A REVIEW ON DEEP TAPERED BEAM ANALYSIS USING ISO-PARAMETRIC ELEMENTS

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Abstract: *Deep beams are the members loaded on one face and supported on the opposite face so that compression struts can develop between the loads and the supports. The analysis of deep beam by finite element method is presented in this paper, which involves the convergence study of deflection, bending stress and shear stress stresses at a critical point of the beam.There are several analytical tools available for analyzing of deep beam. Among all the available analytical methods, finite element analysis (FEA) offers a better option. The structural bending members can be broadly divided into two regions. The first region is the Bernoulli regions (B-regions), where the strain distribution is linear The second region is the D or Distributed regions, where the strain distribution is nonlinear as in the case of deep beams. It is recognized that the distribution of the strain across the section of deep beam is nonlinear and hence, these structural elements belong to the D-Regions. Traditionally, the D-Regions have been designed using empirical formulae or past experience. The analysis of deep beams we generally use SAP, ANSYS software. Result of flexural stress and shear Stress of cantilever prismatic deep beam obtained using FEM program for Iso-parametric elements and ANSYS 2D and 3D analysis are compared.*

Keywords: **Deep beam, Aspect ratio, Convergence study, Flexural stress**

I. INTRODUCTION

Deep beam defind as when ratio of effective span to overall depth is less than 1) 2.0 for simply supported beam 2) 2.5 for continuous beam. The main objective of this project is to provide a brief idea about behavior of tapered deep beams and the use of Finite Element Method Program for isoparametric elements for the analysis of deep beams. The study is focused on the variation of distribution of flexural stress and shear stress through the section of deep beam. The specific objectives of this thesis include.

1. Analysis of deep beams and deep tapered beam subjected to point load.
2. Comparative study of deep beams of various aspect ratios using FEM.
3. Comparisons of the results obtained from FEM Program for Iso-parametric elements, and ANSYS 2D and 3D

II. LITERATURE REVIEW

2.1 M. Muzibur Rahman, S. Reaz Ahmed **(2008)**

The displacement potential formulation is investigated here to analyze the elastic behavior of a guided deep beam under uniform loading with two simple supports. The lateral displacement, bending stress and shear stress are studied. The displacement potential solutions are then compared with those of the classical bending theory as well as finite element method (FEM).The comparative study reveals that the classical theory of bending is simply inadequate to predict the stress and displacements fields of the guided beam, however, the solutions obtained by FEM are found to approach towards the analytical solution far better than that of classical theory.

2.2 Yuwaraj M. GhugalAnd Rajneesh Sharma **(2009)**

Hyperbolic shear deformation theory is used for thick isotropic beams. The hyperbolic sine function is used in the displacement field in terms of thickness coordinate to represent shear deformation. General solutions of thick isotropic simply supported, cantilever and fixed beams subjected to uniformly distributed and concentrated loads are obtained. Expressions for transverse displacement of beams are obtained and contribution due to shear deformation to the maximum transverse displacement is investigated.

2.3 B.R.Niranjan and S.S.Patil **(2012)**

Analytically studied R.C. simply supported beams subjected to two point loads using FEM. Flexural stress, flexural strain, and shear stress variations at different sections for various L/D ratios were studied and compared with Euler Bernoulli Theory (EBT). L/D ratios are varied as 1.25, 1.375, 1.5 .It is concluded that the flexural stress and strain variation graphs indicate that the definition of simply supported deep beam as per IS456:2000 i.e when L/D ratio is less than or equal to 2.0 is reasonably accurate. Flexural strain and stress of deep beams is not linear. Shear effect is predominant in beams having L/D ratio less than or equal to 2.0 which may lead to warping of the section. The flexural steel requirements are inversely proportionally to the Effective span to Depth Ratio of deep beam.

2.4 Wai Chee Mun, Ahemad Rivai, Omar Bapokutty**(Oct-2013)**

In this paper they have investigated the factors influencing the selection of elements in finite element analysis (FEA) by considering the effects of different types of elements on the results of FEAA simple case study of an I-beam subjected to an asymmetric load is carried out by FEA. Three different models of the I-beam were prepared and analyzed separately using 1D elements2D elements, and 3D elements. The FEA results of these models showed good agreement with the theoretical calculation despite the small and negligible errors in the analysis.

2.5 Sudarshan D. Kore, S.S.Patil **(2013)**

The experimental investigation using different country codes is carried out to find out the strength, cracking pattern and behavior of deep beam under two point loads for L/D ratios such as 1.71, 1.6 and 1.5The conclusions made are

- As L/D ratio decreases the flexure steel increases
- As L/D ratio decreases there is an increase in strength of deep beam
- As L/D ratio increases the lever arm decrease

2.6 DR. P. N. Godbole **(2013)**

In the book titled “Introduction To Finite Element Method” P. N. Godbole Presented different isoparametric elements such as two noded bar element for 1D analysis, linear, quadratic and cubic and triangular elements for 2D analysis and their formulation in Finite Element Method. It gives the details of Finite Element Method Program for analysis of 2D problems of plain stress, plain strain, axisymmetric problems using linear and quadratic isoparametric elements.

III. ANALYTICAL METHOD OF DEEP BEAM

The Euler-Bernoulli elementary theory of bending (EBT) of beam disregards the effect of shear deformation. The theory is suitable for slender beams and not for the deep beams since it is based on the assumption that the plane section before bending remains plane after bending. The elementary beam theory neglects the transverse shear deformation and hence underestimates the deflections in case of deep beams, where shear deformation effects are significant. The discrepancies in the elementary theory of beam bending forced the development of higher order or refined shear deformation theories. Following are the various methods which can be used for the flexural analysis of deep beams:

- Finite Element Method
- Finite Difference Method
- Stress Function Approach
- Elementary Beam Theory
- First-order Shear Deformation Theory
- Higher order Shear Deformation Theory
- Trigonometric Shear Deformation Theory
- Parabolic Shear Deformation Theory
- Hyperbolic Shear Deformation Theory

IV. FINITE ELEMENT METHOD

The finite element method (FEM) is a numerical analysis technique for obtaining approximate solutions to a wide variety of problems in engineering and science. The FEM is ideally suited for problems involving complicated geometries, loadings and boundary conditions, for which analytical mathematical solutions are not possible. This method is similar to matrix displacement method of structural analysis in which a skeletal structure is made up of one-dimensional members connected at joints (bars/truss, beam/frame type). The basic concept of finite element method is based on dividing the complete structure0/domain/region into smaller pieces or sub-regions known as elements. It is assumed that, these elements are interconnected at finite number of joints or nodes. The elements can be of any size depending on the problem. The dividing or splitting of the structure into number of elements is called discretization or idealization.

V. ANSYS

ANSYS software is a powerful and flexible general-purpose finite element analysis and computational fluid dynamics package used for civil engineering. Mechanical engineering, electrical engineering, physis and chemistry simulations. Simulation tools including ANSYS Mechanical APDL,ANSYS CFX and

ANSYS FLUENT, can also solve mechanical problems, static/dynamic structural analysis, heat transfer and fluid problem as well as acoustic and electromagnetic problems.

ANSYS is a general purpose finite element modeling package for numerically solving a wide variety of problems in engineering, in particular:

1. Static/dynamic structural analysis (both linear and non-linear)
2. Fluid analysis- Laminar and turbulent flow
3. Acoustic analysis
4. Electromagnetic analysis
5. Thermal analysis-conduction, convection , radiation
6. Transient thermal analysis
7. Spectrum analysis
8. Bucking analysis
9. Harmonic analysis
10. Model analysis – Vibration characteristics

VI. COMPONENTS OF DEEP BEAM

6.1For Finite Element:The basic requirement for the element to be Iso-parametric is to use same shape function or interpolation function to define the element shape (i.e. coordinates) as is used to define the unknown functional (i.e. displacement) within the element. The element can be for one-, two-, three-dimensional elasticity problems or for plates and shell problem.

6.2For Ansys:PLANE82 is a higher order version of the 2-D, four-node element (PLANE 42). It provides more accurate results for mixed (quadrilateral-triangular) automatic meshes and can tolerate irregular shapes without as much loss of accuracy. The 8-node elements have compatible displacement shapes and are well suited to model curved boundaries.

The 8-node element is defined by eight nodes having two degrees of freedom at each node: translations in the nodal x and y directions. The element may be used as a plane element or as an axisymmetric element. The element has plasticity, creep, swelling, stress stiffening, large deflection, and large strain capabilities. Various printout options are also available. See PLANE82 in the Theory Reference for the Mechanical APDL and Mechanical Applications for more details about this element. See PLANE83 for a description of an axisymmetric element which accepts nonaxisymmetric loading.

VII. USES OF DEEP BEAM

The use of reinforced concrete deep beam has become more prevalent in recent years. Deep beams often appear in form of transfer girders in high rise building as well as pile caps, foundation walls, water tanks, bins, folded plate roof structures, floor diaphragms, shear walls & brackets or corbels. Plane section before bending remains plane after bending does not hold good for deep beams. The behavior of deep beam is significantly different from that of beams of more normal proportions, requiring special consideration in analysis, design and detailing of reinforcement. A deep beam is in fact a vertical plate subjected to loading in its own plane. The strain or stress distribution across the depth is no longer a straight line, and the variation is mainly dependent on the aspect ratio of the beam.

VII. CONCLUSION

Most importantly it is observed that maximum value of shear stress in case of DEEP TAPERED BEAM is always on the tapered edge and it goes on reducing towards the straight edge giving the minimum value on straight edge.

Deflection values given by EBT are much less than the values given by FEM program and ANSYS in case of rectangular deep beam. Hence, the present method of analysis is more relevant and useful for the analysis of deep elements.

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