National Exams December 2002

98-Civ-B9

Civil Engineering Analysis & Finite Element Method

Time: 3 hrs

Answer any 15 (out of 20) questions.

NOTES:

- If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.
- This is a closed book exam. Candidates may use one of two calculators (the Casio or Sharp approved models : non-programmable)
- All questions are of equal value.
- The first 15 answers that appear in your answer book will be marked.

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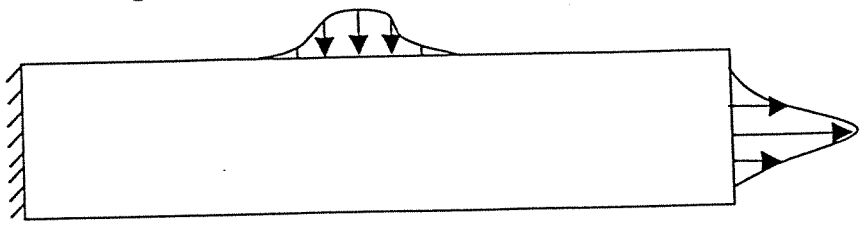
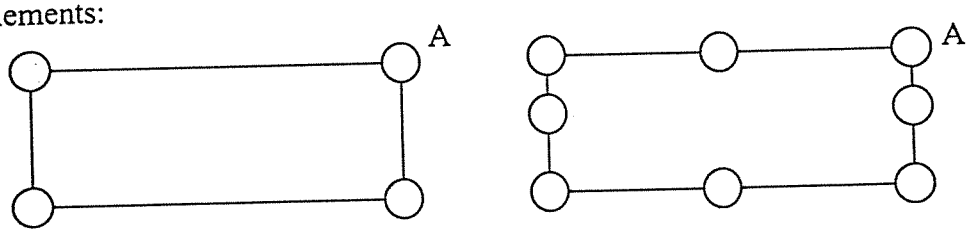
1. What nodal degrees of freedom will you consider for in-plane displacement analysis of following structure?



2. Explain with sketches when you will use plane-stress and plane-strain elements.

3. Draw the appropriate shape functions for the corner node A in following elements:



4. Explain with sketches the concept of "incompatible" finite element formulations.

5. Explain one possible technique for the error estimation of finite element stress analysis results.

6. What are the differences between 'h' and 'p' adaptive mesh refinement techniques?

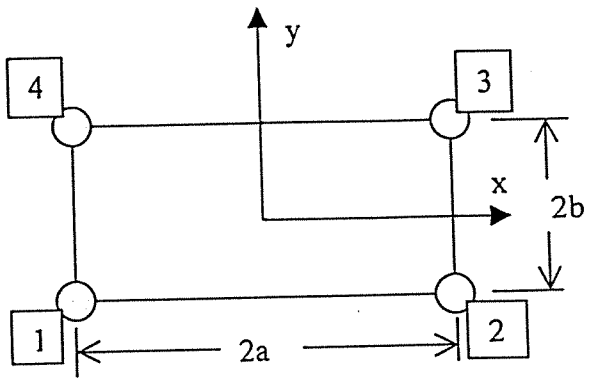
7. Finite element analysis gives stresses in general coordinate directions in terms of σ_x, σ_y, etc. Discuss how you can interpret these results for ductile (e.g. mild steel) and brittle (e.g. concrete) materials.

8. Explain the finite element equation system that can be used to predict the elastic buckling load of a structure?

9. How does the order of Gauss integration of stiffness properties affect the deformation response of a finite element?

10. What are the differences in deformation behaviour of 3- node and 4-node solid elements in 2-D analyses?

11. Find out the general expression for shear strain in the following element for given nodal displacements.



Given, displacement at any point inside the element:

$$u = \Sigma Hi.ui$$

where, interpolation functions, Hi, are given by:

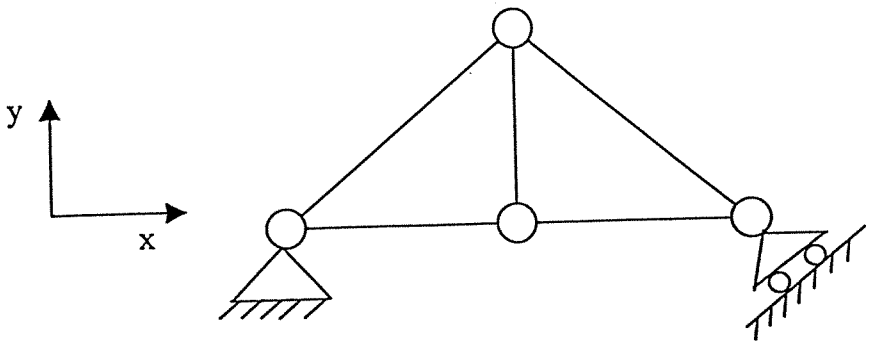
$$H1=(x-a)(y-b)/4ab$$
$$H2=-(x+a)(y-b)/4ab$$
$$H3= (x+a)(y+b)/4ab$$
$$H4=-(x-a)(y+b)/4ab$$

and the nodal displacements, ui, are:

$$u_1^x = -k;\ u_2^x = +k;\ u_3^x = -k;\ u_4^x = +k;$$ all other displacments=0.

12. Discuss the implications of this shear strain on the behavior of finite element in problem # 11.

13. How many independent displacement degrees of freedom does the following structure have? Identify those with a sketch.



14. Distortion energy in a 3-D solid (per unit volume) is given by:

$$U_d=(1+\nu)[(\sigma_1-\sigma_2)^2+(\sigma_2-\sigma_3)^2+(\sigma_3-\sigma_1)^2]/6E$$

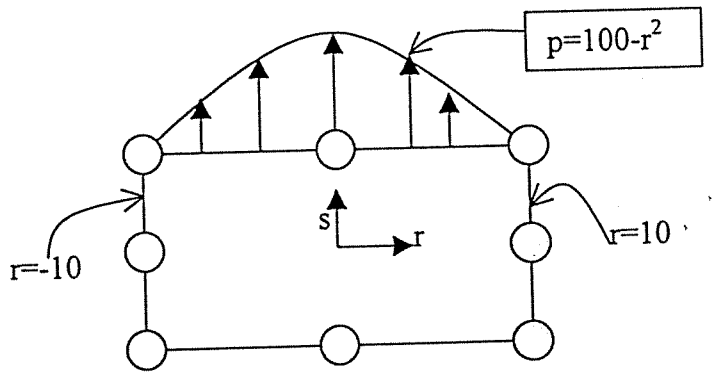
where σ_1,σ_2 and σ_3 are principal stresses, ν is Poisson's ration and E is the elastic modulus. Assuming that at impending failure state, the distortion energy per unit volume of a 3-D solid element is same as that in the yielding failure of a uniaxial tensile test specimen, find out the definition of von Mises stress.

15. Stresses at a node, calculated from adjacent elements, are not same. How will you interpret these results?

16. What is 'reduced' integration? What are its positive and negative effects on the deformation response of a finite element?

17. What is 'Jacobian' in displacement based finite element formulation? What information can you extract from it about the performance of an element?

18. Calculate the consistent nodal loads on the following element?



19. What are the differences between "Euler-Bernoulli" and "Timoshenko" beam elements? Which one is more appropriate for a deep beam analysis?

20. What element type will you use to investigate the elastic buckling resistance of following thin solid structure?