Self-Weight Buckling of Thin Square Columns as Function of Thickness

Sameer. Shaik[1], Somsai kumar.Kompalli[2], Naga Sai Ram.Gopisetti[3]
[1, 2, 3]Department of Mechanical Engineering
[1, 2, 3] K L University, GreenFields,Vaddeswram,Guntur

Abstract- *The present study focuses on the analysis of square columns under the self-weight buckling. The finite element analysis is conducted as the function of thickness as parameter and the under gravity the eigen values are studied for the first 12 mode shapes and it is found that for every two-mode shape are identical in nature in respective of magnitude of deformation .The regression analysis of the data for the first two mode shape are considered and an equation is framed as the function of mode shape deformation and the thickness and it is found that as the thickness goes on increases there is decrease in the deformation.*

Keywords- Self weight Buckling, eigen values, mode shape, thickness.

I. INTRODUCTION

Buckling is the phenomena which occurs in the columns which slenderness ratio defines the type of buckling. The of length to the minimum radius of gyration or the characteristic length gives the slenderness ratio denoted by "λ". The three types of buckling are if the slenderness ration equals do not exceed 50 then it is called as short columns, and if the slenderness ration equals to 200 then it is called as long columns and if the slenderness ration is in between 50 to 200 then it is called as midrange columns. The possible configurations of buckling are dependent on the boundary conditions.

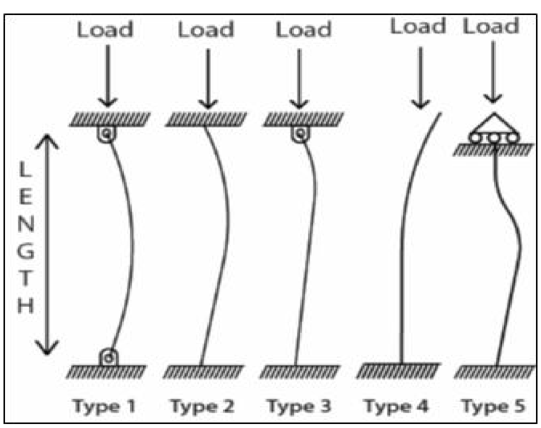

Figure 1 Type of buckling under the load and boundary conditions

the solution for the all types of configurations is different which is given by the Rankin and the it is function of the load and geometric parameters and the constant. The quantification of the buckling deformation is made in terms of mode shapes and eigen values. The buckling can happen by the load acting in it longitudinally and load by itself this type of buckling is called as self-weight buckling. This self-weight buckling is a natural type and often encounter in most cases. Though there are many mode shapes possible the first two cases are widely seen like in current poles, and even applied to construction of towers and structures.

II. LITERATURE REVIEW

The exact solution for the self-weight buckling with different boundary conditions are analyzed by (Duan en Wang)[1]. The buckling of thin cylinder under the axial compression loading is analyzed experimentally by (Mandal en Calladine) [2]. The self-weight buckling of non-Prismatic columns have analyzed by the (Wei et al.) [3]. The slender elastic buckling by the self-weight under double hinged condition is analyzed by the (Vaz en Mascaro)[4]. The Paradoxical behavior of the self-weight buckling have studied by the (Lancaster, Calladine, en Palmer)[5]. The computation of self-weight buckling by the p -element through various shell theories have been made by the (Lim en Ma)[6].

III. METHODOLOGY

The core idea is the derive a function that the is in the function of thickness and the load where the material constants are made as constants for the type 4 condition for the standard benchmark problem statement which is defined as flows.

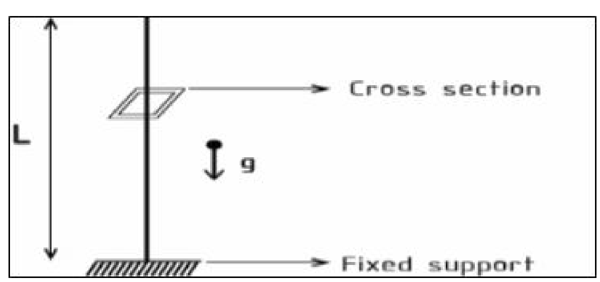

Figure 2 schematic drawing of problem statement

Table 1 The Design nomenclature variables and their values used in the analysis

Si.no	Variable	Symbol	Value	Units
1	Length	L	1	m
2	Gravity	g	9.81	m/s
3	Cross-section area	A	Parametric	m
4	Thickness	t	Parametric	m
5	Young's Modulus	E	Parametric	MPa
6	Second Moment of Inertia	I	Parametric	-
7	Density	ρ	Parametric	Kg/m^3

Here it is to be noted as the crosection and the thickness are related to each other and since the both the variables are parametric the thickness "t" is assigned from 0.05 m, 0.10 m, The critical height for which the self-weight buckling acts is as follows

$$L_{critical} = \sqrt[3]{7.8373\frac{EI}{\rho g A}} \quad \ldots\ldots\ldots\ldots\ldots..(1)$$

Since we know that the "g" is constant and equal to the 9.81 m/s then the eq(1) is defined as follows.

$$L_{critical=}\sqrt[3]{0.789\frac{EI}{\rho A}} \quad \ldots\ldots\ldots\ldots (2)$$

The area of the cross section as the function of thickness "t" is given as follows

$$A = A^2{}_{out} - A^2{}_{in} = t\cdot(A_{out} + A_{in}) \ldots\ldots (3)$$

On substituting eq (3) in eq (2) then the critical length is defined as follows.

$$L_{critical} = \sqrt[3]{0.789\frac{EI}{\rho\cdot t\cdot(A_{out}+A_{in})}} \quad \ldots\ldots.. (4)$$

The equivalent buckling load for the type 4 condition with the critical length is given as the follows.

$$F_{eq} = \frac{\pi^2\cdot EI}{4\cdot\sqrt[3]{0.789\frac{EI}{\rho\cdot t\cdot(A_{out}+A_{in})}}} \quad \ldots\ldots\ldots.. (5)$$

The total deformation caused by the load applied is given as follows

$$\delta = \frac{F\cdot L_{critical}}{E\cdot t\cdot(A_{out}+A_{in})} \quad \ldots\ldots\ldots.. (6)$$

so, the deformation is the function of thickness i.e as the thickness decrease the deformation also decreases for the following equation

$$\delta = 2.48\cdot\left[\frac{0.789\cdot EI^2}{\rho}\right]^{0.66}\cdot(t\cdot(A_{out}+A_{in}))^{1.66} \ldots\ldots \ldots (7)$$

Clearly from above the equation the deformation is function of thickness as follows.

$$\delta = f(t) \ldots\ldots\ldots\ldots\ldots\ldots. (8)$$

The deformation is studied as the eigen values.

III. FINITE ELEMENT ANALYSIS

The finite element analysis was conducted to find the deformation of the eigen values, since the deformation due to buckling cannot be found directly so the coupled system analysis is conducted with the over 997 nodes with the element type of SOLID186 with symmetric solver.

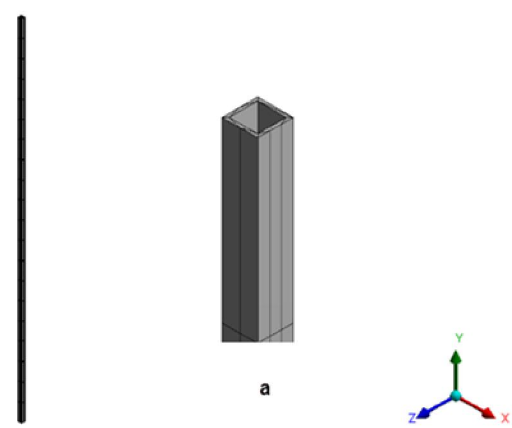

Figure 3 The mesh model of the column (a) the 2x scale of brick mesh of the model

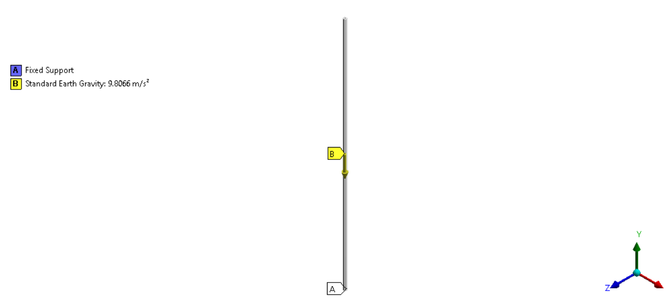

Figure 4 The boundary conditions applied to meshed model

the static structural system solution is made as pre-stress environment and coupled with Eigenvalue Buckling system.

This helps in solving the both the deformation and the model analysis to form the buckling mode shapes .

IV. RESULTS

After the analysis is solved the path solution along the Y-axis of the model is chosen in order to plot the deformation

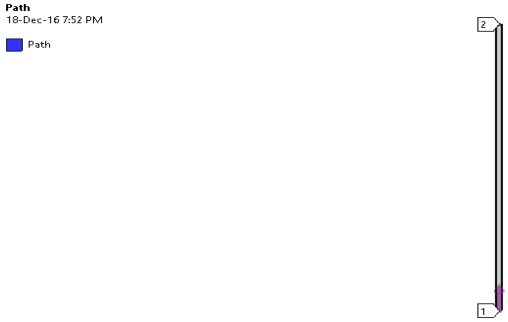

Figure 1 The path solution edge

The deformation results obtained are shown in below.

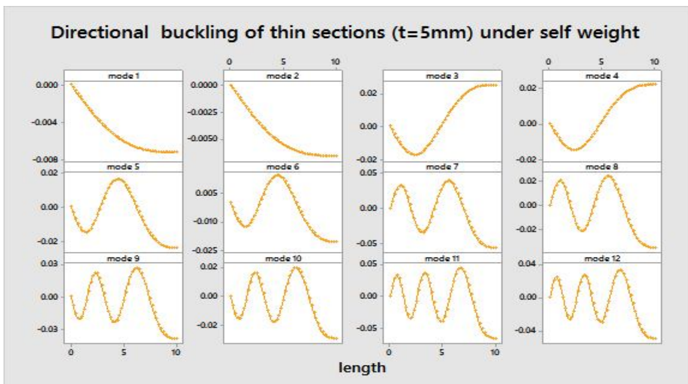

Figure 2 Buckling of thin section for 5 mm thickness

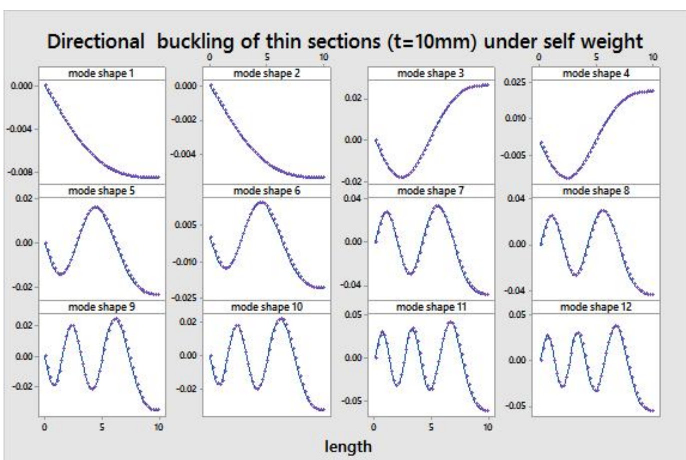

Figure 3 buckling of thin section for the 10-mm thickness

It is inferred form the above graphs the mode shapes formed as the resultant of the deformation of buckling. And there exist a identical shape structure in deformation.

V. CONCLUSION

It is found the above study that in decrease in the thickness of the columns there is magnitude decrease in the deformation, but the mode shape of the buckling i.e. deformation of the columns will have double identical mode properties and will not be repeated.

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