

# BUCKLING ANALYSIS OF RECTANGULAR PLATES USING FEA SOFTWARE

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**Abstract:** - In this era, various building is collapsed as well as some parts will be fractured due to extra load which are applying on it. Due to that load, the buckling phenomenon takes place. The motto of this paper is to give the information about buckling analysis which takes place on rectangular plate and calculating the critical buckling load. Three-dimensional CAD model of rectangular plate is designed using Ansys. Finite Element Analysis (FEA) software ANSYS Version 21.0 is used to determine the critical buckling load & different modes of Eigen value buckling. Comparative analysis of Theoretical and FEA Analytical value will be done for validation of work.

**Index Terms** – Buckling, Critical buckling load, rectangular plate, Ansys

## I. INTRODUCTION:

In engineering, buckling is the sudden change in shape of a component under load, such as the bowing of a column under compression or the wrinkling of a plate. If a structure is subjected to a gradually increasing load, when the load reaches a critical level, a member may suddenly change shape and the structure and component is to be buckled.

Steel plate is widely used in different sectors like automobile, Building, ships etc. these plates under compression tend to buckle out of their original plane. buckled shape of steel plate is depend on the loading and support conditions. However, columns and plates continue to carry loads even after buckling in a stable manner.

This Project aims to design the rectangular plate and calculating the critical buckling load with the help of Euler's buckling theory.it also gives the buckling analysis using the different load boundary conditions using Ansys R21.

## II. BUCKLING OF PLATE:

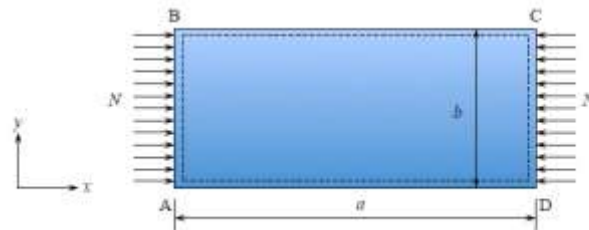


Figure 1 Rectangular plate with loading condition

In the rectangular plate which is shown above, the plate is simply supported with the four sides of plate. The side AB and CD having the load which is acting on them. Whereas the AD and BC are unloaded edges of plate.

For a rectangular plate which supported along every edge, the derived governing equation stated as

$$D \{ \delta^4 \omega / \delta x^4 + 2 \delta^4 \omega / \delta x^2 \delta y^2 + \delta^4 \omega / \delta y^4 \} + N \delta^2 \omega / \delta x^2 = 0 \text{ (Equation 1)}$$

For this equation, the solution of this is depends on the two harmonic function which is as follows

$$\omega (x, y) = \sin m\pi x/a * \sin n\pi y/b \text{ (Equation 2)}$$

The deferential equation is satisfied for all values of (x; y) if the coefficients satisfy

$$N = D * (\pi * a / m)^2 * \{ (m/a)^2 + (n/a)^2 \}^2 \text{ (Equation 3)}$$

From these, the equation for critical buckling load is as follows,

$$N_c = K_c * \pi^2 * D / b^2 \text{ (Equation 4)}$$

Where,  $k_c$  = Buckling Coefficient,  $D$  = Elastic bending stiffness,  $b$  = width of plate.

The elastic bending stiffness can be calculated by the formula which is as follows,

$$D = E * t^3 / 12 (1 - \mu^2) b \text{ (Equation 5)}$$

Where  $E$  = Youngs Modulus,  $t$  = thickness of plate,  $\mu$  = Poisson's ratio.

The buckling coefficient is given by

$$K_c = (m^2 b/a + a/m^2 b)^2 \text{ (Equation 6)}$$

Where the  $m$  = no. of half waves,  $a$  = length of plate,  $b$  = width of plate.

The buckling coefficient value for different boundary condition of plate is as follows

Table 1 Buckling Coefficient ( $K_c$ ) values

Plate Support Condition	$K_c$ Value
Hinged-Hinged	4.00
Fixed – Fixed	6.97
Hinged – Free	1.27
Fixed – Free	0.43

The  $m$  parameter is calculated by using this below graph

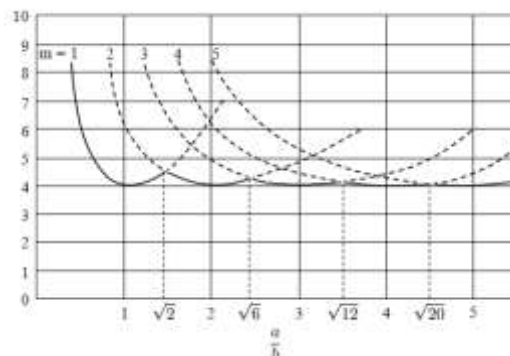


Figure 2 No. of half waves ( $m$ ) determining graph

### III. PROBLEM STATEMENT & OBJECTIVE –

#### • PROBLEM STATEMENT –

Design & Analysis of rectangular buckling plate & calculation of the critical buckling load acting on the plate under applied load boundary conditions.

#### • OBJECTIVE-

1. Design and selection of plate for the buckling process.
2. Theoretical Calculation of critical buckling loads acting on plate under different boundary conditions.
3. CAD modeling of rectangular plate in Ansys 21.0 software.
4. To perform static structural Analysis of Rectangular plate in ANSYS 21 workbench.
5. Comparative Analysis between theoretical & Analysis results.

### IV. RESEARCH METHODOLOGY –

- 1) Find out research papers. Gathered research papers.
- 2) Learn about the buckling & critical buckling load.
- 3) Describe literature gap & identify the project.
- 4) Finalizing the sizes of 3D model of rectangular plate.
- 5) Theoretical calculation of critical buckling load takes place.
- 6) FEA Analytical calculation of critical buckling load takes place using Ansys R21.
- 7) Comparative analysis of FEA & theoretical will be done for validation of work

### V. THEORETICAL CALCULATION -

#### 1) Rectangular Plate Dimensions-

Length of plate ( $L$ ) = 150 mm = 0.15 m

Breath of plate ( $B$ ) = 75mm = 0.075 m

Thickness of plate ( $t$ ) = 5mm, 8mm, 10mm, 12mm.  
= 0.005m, 0.008m, 0.010m, 0.012m.

#### 2) Material used –

Structural Steel – Properties of structural steel –

- 1) Density = 7850 kg/m<sup>3</sup>
- 2) Young's Modulus = 210000 MPa =  $2.1 \times 10^{11}$  N/m<sup>2</sup>
- 3) Poisson's ratio = 0.30

- 3) Load boundary conditions –
  - 1) When Both Edges of Rectangular Plate are fixed – ( $K_c = 6.97$ )

**VI. CAD MODEL OF PLATE –**

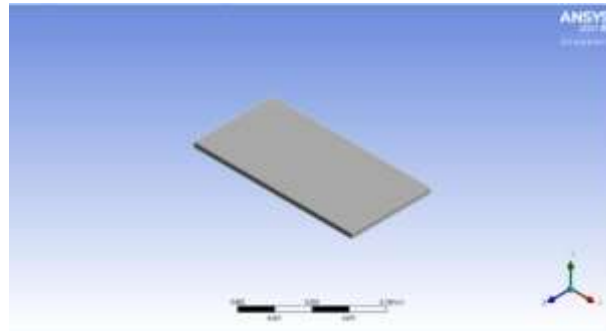


Figure 3 CAD model of rectangular plate

**VII. FEA ANALYSIS -**

- 1) Material properties of plate-

Properties of Outline Row: Structural Steel			
	A	B	C
1	Property	Value	Unit
2	Material Field Variables	Table	
3	Density	7850	kg m <sup>-3</sup>
4	Isotropic Secant Coefficient of Thermal Expansion		
5	Coefficient of Thermal Expansion	1.2E-05	C <sup>-1</sup>
6	Isotropic Elasticity		
7	Derive from	Young's Modulus	
8	Young's Modulus	2E+11	Pa
9	Poisson's Ratio	0.3	
10	Bulk Modulus	1.667E+11	Pa
11	Shear Modulus	7.692E+10	Pa
12	Alternating Stress Mean Stress	Tabular	
16	Strain-Life Parameters:		
24	Tensile Yield Strength	2.5E+08	Pa
25	Compressive Yield Strength	2.5E+08	Pa
26	Tensile Ultimate Strength	4.6E+08	Pa
27	Compressive Ultimate Strength	0	Pa

Figure 4 Material properties of plate

- 2) Meshing-

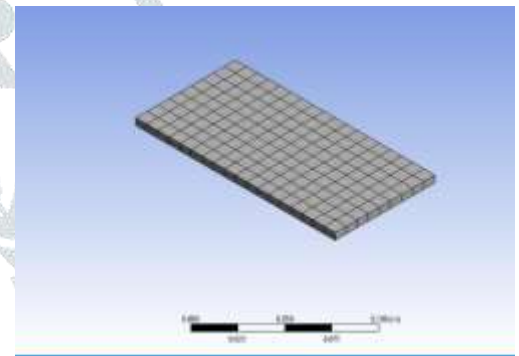


Figure 5 Meshing of plate

- 2) Load- Boundary Condition-

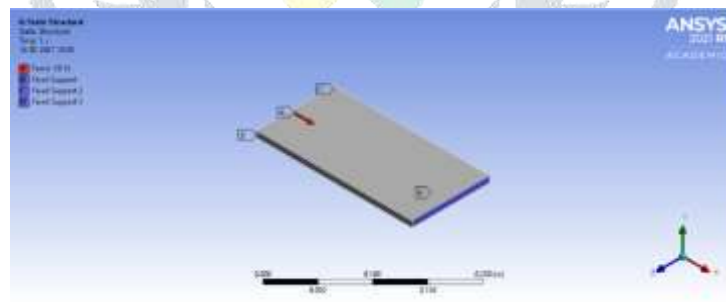


Figure 6 Load- Boundary Condition

- 3) Eigen Value Buckling Modes-

- 1. For 5mm thickness-  
Mode 1-

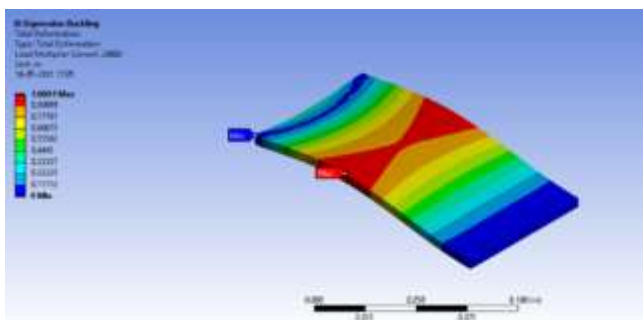


Figure 7 Buckling mode 1 of 5mm thickness plate

- Mode 2-

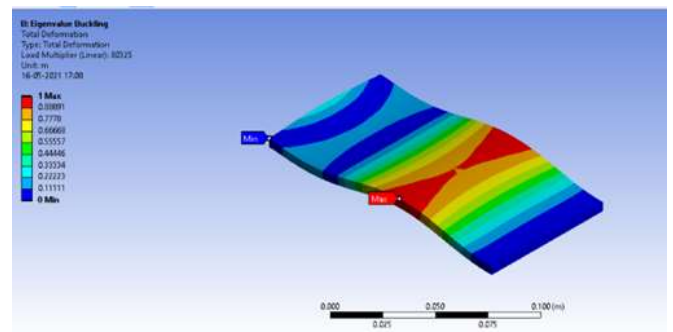


Figure 8 Buckling mode 2 of 5mm thickness plate

2. For 8 mm thickness-  
Mode 1-

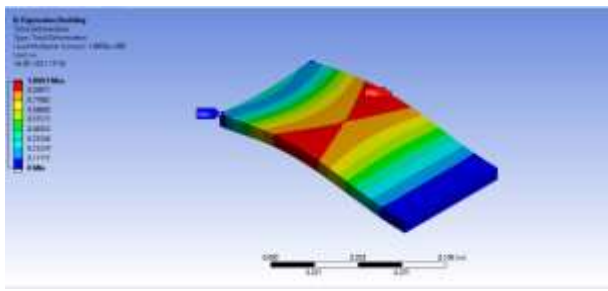


Figure 9 Buckling mode 1 of 8mm thickness plate

Mode 2 -

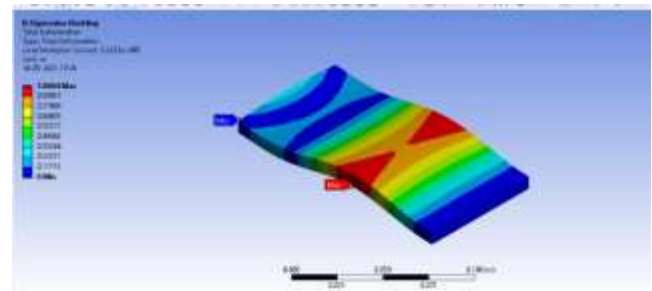


Figure 10 Buckling mode 2 of 8 mm thickness plate

3. For 10 mm thickness –  
Mode 1-

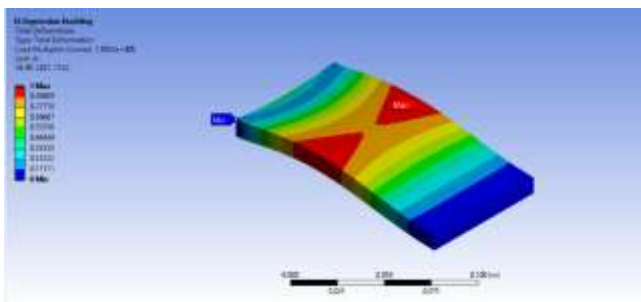


Figure 11 Buckling mode 1 of 10mm thickness Plate

Mode 2-

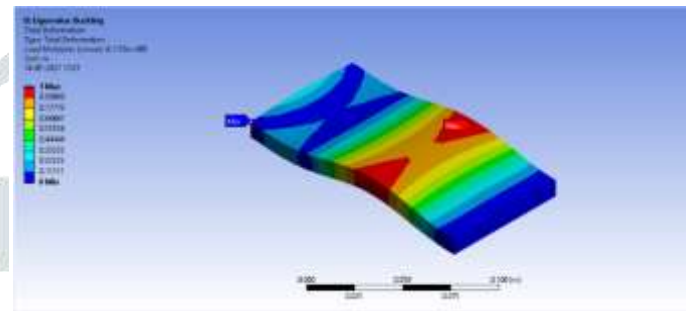


Figure 12 Buckling mode 2 of 10mm thickness plate

4. For 12 mm thickness –  
Mode 1-

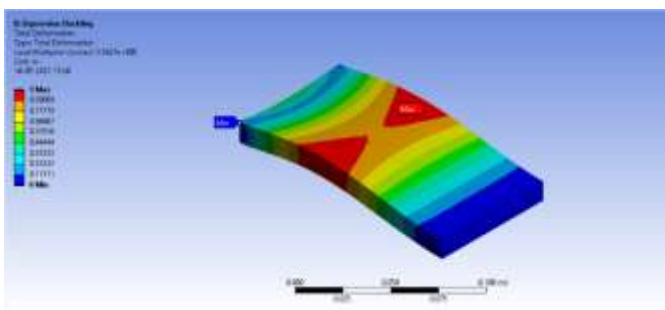


Figure 13 Buckling mode 1 of 12 mm thickness plate

Mode 2-

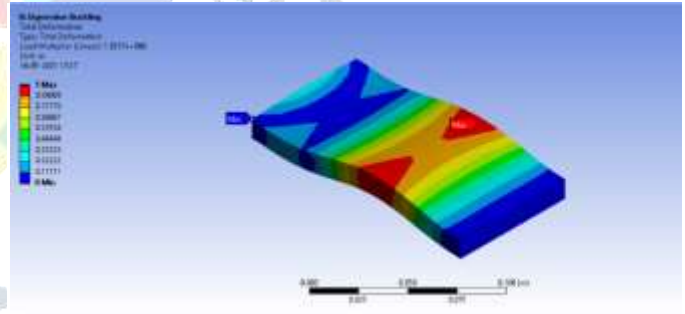


Figure 14 Buckling mode 2 of 12 mm thickness plate

**VIII. RESULT –**

The comparative analysis of theoretical and FEA analysis value are as follows

Table 2 Theoretical & FEA Analysis result

S r. No	a mm	b (mm)	t (mm)	a/b	b/t	Theo. load (*10 <sup>6</sup> N/m)	Ansys load (*10 <sup>6</sup> N/m)	Diff .
1	150	75	5	2	15	0.293	0.266	0.027
2	150	75	8	2	9.3	1.204	1.045	0.159
3	150	75	10	2	7.5	2.351	1.983	0.36
4	150	75	12	2	6.2	4.063	3.362	0.701

**IX. CONCLUSION –**

Based on the theoretical Calculation & FEA analysis given through the Ansys R21, it is concluded that

- 1) As the thickness of rectangular plate increases, the critical buckling load also increases.
- 2) As the b/t ratio of the rectangular plate decreases, the critical buckling load increases.
- 3) There is slight difference in the theoretical and Ansys values of critical buckling loads from this the buckling of plate's takes place.

**X. REFERENCES –**

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