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Study of Linear and Non-Linear Buckling Analysis of Reinforced Concrete Wall

Salil Gurudev
salilgurudev1509@gmail.com
Sagar Institute of Research & Technology, Bhopal, Madhya Pradesh

Dr. Rakesh Patel
rakeshasct@gmail.com
Sagar Institute of Research & Technology, Bhopal, Madhya Pradesh

ABSTRACT

RCC walls are used worldwide to resist loads due to gravity and earthquake. Many of the tall buildings had buckled during recent earthquakes due to poor design and construction practices. When the RCC structure is subjected to axial compressive loading it fails due to buckling. The objective of the study is to predict the linear and non-linear buckling behaviour of RCC walls using the finite element model. This paper investigates the effect of various parameters that influence the behaviour of the wall. These parameters include; slenderness ratio, the percentage of reinforcement. Different percentages of reinforcement with constant slenderness ratio for a wall is analyzed through ANSYS 15.0.

Keywords: *ANSYS 15.0, Buckling Phenomena, FEM, Linearity, Non-Linearity, RC Wall.*

1. INTRODUCTION

Design practices previous to the 1990s favored rectangular partitions with enlarged boundary factors, contributing to the stability of the flexural compression sector. Extra lately, prevailing practices in many countries favour square sections without enlarged obstacles. The extra narrow flexural compression zones may be susceptible to inelastic lateral buckling. Lateral unpredictability rises when the wall section are subjected to compressive load. Buckling can take place when the RCC wall is subjected to compressive load. This is due to the fact residual tensile strains in the formerly yielded longitudinal reinforcement leave the wall boundary with open cracks, resulting in reduced lateral stiffness. Failure modes are hypothesized. One speculation is that tensile yielding for loading in a single direction softens the boundary for next loading inside the opposite route, main to the lateral instability of an otherwise intact wall. A second speculation is that the wall crushes first, leaving an even smaller and abnormal pass section. This crushed section can also come to be straight away volatile or, alternatively, next anxiety and compression cycles may lead to instability of the reduced pass phase consistent with the primary hypothesis, main to a secondary buckling failure[1].

2. LITERATURE SURVEYED

Discussed the possibilities of modeling reinforcement details of models of reinforced concrete in practical use. The structure of the analytical studies was modelled in a Finite Element software ANSYS. The samples are modelled as (i) a discrete model and (ii) a smeared model. It reports the results of the analysis of the flanged shear wall with two different types of modelling under cyclic load. The consequences of minor changes in modelling are discussed and it is shown that the two models produce satisfactory results[2].

Presented themselves for buckling of sections subject to cycles of inelastic stress and compression strain. The theory is applied to tests of reinforced concrete prisms and one Chilean building (Alto Huerto), which had a curved wall after the earthquake in Chile in 2010. They concluded that buckling is not a failure after crushing of wall[3].

Completed finite element analysis of the double-walled steel-concrete composite scissor wall is performed to simulate the entire process behaviour of the scissor wall. The load-displacement relationship is obtained and the slippage property of the steel sheet concrete connection is also intensively investigated by maintaining the spring elements on the interface. Finally, the influence of the axial compression ratio and the steel sheet thickness is presented by a parametric analysis. The conclusions drawn from the analysis are that the maximum slippage of the shear wall takes place on the tension side of the wall bottom where the concrete tears and the axial force moment curve has a parabolic property. The relevant conclusions are useful for the routine design[4].

Investigates the behaviour of an explosion of the reinforced concrete subject to air-jet loading. In this study, an armed concrete blasting wall was designed to withstand a radius load for the capacity of 5 kg of TNT at a distance of 2 meters. The thickness of the explosion wall is 250 mm and the height is 4500 mm. AUTODYN 3D hydrocode software was used to simulate the behaviour of the reinforced concrete blast wall with air jets. A total of four different load weights from TNT, representing a minimum payload of person or vehicle to carry an explosive, were simulated at a distance of 2 meters from the explosive wall. These explosive capacity representative bombs are a hand-carried bomb by personnel with a load capacity of 5 kg, motorcycle 50 kg, car 400 kg and also with the capacity of 1500 kg of TNT explosive. The simulation results show that the explosive wall increased the explosion load to 5 kg and had slight damage to the wall if it was subjected to 50 kg TNT loading weight, but the explosives wall failed when exposed to 400 kg and 1500 kg TNT loading weight at a distance of 2 meters. The results show that the simulation results with AUTODYN 3D simulation software are comparable with the design data[5].

Explores the impacts of a variety of folding parameters and incorporation of infill plate opening on the auxiliary execution of trapezoidally corrugated SPSWs under monotonic stacking through limited component recreation utilizing ANSYS. Clasping steadiness, solidness, quality, and flexibility exhibitions of various SPSW models created in light of web-plate thickness, folding edge, and opening size parameters are explored. Square openings are actualized at the focal point of the infill plates with regions equivalent to 5, 10, 15, 20, 25, and 30 percent of the web-plate out-of-plane anticipated region. The exactness of the limited component displaying is confirmed through correlation of numerical and exploratory outcomes. Discoveries of the study demonstrate that appropriate outline of the limit outline individuals and ideal choice of the web-plate thickness and additionally folding parameters can bring about alluring execution of steel shear dividers with trapezoidally-ridged and punctured infill plates, especially in spite of the adverse impacts of web-plate opening, as incompletely appeared in their work[6].

Presents a comprehensive study of the concrete wall against this dynamic loading. Concrete wall subjected to blast loading is modeled in Finite Element package ANSYS and then analyzed in AUTODYN with and without steel plate to study the impact of blast loading[7].

3. OBJECTIVE OF STUDY

Linear and nonlinear buckling analysis are performed for a specific RCC wall using FEA packages. Different parameters that influence the behaviour of the wall in axial and lateral loading are to be studied. These parameters are;

- slenderness ratio, the percentage of reinforcement

4. RCC WALL DETAILS

The length of the wall is 1500 mm and the height of the wall is 5000 mm. The wall is subjected to axial load and lateral load to find deformation, peak stress and strain values. The thickness of the wall is constant, which is 250 mm for varying percentage of reinforcement.

5. MATERIAL PROPERTIES

The grade of reinforcement bar model was Fe 415, Elastic modulus was 2 × 105 MPa and Poison ratio 0.3, whereas concrete grade was M40, Elastic modulus was 25000 MPa and Poison's ratio was 0.15.

6. ELEMENT TYPES

6.1 Reinforced Concrete

An eight-node solid element, SOLID 65 was used for the 3D modelling of concrete. In general, SOLID 65 is used for the 3D modelling of solids with or without reinforcing bars (reinforcing bars). The solid can compress and crush under pressure. The element is defined by eight nodes with three degrees of freedom on each node (Translations in the nodes x, y, and z). Three different rebar specifications can be defined. The geometry and junction locations for this element type are shown in Figure 1. The special features on which SOLID 65 can be analysed are: Plasticity, creep, cracking, crushing, big deviation, big load, Stress reinforcement, heavy load, birth, and death[8].

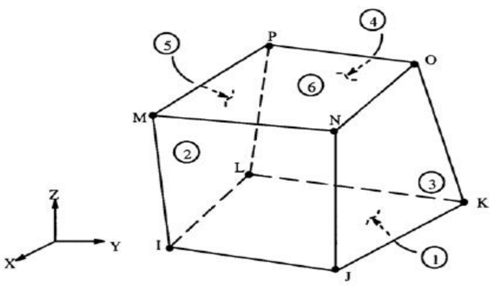


Fig. 1: Solid 65 Element

Source: http://www.ansys.stuba.sk/html/elem_55/chapter4/ES4-65.htm[9]

6.2 Steel Reinforcement

A Link8 element was used to model the steel reinforcement. The Link 8 is a 3-D spar uniaxial tension-compression element with three degrees of freedom at each node that is translations in the nodal x, y, and z directions. Two nodes are required for this element.

Each node has three degrees of freedom, – translations in the nodal x, y, and z directions. The element is also capable of plastic deformation, creep, swelling, stress stiffening, and large deflection. The geometry and node locations for this element type are shown in figure 2.

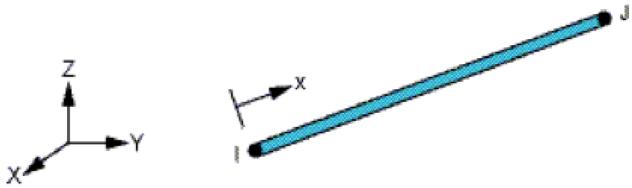


Fig. 2: Link 180 Element

Source: https://www.sharcnet.ca/Software/Ansys/17.0/en- s/help/ans_elem/Hlp_E_LINK180.html[10]

7. MODELLING IN ANSYS 15

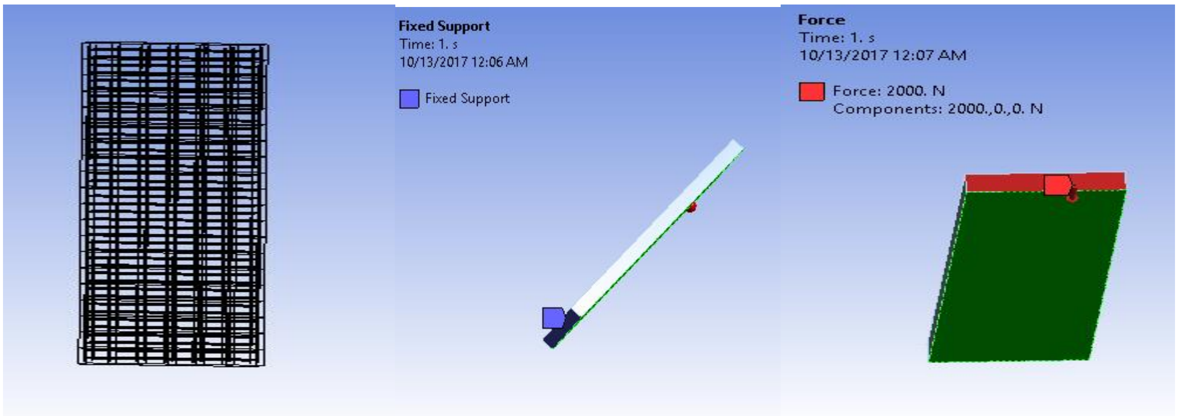
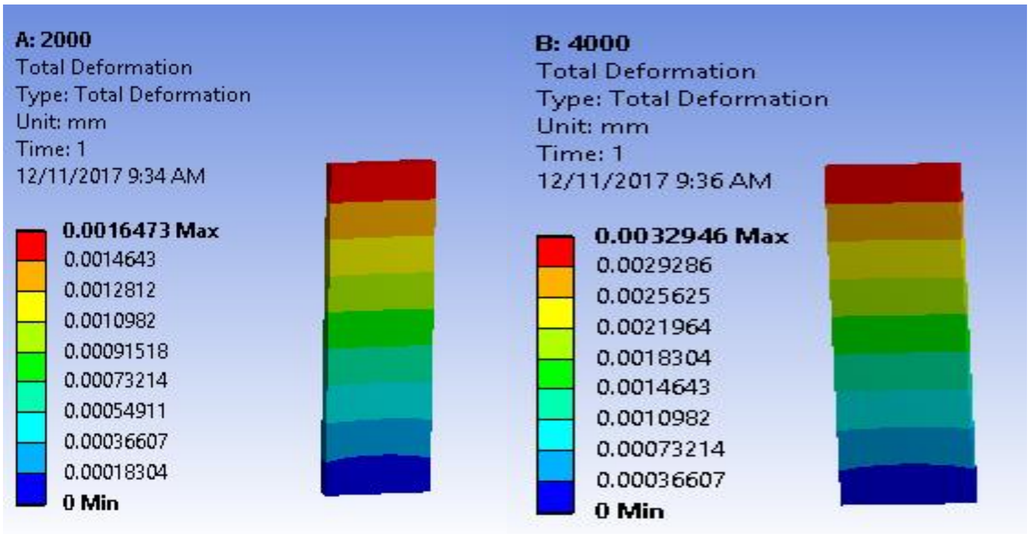


Fig. 3: Meshing and Boundary Condition in Model

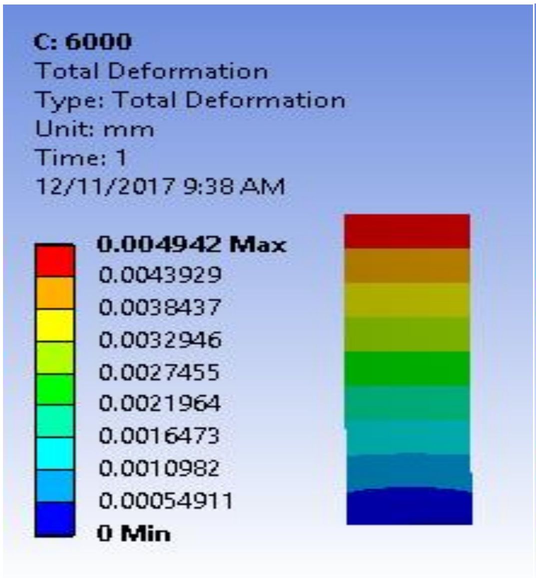
8. RESULTS AND DISCUSSION

8.1 Linear Analysis of RCC Wall FEM Results

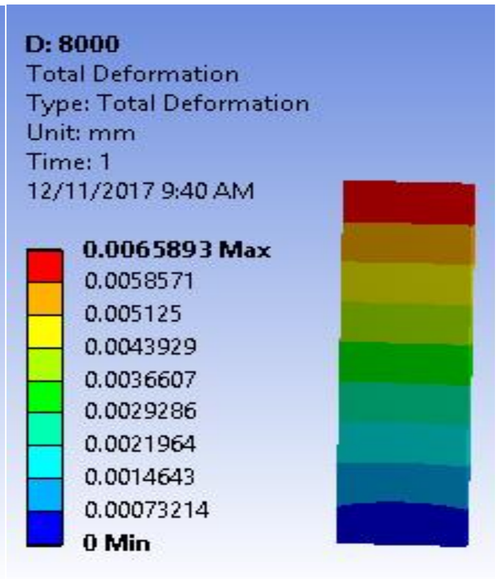
Displacement is the extent to which a structural element is moved under a load. It can refer to an angle or a distance. It is directly related to the slope of a deflected shape of the element under that load. The increase in the load from 2000 KN to 12000 KN increases the displacement values. The variation in displacement relative to the load is shown in the table and graph below.



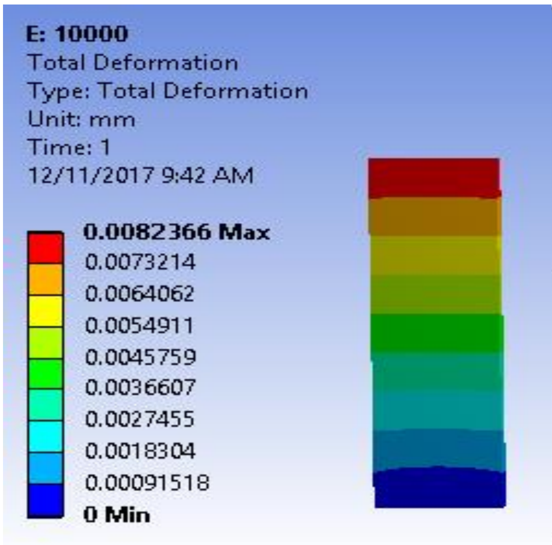
4 (a) **4 (b)**



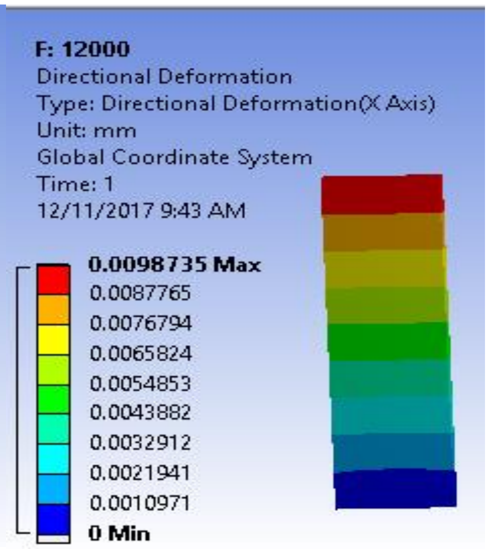
4 (c)



4 (d)



4 (e)



4 (f)

Fig. 4: Deformation for 0.84 % with Varying Load in Linear Analysis (Axial Loading)

From fig. 5 it is clear that wall with 0.84 % buckles more when to compare to the wall with 0.994% and 1.34%.

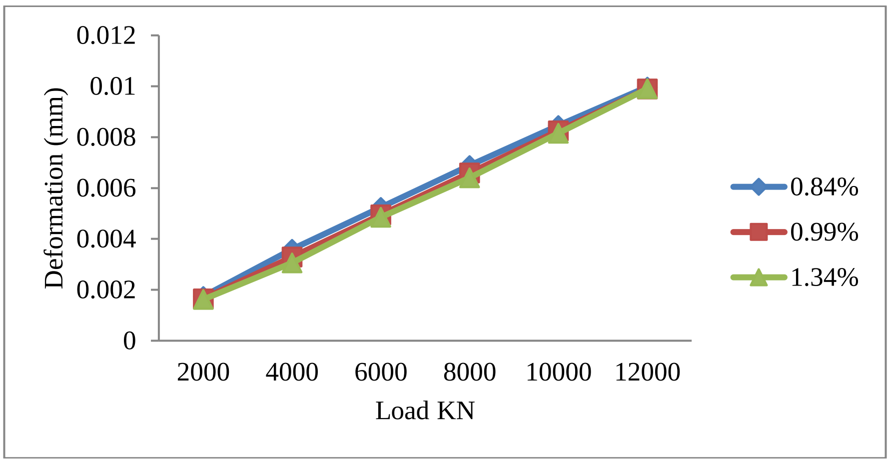


Fig. 5: Deformation Comparison in Linear Analysis for Reinforcement at 0.84 %, 0.994 % and 1.34 %

The values obtained from the analysis are noted. The peak stress, peak strain values were compared and stress-strain curves were plotted.

The stress is higher at the level of 12000 MPa. After that the material is going to the plastic stage. It means that RCC wall completely collapses after the load of 10000KN.

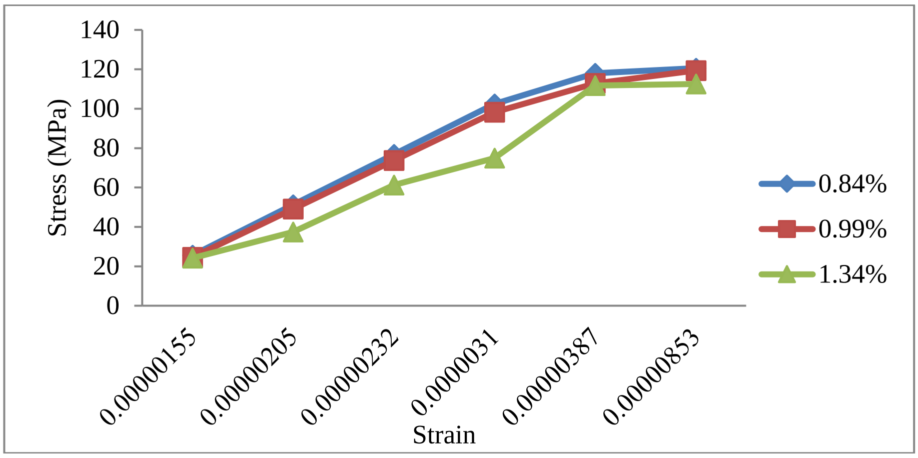


Fig. 6: Stress Vs Strain Behaviour in Linear Analysis for three Percentage of Steel for Axial Loading

8.2 Non-Linear Analysis of RCC Wall FEM Results

From fig. 7 it is clear that wall with 0.84 % buckles more when to compare to the wall with 0.994% and 1.34%.

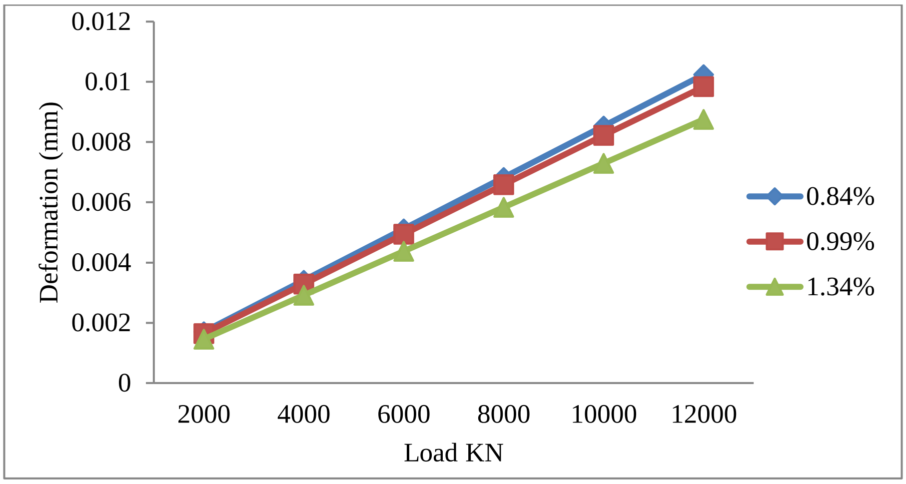


Fig. 7: Deformation Comparison for Reinforcement at 0.84 %, 0.994 % and 1.34 % in Nonlinear Analysis (Axial Loading)

The values obtained from the analysis are noted. The peak stress, peak strain values were compared and stress-strain curves were plotted.

The stress is higher at the level of 12000 MPa. After that the material is going to the plastic stage. It means that reinforced concrete wall completely collapses after the load of 10000KN.

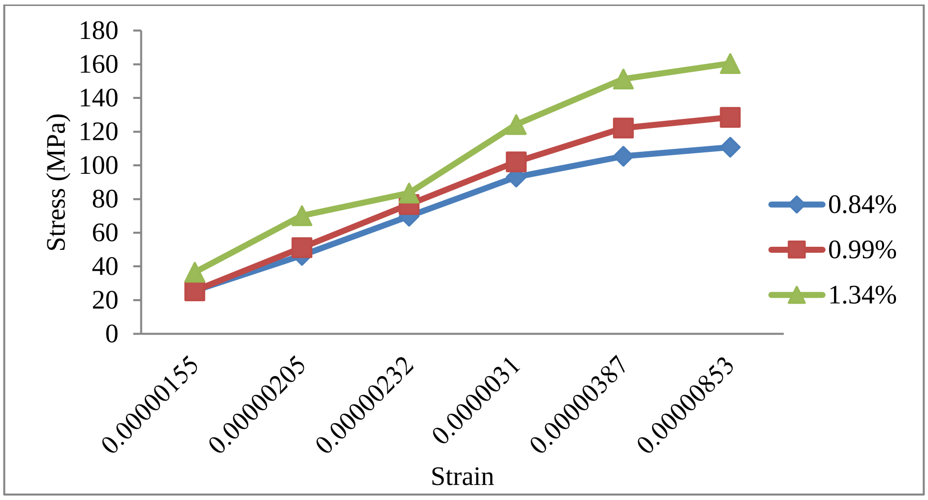


Fig. 8: Stress-Strain Analysis in Nonlinear Analysis for Axial Loading

Stress concentration is higher for wall with 1.34 % more when compared to wall with 0.84 and 0.99 %

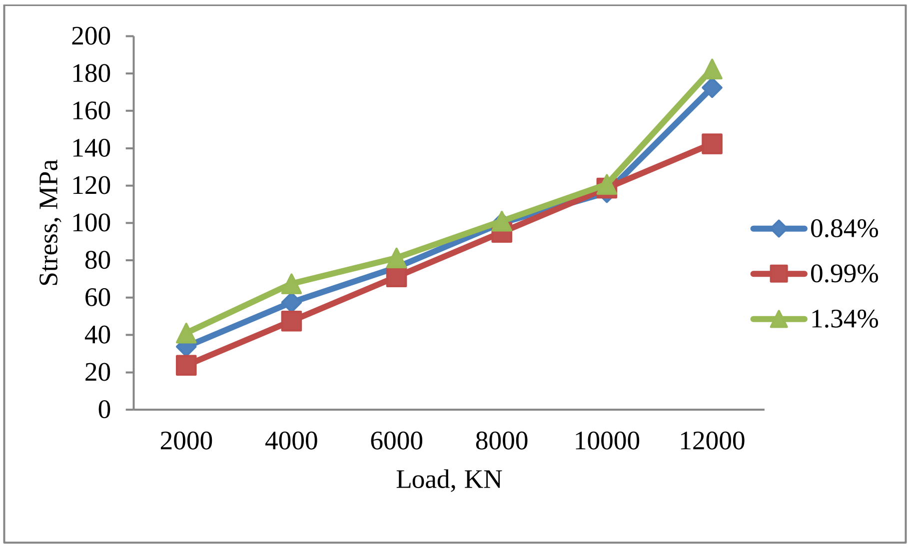


Fig. 9: Stress for Reinforcement at 0.84 %, 0.994% and 1.34 % in Nonlinear Analysis (Lateral Loading)

The values obtained from the analysis are noted. The peak stress, peak strain values were compared and stress-strain curves were plotted.

The stress is higher at the level of 12000 MPa. After that the material is going to the plastic stage. It means that RCC wall completely collapses after the load of 10000KN.

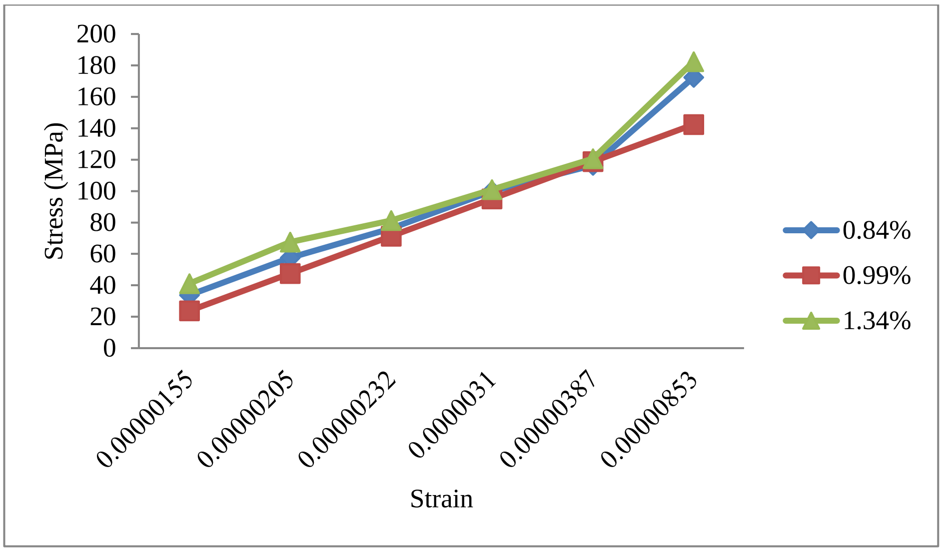


Fig. 10: Stress-Strain Results for Lateral Loading in Nonlinear Analysis (Lateral Loading)

9. CONCLUSION AND FUTURE SCOPE

9.1 Conclusions

Following conclusions can be drawn from the study:
Buckling of wall analysis is performed in ANSYS WORKBENCH 15l. The parameters which significantly affect the behavior of the wall were examined to find results.

9.1.1 For Axial Condition

Deformation increases with increase in load for 0.84 %, 0.994 % and 1.34 % in linear and non-linear mode. It is clear that wall with 0.84 % buckles more when to compare to the wall with 0.994% and 1.34 % in linear and non-linear mode. Stress concentration is higher on the wall with 1.34 % more when compared to the wall with 0.84 and 0.99 % in linear and non-linear mode. The stress is higher at the level of 12000 MPa. After yielding material is goes to the plastic stage. However, the deformation is large and hence reinforced concrete wall completely collapse after the load of 10000KN in linear and non-linear mode.

9.1.2 For Lateral Condition

Deformation increases with increase in load for 0.84 %, 0.994 % and 1.34 % in linear and non-linear mode. It is clear that wall with 0.84 % buckles more when to compare to the wall with 0.994% and 1.34 % in linear and non-linear mode. Stress concentration is higher for the wall with 1.34 % more when compared to the wall with 0.84 and 0.99 % in linear and non-linear mode. The stress is higher at the level of 12000 MPa. After yielding material is goes to the plastic stage. However, the deformation is large and hence reinforced concrete wall completely collapse after the load of 10000KN in linear and non-linear mode.

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