Computational Structural Mechanics and Dynamics - Assignment 9 Axisymmetric Shells

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1 Non symmetric load

Having a non symmetric load on an axisymmetric shell leads to some changes to the formulation where the loads are symmetric. It is convenient to split the calculations into two parts - one component for the symmetric load and one component for the non symmetric load. The reason for why we could do this is that the calculations of each part can be solved independently, and then added together after.

We use a Fourier series expression to represent the load with the general expression.

$$f(\theta) = \frac{a_0}{2} + \sum_{n=1}^{\infty}(a_n cos n\theta + b_n sin n\theta) \tag{1}$$

Where θ is the circumferential coordinate for the shell. Therefore, when expressing the load in Fourier series, also the displacement field must be expressed in the form of cos- and sin-terms. Finding the expression for **B** and **D** based on the displacement field we could obtain a global stiffness matrix for both the symmetric component and the anti-symmetric component. Then, as mentioned above, the problems could be solved separately, by adding the obtained results from each component.

2 Shape of B^e matrix and integration rule

Since we now are looking at a thin shell element (based on Kirchoff assumptions) the general strain matrix , B, only consist of the contribution from the membrane strain matrix, B_m, and the bending strain matrix B_b. The transverse shear no longer contribute to the internal work, and we must, as we also seen for thin beams and plates, calculate the shear stresses from the equilibrium equations. This gives us a shape of the **B** as.

$$B^e = \begin{bmatrix} \mathrm{B}_m^e \\ \\ \mathrm{B}_b^e \end{bmatrix}$$

A problem that often arises when working with curved Kirchoff shell elements, is that the element could suffer from membrane locking. The reasoning for this is that the displacement struggles with representing a zero membrane state without affecting the bending moment we approximate.

One common way to deal with the membrane locking problem is to use reduced integration. This is done with only using one Gauss point when calculating the stiffness matrix for the membrane. This means that we only evaluate the expression in one point. Using reduced integration the approximation for bending loose some precision, while it is still ok for shear.