experimental analysis values.

Reference List all the material used from various sources for making this project proposal

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