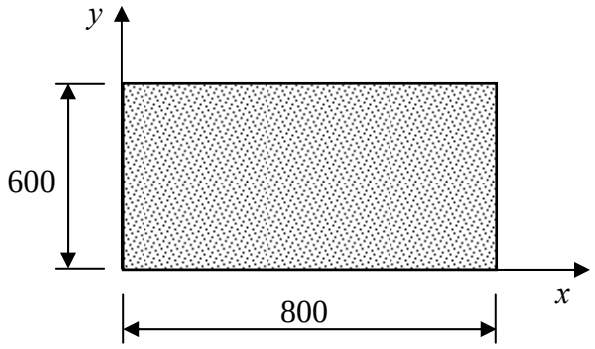
# MEK 4540 – Autumn 2009: Compulsory Assignment no. 3

**To be handed in by 20.11.2009 (see below)**




## Part A

The same panel as that studied in Assignment no. 2 is to be analysed by means of ANSYS. The panel has dimensions 800 mm x 600 mm as shown in the figure. The analysis is confined to the lay-up $[0/90]_{2s}$ in relation to the axes shown in the figure (i.e. the outermost plies are parallel to the *x*-axis). Each ply is assumed to have the following properties:

| | |
|---|---|
| E-modulus in fibre direction: | $E_1$ = 181 GPa |
| E-modulus in transverse direction: | $E_2$ = 10.3 GPa |
| E-modulus out-of-plane: | $E_3$ = 10.3 GPa |
| Shear moduli: | $G_{12} = G_{13}$ = 7.17 GPa |
| | $G_{23}$ = 4.0 GPa |
| Poisson's ratio: | $\nu_{12} = \nu_{13} = \nu_{23}$ = 0.28 |
| Thickness: | $h$ = 1.0 mm |
| Tensile strength in fibre direction: | $\sigma_{1t}^{f}$ = 1500 MPa |
| Compressive strength in fibre direction: | $\sigma_{1c}^{f}$ = -1500 MPa |
| Tensile strength in transverse direction: | $\sigma_{2t}^{f}$ = 40 MPa |
| Compressive strength in transverse direction: | $\sigma_{2c}^{f}$ = -246 MPa |
| Shear strength, in-plane (1-2 direction): | $\sigma_{12}^{f}$ = 68 MPa |
| Stress coupling coefficient, 1-2 direction: | $C_{12}$ = -1.0 |

The strength values in other directions are input as large values, e.g. 10 000 MPa; stress coupling coefficients in other directions than $C_{12}$ are set equal to zero.

The panel is simply supported on all four edges and is subjected to a uniformly distributed pressure of 40 kPa.

The element type SHELL281 shall be used and the properties shall be input for each ply. The recommended element size is 25 mm or less.

The following results shall be obtained from a linear analysis:

1. Maximum deflection (displacement in *z*-direction). The result is to be compared with that obtained in Assignment no. 2.
2. Maximum Tsai-Wu-factor (inverse strength ratio). Plies no. 1, 2, 7 and 8 should be checked.

How large a pressure loading can the panel withstand if the deflection is not to exceed 6 mm (= 1% of the panel width) and, at the same time, the Tsai-Wu factor is not to exceed 0.3?

*Hint: Use linear scaling of the results from the analysis that has already been performed – it is unnecessary to repeat the analysis with different load values because the response is linear-elastic.*

## Part B

The thickness of each ply is reduced from 1.0 mm to 0.5 mm and an extra 30 mm thick layer of core material is inserted between plies 4 and 5 so as to make a sandwich panel. The core material can be considered as isotropic with the following properties:

| | |
|---|---|
| E-modulus: | $E_c$ = 300 MPa |
| Poisson's ratio: | $\nu_c$ = 0.38 |
| Shear strength: | $\tau_u$ = 4.5 MPa |
| Tension/compression strength: | $\sigma_u$ = 6.0 MPa |

The pressure loading is increased to 100 kPa.

Modify the FE model from Part A to take account of the new lay-up, and obtain the following from a linear analysis:

1. Maximum deflection (displacement in *z*-direction).
2. Maximum Tsai-Wu factor (inverse strength ratio) in the face laminates (not in the core).
3. Maximum shear stresses in the core in both *xz*- and *yz*-directions

How large a pressure loading can the panel support if the deflection is limited to 6 mm (= 1% of the panel width), the Tsai-Wu factor shall not exceed 0.3 and, at the same time, the shear stress in the core shall not exceed 40% of the shear strength? *Hint: As in Part A, use linear scaling of the results you have already derived to find the samllest value of load that satisfies all three requirements..*

## REPORT

The report shall be concise and contain:

- A brief overview of the steps in the modelling process
- Numerical results as specified above
- Any problems or uncertainties that were encountered
- A few images from the ANSYS analysis (e.g. displaced form, contours)
- Journal file from ANSYS (optional).

## SUBMISSION

The report shall be submitted in electronic form (preferably pdf format) to Brian.Hayman at dnv.com or in paper version to the undersigned at latest Friday 20 November 2009:

- electronically (preferably pdf) to Brian.Hayman at dnv.com by 09.00, or
- on paper to Brian's mailbox on the 7th floor by 09.00, or
- on paper at the lecture at 09.15.

B. Hayman
05.11.2009