Universitat Polytechnica de Catalunya
MSc Computational Mechanics
Spring 2018

Computational Structural Mechanics and Dynamics

Assignment 7

Due 02/04/2018

Alexander Keiser

Assignment A1

a) Think first and answer later.

What kind of strategy (theory, elements, integration rule, boundary conditions, etc) will you use for solving the following problems:

a.1

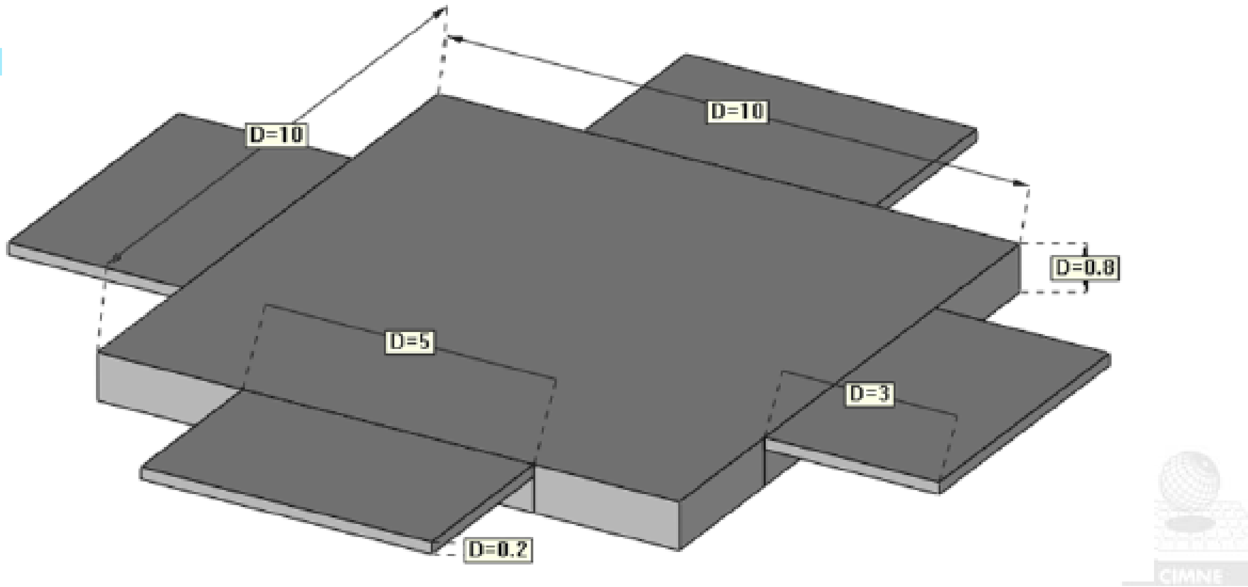


Figure 1: Problem Statement of Problem A1

The first thing that is apparent is the symmetry of the problem. We can reduce the computational cost of the problem significantly if we divide the entirety of the geometry into quadrants and analyze one quarter of the problem. It is important to note that the quarter of the geometry we will be analyzing is comprised of 3 pieces of separate plates. These will need to be analyzed individually as they do not share the same midplane. It is important to first compute the ratio of width to thickness of each plate as to evaluate if we should treat them as thin or thick. And since both plate geometries have relevant ratios lower than 0.1 we can consider them to be thin plates and analyze them as such. It is very important to note that the plates do not share the same midplane as they do in the following example a2. These plates share the same top plane. Therefore it would be more appropriate to apply Kirchhoff theory to the side plates and to the middle plate as long as they are treated as separate entities since they do not share the midplane. If one wanted to place more emphasis on shear, Mindlin-Reissner theory could be applied at the areas of thickness change. Additionally we will need to apply boundary conditions along the intersections of each of these plates and the symmetrical axis. We will want to restrict rotation and translation about the normal of the symmetric planes to ensure accurate analysis. We will also want to consider zero relative movement between the connecting faces of each plate.

Assignment A2

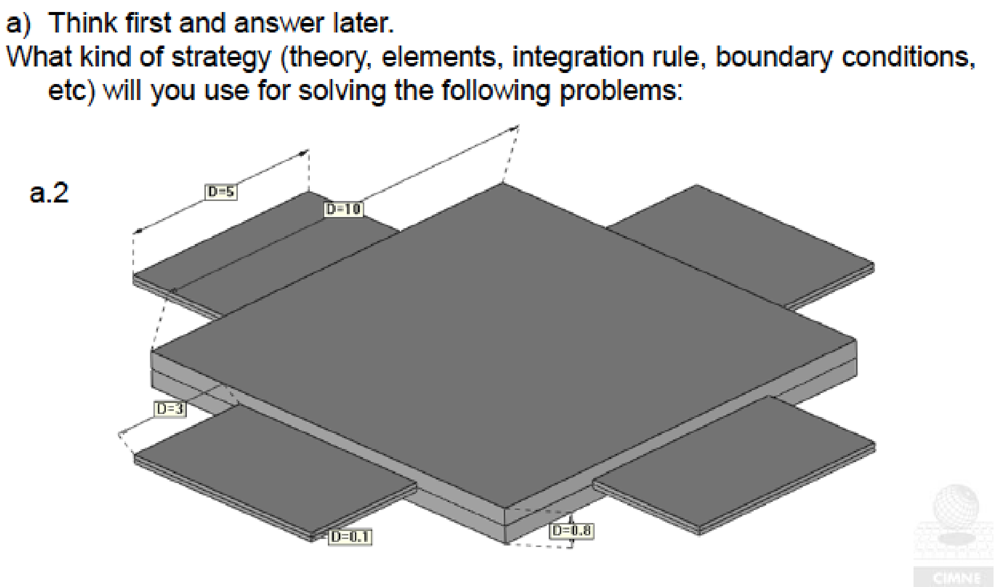


Figure 2: Problem Statement of Problem A2

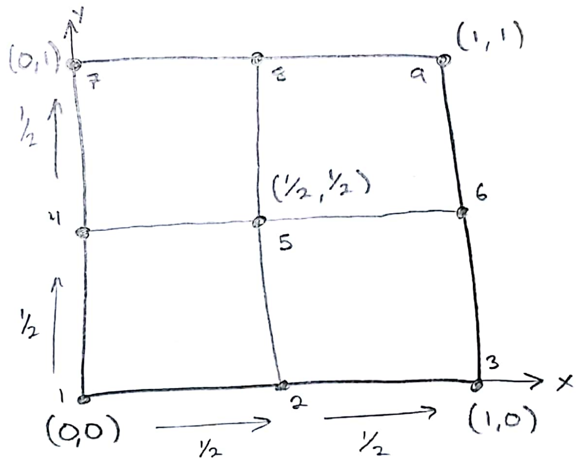
Similarly to the first problem a2, the first thing that is apparent is the symmetry of the problem. We can reduce the computational cost of the problem significantly if we divide the entirety of the geometry into quadrants and analyze one quarter of the problem. It is important to note that the quarter of the geometry we will be analyzing is comprised of 3 pieces of separate plates. However, since they share the same midplane, these can all be analyzed together and treated as one plate. It is important to first compute the ratio of width to thickness of plate as to evaluate if we should treat it as thin or thick. We will compute the ratio as the smallest thickness to the largest width. And since this relevant ratio is lower than 0.1 we can consider this combined plate to be thin and analyze it as such. It would be appropriate to use Kirchhoff theory for the entire body as the entire body is thin and shares the same midplane. However, similarly to the previous problem, we could use Mindlin-Reissner theory at the areas of thickness change for more emphasis on shear.Additionally we will need to apply boundary conditions along the symmetrical axis as we did in the first problem a1. We will want to restrict rotation and translation about the normal of the symmetric planes to ensure accurate analysis.

Assignment A3

Here we will define and verify a patch test of a 4 quadrant 9 noded element.

Definition and Verification of patch test for MCZ element

- The patch test will be conducted by setting internal node forces equal to zero and using specific displacement values to compute displacement & rotation functions. for this assignment we will use a 9-noded element with 4 quadrants. This can be seen below.



our displacement & rotation functions can be seen below

$$\theta_x = x + \frac{y}{2}$$

$$\theta_y = y + \frac{x}{2}$$

$$W = \frac{1}{2}x^2 + \frac{1}{2}y^2 + \frac{1}{2}xy$$

on the next page we will calculate the analytical values for $x, y, W, \varepsilon_x, \varepsilon_y, \gamma_{xy}$ and compare to values given by the provided MCZ element code.

Now that we have defined the element and functions, we will compute analytically and compare with the provided code results for node 5 to verify on the next page.

Below we can see the results of the comparison previously discussed. the results verify the patch test.

Comparison of values at Node 5

NODE 5	w	θ_y	θ_x	ε_x	ε_y	γ_{xy}
ANALYTIC	0.25	0.75	0.75	−1	−1	−1
MCZ CODE	0.37	0.75	0.74	−1	−1	−1

→ since the epsilon values are essentially the same, we can say that the patch test is verified and the method is satisfied.