

Analysis of Plates by using ANSYS

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ABSTRACT: Plates plays a major role in the modern day to day applications like in industries, bridges, floor panels, shear walls and other structural components so it is very important to study their deflections and stresses under various loading conditions in order to understand their possible conditions of failure. The aim of this project is to analyze the aluminum plate under the various type of loading conditions. The analysis has been carried out by using the Kirchhoff thin plate theory and finite element analysis software ANSYS. It is helpful to obtain the result not only at node points but also for the entire surface of the plate. By comparing the theoretical values with ANSYS result we can obtain the optimum thickness of the plate.

I. INTRODUCTION

Plates play a major role in the modern day to day applications like in bridges, floor panels (as a flat plate system), shear walls, industries and other structural components. A flat plate is a one- or two-way system, basically it is supported directly on load bearing walls or on columns and it is one of the best forms of construction of floors in buildings. The principal feature of the flat plate floor is a uniform or near-uniform thickness with a flat soffit it requires only simple formwork and it is easy to construct. In the case of bridges the plates are also used as a deck panels and the plate may be deflected under the action of loads. So it is very important to study their deflections under various loading conditions in order to understand their possible conditions of failure. To study the deflection failures thickness of the plate is also an important factor.

This research will cover on the analysis of the plate structure. We have been decided to select aluminum for the analysis. By implementing the aluminium plates in the case of bridge deck system we can reduce the self weight of the structure, we can also increase the max live load carrying capacity of the deck.

For this research, the analysis will be done by using plate theory, so that we can determine the maximum deflection and stresses of the plate it can also performed under the finite element software ANSYS in this we can obtain the deformed shape, mode shapes of a plate. Thus the result and data will compare to actual and experimental value. From the comparison we can obtain the optimum thickness of the plate.

II. RELATED WORK

A plate structure is geometrically similar to the structure of 2D plane stress problem, but basically it carries only transversal loads that lead to bending deformation in the plate. For example, consider the horizontal boards on a bookshelf that support the books. These boards can be approximated as a plate structure, and the transversal loads are of course the weight of the books and the higher floors of a building are a typical plate structure that carries most of us every day, as are the wings of aircraft, which usually carry loads like the engines.. The plate structure can be schematically represented by its middle plane lying on the x - y plane. The deformation can caused by the transverse loading on a plate which is represented by the deflection and rotation of the normal's of the middle plane of the plate, and they will be independent of z and a function of only x and y . The element can be developed to model such plate structures are known as the plate element.

A plate is a planer structure with the very small thickness in comparison to the planer dimensions. The forces applied on the plate are perpendicular to the plane of the plate. Therefore, plate can resists the applied load by means of a

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bending in two directions and twisting moment. A plate theory can take the advantage of its disparity in length scale to reduce the full three-dimensional solid problem to a two-dimensional problem. The aim of plate theory is to calculate the deformations and stresses in a plate subjected to various loads. A flat plate, like a straight beam carries lateral load by bending. The analyses of plates are categorized into two types based on thickness to breadth ratio. They are thick plate and thin plate analysis. If the thickness to width ratio of the plate is less than 0.1 and maximum deflection is less than one tenth of thickness, then the plate can be classified as a thin plate. The well known as Kirchhoff plate theory is used for the analysis of such thin plates.

The aluminium alloy 6005 T6 has been adopted to analyse the structural plate

Basically it is light, good corrosive resistant and durable, and also because of its wide variety of structural shapes and forms that can be created. These properties have widely exploited in aerospace, architectural railway carriage and applications and they are also used for the bridgeworks. The low self-weight can be extremely useful for the handling, during the fabrication and construction, as well as in the final design. The durability of the aluminium alloys is extremely good and is one of the best underestimated virtues of the material. With the right approach, an aluminium structure will compete with any other material on cost, and will outperform most in service. Price per tonne of the basic material is high compared with steel, but when fabrication, erection and treatment costs are taken into account there is little difference for the complete structure. Aluminium will often be cheaper than the steel and concrete when whole-life costs are to be calculated.

III. ANALYSIS

We will consider a four noded quadrilateral element with 12-degrees-of-freedom and Each node has 3 degrees of freedom, one displacement and two rotations

1. To perform the analysis under the ANSYS software the structural behaviour of the element is considered as linear
2. Type of material is Aluminium alloy 6005 T6
3. Shape of element is rectangle

For the analysis purpose we select that thin plate theory with small deflections

In thin plates with small deflections, the following assumptions are made

- (a) There is no deformation in the middle plane of the plate. This plane remains same during the bending.
- (b) Points of the plate lying initially on a normal to the middle surface of the plate remain on the Normal to the same surface even after the bending.
- (c) The normal stresses in the direction transverse to the plate are negligible.

This theory is satisfactory for plates with the ratio of thickness to width exceeding 1/10 and the ratio of maximum deflection to thickness is less than the 1/5. Many engineering problems lie in the above category and satisfactory results are obtained by the classical theories of the thin plates.

The stresses in the middle plane are negligible, if the deflections are small in comparison with the thickness. If the deflections are large, then plane stresses developed in the neutral surfaces is to be considered. This gives rise to theory of thin plates with large deflections, in which geometric non-linearity is incorporated.

Classical thin plate theory is based upon the assumptions initiated for the beams by Bernoulli but it is first applied to plates and shells by Love and Kirchhoff. This theory is known as Kirchhoff's plate theory. Usually, three assumptions are used to reduce the equations of three dimensional theory of elasticity to two dimensions.

The following assumptions are considered with the Kirchhoff theory:

1. The line normal to the neutral axis before bending it remains straight after the bending.
2. The normal stress in the thickness direction is neglected. I.e. $\sigma_z = 0$, this assumption converts the 3D problem into a 2D problem.
3. The transverse shearing strains are assumed to be zero. i.e., shear strains γ_{xz} and γ_{yz} will be zero. Thus, the thickness of the plate does not change during its bending.

(2) The ANSYS program has many finite element analysis capabilities, ranging from a simple, linear, static analysis to a complex, nonlinear, transient dynamic analysis. The following are the typical ANSYS steps

- General Steps

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Step 1: Ansys Utility Menu

- File – clear and start new – do not read file – ok
- File – change job name – enter new job name – xxxx – ok
- File – change title – enter new title – yyy – ok

Step 2: Ansys Main Menu – Preferences

- select – STRUCTURAL - ok

Step 3: Preprocessor

- Element type – select type of element from the table and the required options
- Real constants – give the details such as thickness, areas, moment of inertia, etc. required depending on the nature of the problem.
- Material Properties – give the details such as Young’s modulus, Poisson’s ratio etc. depending on the nature of the problem.

Step 4: Modeling – create the required geometry such as nodes elements, area, volume by Using the appropriate options

Step 5: Generate – Elements/ nodes using Mesh Tool if necessary (in 2D and 3D problems)

Step 6: Apply boundary conditions/loads such as DOF constraints, Force/Momentum, Pressure etc.

Step 7: Solution –to Solve the problem

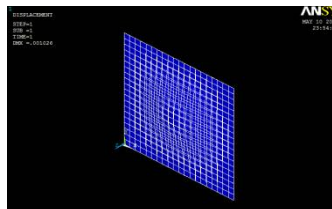
Step 8: General Post Processor – plot / list the required results.

Step 9: Plot ctrl – animate – deformed shape – def+undeformed-ok

Step 10: to save the solution o to ansys tool bar- save,,,model

IV. EXPERIMENTAL RESULTS

The analysis of aluminium alloy 6005 T6 deck plate has been carried out using the standard AASTHO specifications, according to this code the maximum deflection should be less than or equal to $L/800$.



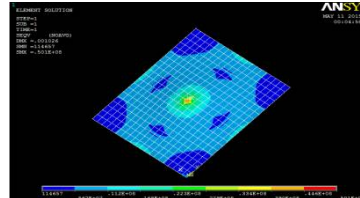
(a)

From the above fig(a) the maximum deflection of the plate is 1.02mm, this value is less than the 2.5 mm, hence the structure is safe under a thickness of 0.07m.

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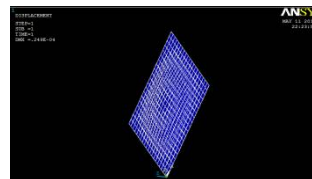
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(b)

From the above figure(b) we can observe that the max stress of the plate is 50.1 N/mm^2 , to get the design value, it should be multiplied by the combination factor 1.5, then the design stress value is 75.15 N/mm^2 . The unit check for stress is, $75.15 / 195 = 0.38$, this value is less than 1. Similarly the design ultimate tensile strength of HAZ is $75.15/92 = 0.81$, this is also less than 1, hence the structure is safe for 0.07m thickness of the plate.



(c)

From the above fig the maximum deflection of the plate is 0.02mm, this value is less than the 2.5 mm, hence the structure is safe under its own self weight .

VI. CONCLUSION

1. From the above discussions we can observe that in the case of clamped , simply supported edged plate the maximum deflection is occurs at the centre of the plate which can be calculated using theory of plate, finite element formulation software ANSYS.
2. By comparing these two results we obtained the optimum thickness of the plate, i.e 0.07m for this thickness the max deflection of the plate is follows
 - In the case of clamped edges $W_{\max} = 1.0\text{mm}$
 - In case of simply supported edges $W_{\max} = 2.1\text{mm}$
 - Hence the acceptable deflection is 1.0mm which is occurred in the case of clamped edges we can suggest that the deck plate is safe under the clamped edges.
3. By implementing these aluminum alloy 6005 T6 plates in the construction of bridge deck slab we can reduce the dead load, and also we can increase the live load carrying capacity. Under the 100kn of live load, self weight it is safe for a thickness of 0.07m.

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