



# Buckling of Circular Cylinder under Axial Load

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## Abstract

Present investigation is initiated to understand the effects of axially applied load upon the buckling behavior of thin circular cylindrical shells. In this study circular cylinder of finite length is taken as variable along with thickness of the cylinder to improve the understanding of buckling behavior. Buckling load is determined by FEM analysis carried out through ABAQUS software. Results shows that as length of the cylinder increases, buckling load decreases while keeping diameter /thickness ratio constant. Results also reveals that buckling load increases as the diameter / thickness ratio decreases while length of the cylinder kept constant.

**Keywords:** Buckling, Circular Cylindrical Shell, FEM analysis.

## 1. Introduction

Although a lot of work has been published to understand the buckling phenomenon occurring in thin shell type structure, uncertainty still existed. Generally thin cylindrical shell type structures are considered highly efficient and they find wide applications in the field of mechanical, civil, aerospace, marine, power plants, petrochemical industries, etc. Moreover, load carrying capacity of these structures depends on buckling strength, which depends largely on geometrical imperfections presented due to their manufacturing methods. Reliable prediction of buckling strength of these structures is important, owing to catastrophic nature of such failures.

## 2. Literature Review

In 1964, Weingarten et al. made experimental study on thin walled cylindrical and conical shell under the influence of axial compression and concluded that the buckling coefficient varies with radius-thickness ratio. In 1980, Brendelt and Ramm adopted Lagrangian formulation approach to understand linear and nonlinear stability analysis of cylindrical shells under uniform pressure or wind load. In 1985, Y. Uematsu and K. Uchiyama conducted an experimental study on buckling behavior of thin, circular cylindrical shells under wind loads. The results shows that the pre buckling deflection is extremely sensitive to the wind pressure distribution, while the buckling pressure is less sensitive to it. It was also observed that the pressure--deflection relationship exhibits a marked nonlinearity as the wind pressure approaches the buckling pressure. In 1986, Simitses through his review paper portrays a clear picture of research carried out in the area of buckling and post buckling of thin-walled, geometrically imperfect, cylinders of various constructions, when subjected to destabilizing loads. In 1998, Mirfakhraei and Redekop conducted a linear elastic buckling of circular cylindrical shells by applying Differential Quadra-

ture Method (DQM). The Fluegge shell stability equations used as the basis of the analysis. In 2002, Winterstetter and Schmidt presented a numerical and experimental study of cylindrical shells which throw a deeper insight into the real buckling behavior under combined loading. Study provided rules to simulate numerically the realistic buckling behavior by means of substitute geometric imperfections. After going through the of the stationary circular cylinder under the axial compressive load and understand the effect of length and diameter / thickness ratio of cylinder on buckling strength..

## 3 Methodology

Figure 1 describe the methodology adopted for present work and all steps needed to complete the analysis falls into three categories, i.e., preprocessing, simulation and post processing. In present study, buckling load of circular cylindrical shell is determined for the following two cases:

- (1) Determination of buckling load for different diameter / thickness ratio while keeping the length of circular cylindrical shell constant, and
- (2) Determination of buckling load for different length of circular cylindrical shell while keeping the diameter / thickness ratio constant

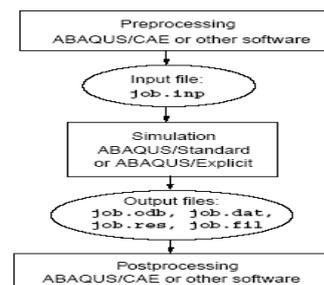


Fig. 1: Methodology

## 4 Results and Discussion

### 4.1 Length of Cylinder Constant:

First length of cylinder is taken as 350 mm and internal radius as 50 mm and buckling load is calculated for different mode as shown below.



Fig. 2.1: Base Scale at 1.25 mm thickness

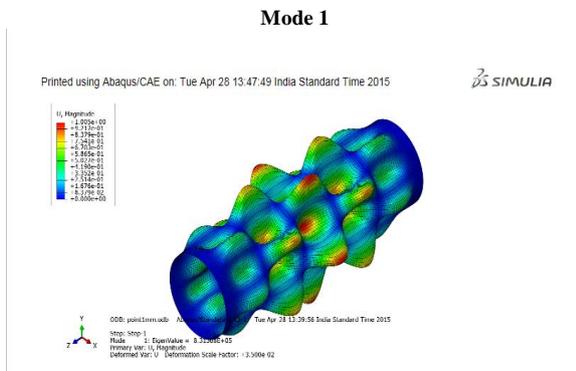


Fig.2.2: first phase deflection at 1.25 mm thickness

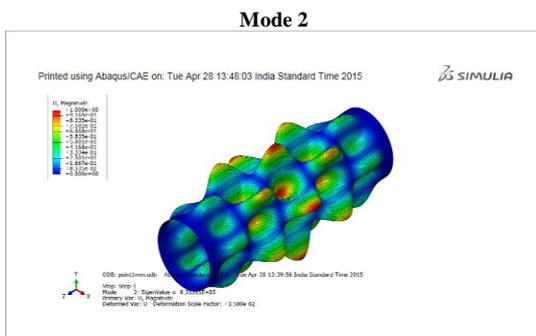


Fig. 2.3: second phase deflection at 1.25 mm thickness

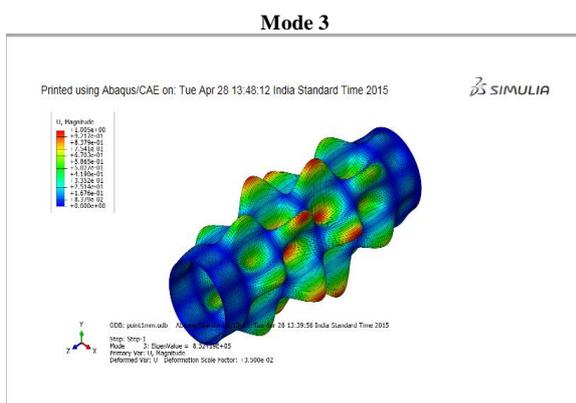


Fig. 2.4: third phase deflection at 1.25 mm thickness

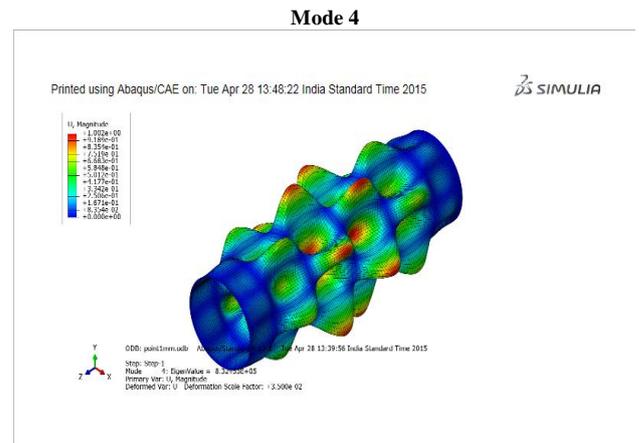


Fig. 2.5: fourth phase deflection at 1.25 mm thickness

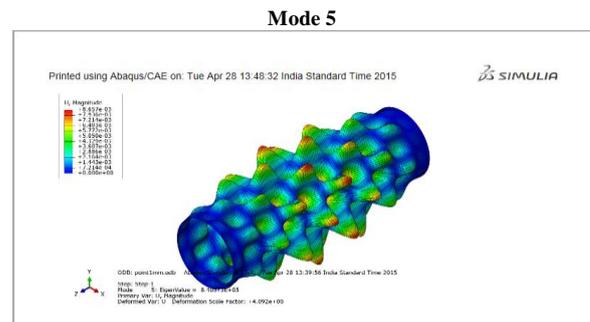


Fig. 2.6: fifth phase deflection at 1.25 mm thickness

The graphical result reveals that half-sinusoidal wave pattern is exhibited along the length and the circumference. Similar results are obtained for different thickness of cylinder and presented in table 1. A graph with these results are plotted and shown in figure 3.

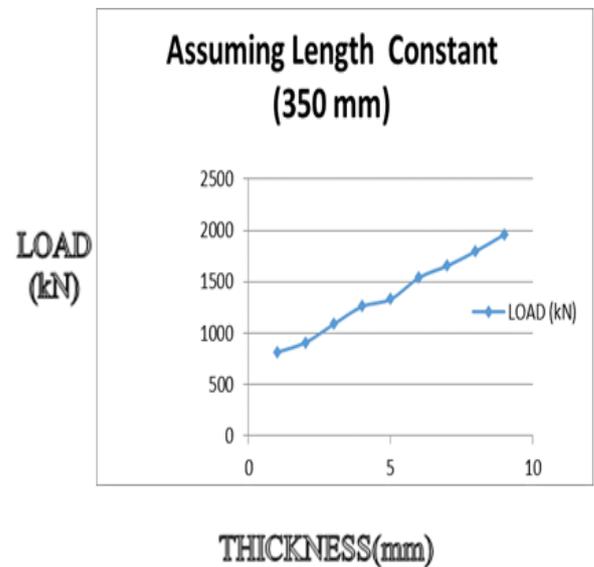


Fig. 3: Variation of buckling loads for circular cylindrical shell with thickness of shell

### 4.2. Thickness of Shell Kept Constant

Here buckling load for cylindrical shell are obtained through software for different length of shell while keeping internal radius / thickness ratio constant and shown in table 2. A graph with these results are plotted and shown in figure 4.

It is clear from the graph shown in figure 4 that when we increase the length of the cylinder while keeping the thickness constant, the corresponding buckling load decreases.

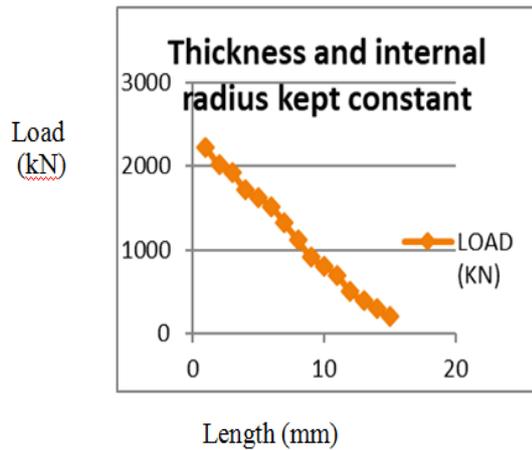


Fig. 4: Variation of buckling load with the length of shell

## 5 Conclusion

Following conclusions can be drawn from the present study:

1. The half sine wave pattern are exhibited along the generator and along the circumference and that depends upon ratio of radius and thickness and is independent of the length of the cylindrical shell.
2. The buckling loads for circular cylindrical shell increase with increasing the thickness of shell at same length.
3. The buckling loads for circular cylindrical shell decrease with increasing the length of shell at same thickness.

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Table 1: Buckling load for varying thickness of shell

Shell thickness (mm)	Length (mm)	Radius (internal)	Radius (external)	Eigen value ( $10^5$ )	Buckling Load (kN)
1.25	350	50	51.25	8.1434	814.34
2.25	350	50	52.25	9.09970	909.970
3.25	350	50	53.25	10.89831	1089.831
4.25	350	50	54.25	12.60569	1260.569
5.25	350	50	55.25	13.31308	1331.308
6.25	350	50	56.25	15.41406	1541.406
7.25	350	50	57.25	16.56238	1656.238
8.25	350	50	58.25	17.98754	1798.754
9.25	350	50	59.25	19.60201	1960.201

Table 2: Buckling load for varying length of shell

Thickness (mm)	Length (mm)	Radius (Internal)	Radius (External)	Eigen value ( $10^5$ )	Buckling load (kN)
10	300	50	60	22.17720	2217.720
10	350	50	60	20.17718	2017.718
10	400	50	60	19.17716	1917.716
10	450	50	60	17.17714	1717.714
10	500	50	60	16.17712	1617.712
10	550	50	60	15.17710	1517.710
10	600	50	60	13.17708	1317.708
10	650	50	60	11.17706	1117.706
10	700	50	60	9.17704	917.704
10	750	50	60	8.07702	807.702
10	800	50	60	7.02700	702.700
10	850	50	60	5.01298	501.298
10	900	50	60	4.00696	400.696
10	950	50	60	3.00294	300.294
10	1000	50	60	2.00132	200.132