Aeroelasticity Course – Exercise $n^o 5$ – Academic Year 2015–2016

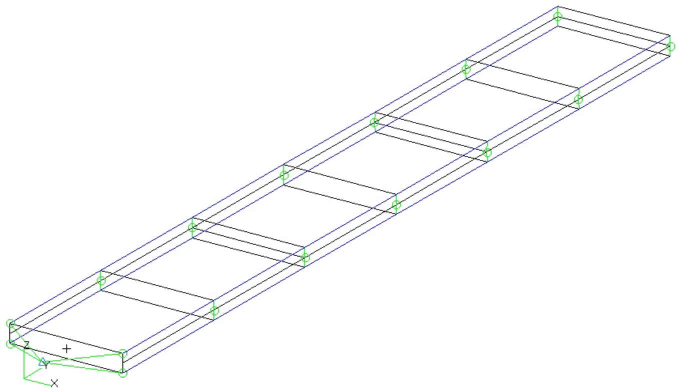

Figure 1: FEM model of a wing box.

Consider the FEM model of a wing box shown in Fig. 1. The following data are given:

$E = 68.948\, GPa$	Young modulus
$G = 27.579\, GPa$	Shear modulus
$\varrho = 2814\, Kg/m^3$	density
$\tau_s = 2.03\, mm$	spar thickness
$\tau_p = 1.02\, mm$	panel thickness
$\tau_r = 1.02\, mm$	rib thickness
$A = 1.29\ 10^{-3}\, m^2$	area of the spar caps
$h = 0.1016\, m$	wing-box height
$w = 0.635\, m$	wing-box width
$\ell = 1.524\, m$	bay length (the overall length is $1.524 \times 3 = 4.57\ m$)

Consider the .dat Nastran input file for aeroelastic stability analysis (sol 145). The reference conditions are $M_\infty = 0.5566$, $\varrho_\infty = 0.9046 Kg/m^3$, and $c_{ref} = 1.27$ ($k := \omega c_{ref}/2U_\infty$). The first six natural modes of vibration are assumed for the analysis. The aerodynamic model for the lifting surface (Doublet-Lattice method) consists of 25 panels along the chord (x-axis) and 20 panels along the span (y-axis). Note that the origin of the frame of reference is at half-chord, so that the abscissa of the leading edge of the wing-box (and of the lifting surface) is $x_{le} = -0.5715$.

Perform the stability analysis with respect to the parameter U_∞ and answer to three of the following questions:

- Identify and comment the results provided by the critical eigenvector.
- Consider the first ten natural modes. Repeat the stability analysis compare the results.
- Move the lifting surface 20 cm ahead. Repeat the stability analysis and compare the results.

- Increment the panel thickness by $0.5\,mm$. Repeat the stability analysis and compare the results.
- Introduce a concentrated mass ($100\,Kg$) to model an engine. Repeat the stability analysis and compare the results.
- Assume the aircraft in flight at $15000\,m$ ($\varrho_\infty = 0.19475 Kg/m^3$). Repeat the aeroelastic analysis and compare the results.
- Assume an incompressible flow condition ($M_\infty = 0.0001$). Repeat the aeroelastic analysis and compare the results.