

Non-Linear Analysis Of Beams

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ABSTRACT : When a structure deforms, under a load its stiffness changes. Depending upon the amount of change in the stiffness, the field variables are calculated using linear or nonlinear approaches. In this paper linear and geometric non-linear analysis of a beam is carried out using two-dimensional finite element method by simulating the problem in commercial software ANSYS. Influence of the parameters (i) span to height ratios(s) and (ii) Load on geometrical non-linear behaviour of the beam for a fixed width-to-height ratio (b/h) of 0.3 is studied.

Keywords -Non-Linear Analysis, Plane stress, Stiffness, FEM, ANSYS

I. INTRODUCTION

1.1 INTRODUCTION TO NON-LINEAR ANALYSIS

An assumption of linear elastic behaviour may be used in the analysis of structures for simplifying the solution procedure. This assumption may yield results far from reality in many situations. In such cases one may arrive at either non-optimum design or failure. The basic difference between both the approaches is only in updating the geometry of the structure during load transferring.

1.2 TYPES OF NON-LINEARITY

Most of the non-linear behavior in product design can be categorized into one of three common types: Material, Geometric, and Boundary non-linearity

1.3 PREVIOUS STUDY

Namik Kemal Ozturun [1] validated a finite element formulation for the static and dynamic analysis of linear-elastic space structures composed of plate- and beam-type members. In general, finite elements can be used efficiently for the analysis of linear-elastic structures with shear walls built by the use of tunnel forms. The element considered in the present study has six degrees of freedom at each node and an in-plane rotational degree of freedom, which makes it compatible with three-dimensional (3D) beam-type finite element models. The rigidity coefficients of the element are determined analytically.

George et al [2] tested the improved geometric non-linear capability in MSC/NASTRAN version 68 on a large scale finite element model of a tie rod. The static buckling load of a tie rod is analyzed. The results of the finite element model are compared with experimental results. It is shown that MSC/NASTRAN's computed buckling load agrees well with the experimental buckling load.

Luiz A. et al [3] discussed an eight-node hexahedral element with uniform reduced integration, which is free of volumetric and shear locking and has no spurious singular modes, is implemented for geometrically non-linear static structural analysis. Numerical examples verify the computational efficiency and the potential of the three-dimensional element in the analysis of shells, plates and beams undergoing large displacements and rotations. Results are compared to those employing classical plate and shell elements.

Bassam [4] aims to clarify some of the conceptual issues which are related to the geometrically non-linear analysis of 3D framed structures, and which have been a source of previous confusion.

Yang et al [5] presents the non-linear analysis of elastic structures; the displacement increments generated at each incremental step can be decomposed into two components as the rigid displacements and natural deformations. The robustness of the procedure is demonstrated in the solution of several benchmark problems involving the post buckling response.

Vladimir and Justin [6] deals with a new bar element with varying cross-sectional area which can be used for geometric non-linear analysis. The results obtained with new element were compared with ANSYS bar element results.

Raul [7] used Finite element models to analyze adhesive bonds in actual structures, but this takes a considerable amount of time and a high computational cost. A stress analysis of crack patch geometry is presented. A numerical simulation of the debonding of the patch is also included.

Andrzej [8] verifies the suitability of commercial engineering software for geometrically non-linear analysis of shell structures. The paper deals with the static, geometrically non-linear analysis of shells made of isotropic materials. The finite element method (FEM) has been chosen to solve the problem. The results of the ROBOBAT Millennium v.19.0 and MSC. Marc v.2005r2 commercial software is compared with the literature results.

1.4 PURPOSE OF PRESENT STUDY

In order to identify the limitations of linear static analysis of beams, the transverse deflection and bending stresses for a width-to-height ratio of 0.3 from 2-D plane stress approach for both linear and geometric non-linear analysis options by varying span-to-height ratio of the beam.

II. GEOMETRICAL MODELING OF THE PROBLEM

A 2-D model of beam is modeled using ANSYS software by modeling longitudinal section of the beam (Fig. 1). The length of the beam is taken as 1m and cross sectional dimensions of the beam are height 'h' which varies according to different span to height ratios such as s=10, 20, 40, 60, 80, 100. The width of the beam is taken according to width to height ratio, a=0.3. The finite element mesh is generated with 8-node quadratic Plane-82 elements. For the beam simply supported boundary conditions are applied. A uniform transverse pressure of 1MPa is applied on the top surface of the beam (Fig. 1).

The following material properties are considered for the present analysis for structural steel material.

- Young's Modulus, E=200GPa
- Poisson's Ratio, $\nu=0.3$

III. FIGURES AND TABLES

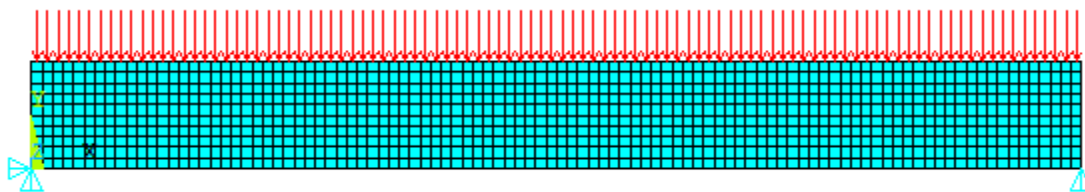


Fig. 1 2-D FE model showing meshing, boundary conditions, and loading (s=10, a=0.3)

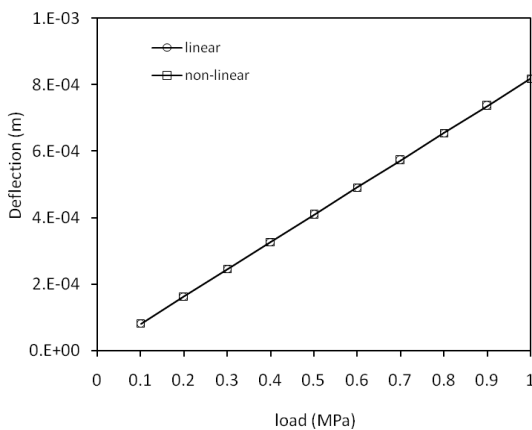


Fig. 2 Variation of deflection with respect to load

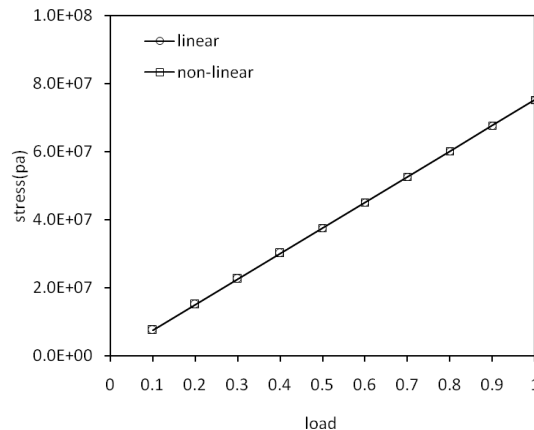


Fig. 3 Variation of stress with respect to load

(For s=10)

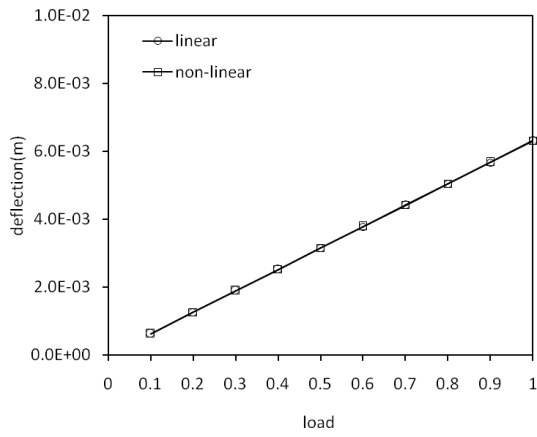


Fig. 3 Variation of deflection with respect to load
(For $s=20$)

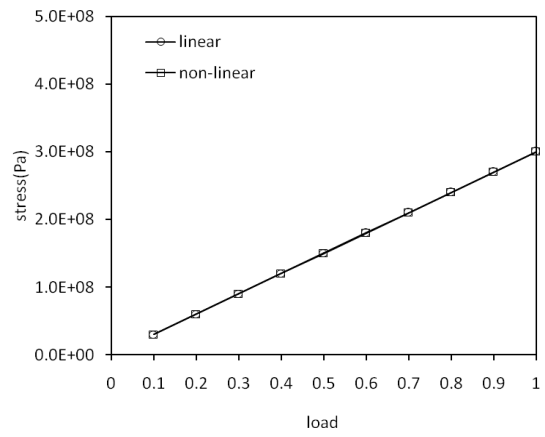


Fig. 4 Variation of stress with respect to load

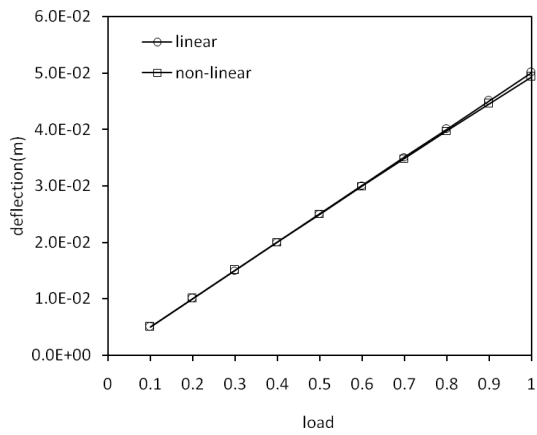


Fig. 5 Variation of deflection with respect to load
(For $s=40$)

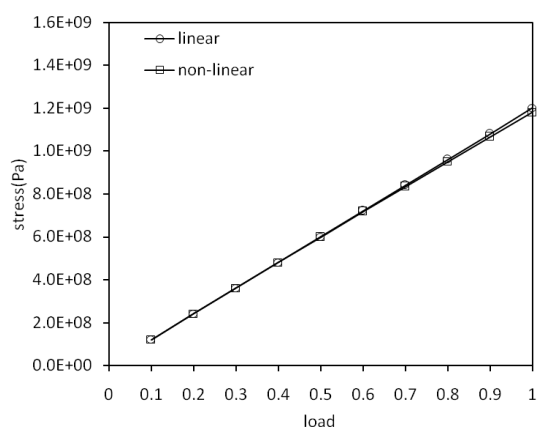


Fig. 6 Variation of stress with respect to load

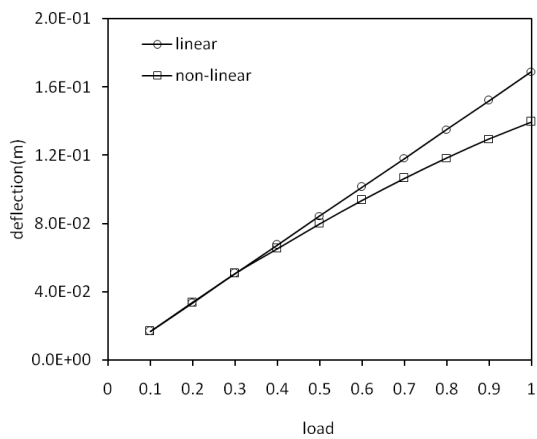


Fig. 7 Variation of deflection with respect to load
(For $s=60$)

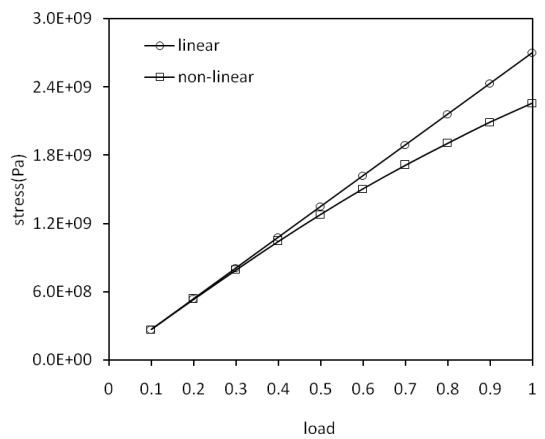


Fig. 8 Variation of stress with respect to load

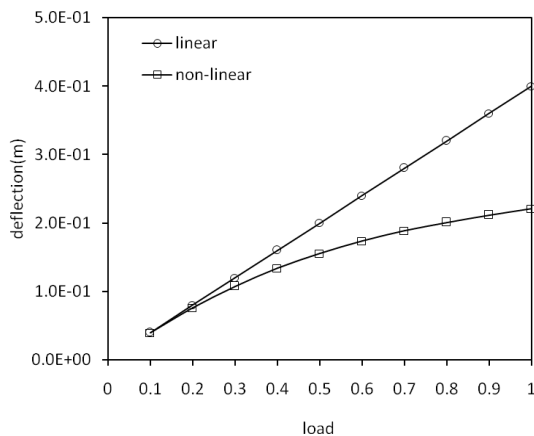


Fig. 9 Variation of deflection with respect to load
(For $s=80$)

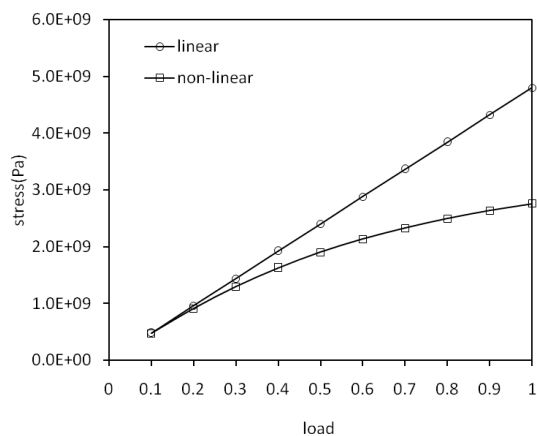


Fig. 10 Variation of stress with respect to load

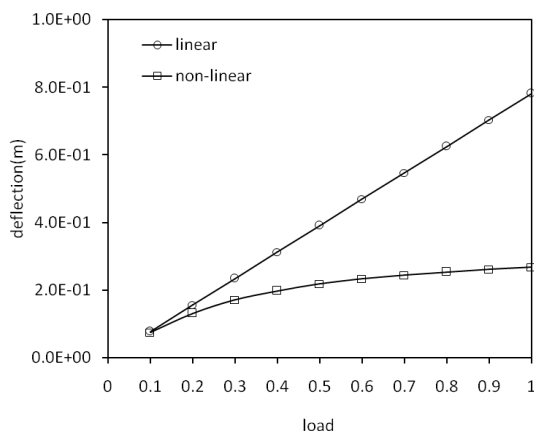


Fig. 11 Variation of deflection with respect to load
(For $s=100$)

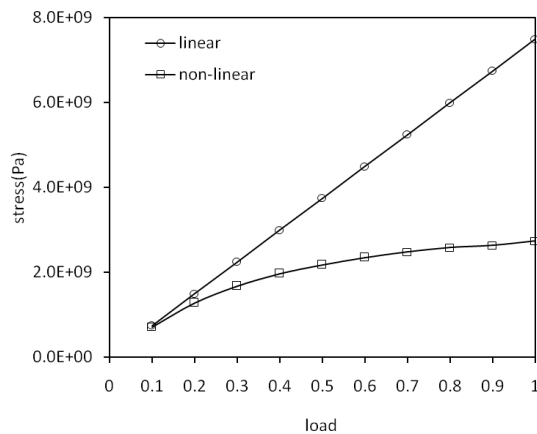


Fig. 12 Variation of stress with respect to load

VI. CONCLUSION

Figs. 2 to 12 show the variation of deflection and bending stress with respect to load. It can be observed that the linear assumption is valid up to $S=20$ for the imposed load and hence it is recommended to carryout non-linear analysis for better design of the structure when $s>20$.

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