Equivalent Dihedral Angle

Some multi-panel wings have *polyhedral*, which is a spanwise-varying dihedral angle $\Upsilon(y)$. In order to apply stability and control criteria to such a wing, it is necessary to determine its *Equivalent Dihedral Angle*, or EDA, in terms of $\Upsilon(y)$. This EDA then takes the place of the constant Υ which appears in stability and control criteria.

Using the convenient normalized spanwise coordinate $\eta \equiv 2y/b$, the EDA is computed as a weighted average of $\Upsilon(\eta)$. Assuming the spanwise loading is approximately elliptical, the appropriate weight function is the ellipse $(1-\eta^2)^{1/2}$ times the roll moment arm η.

$$\mathrm{EDA} \;=\; \frac{\int_0^1 \Upsilon\;(1-\eta^2)^{1/2}\,\eta\,d\eta}{\int_0^1 (1-\eta^2)^{1/2}\,\eta\,d\eta} \;=\; 3\int_0^1 \Upsilon\,\left(1-\eta^2\right)^{1/2}\eta\,d\eta \tag{1}$$

This is still gives good results for more general wings with non-elliptical loading. It's useful to note that $\mathrm{EDA} = \Upsilon$ for the case of a simple V-dihedral wing with constant $\Upsilon(\eta)$.

By introducing the cubed-ellipse function

$$f \;=\; \left(1-\eta^2\right)^{3/2} \tag{2}$$

$$df \;=\; -3\left(1-\eta^2\right)^{1/2}\eta\,d\eta \tag{3}$$

equation (1) can be rewritten as follows.

$$\mathrm{EDA} \;=\; \int_1^0 \Upsilon\,df \tag{4}$$

For the usual case where the wing consists of flat panels, Υ is piecewise constant, with values Υ_1, $\Upsilon_2 \ldots$ in between the dihedral-break stations η_0, η_1, $\eta_2 \ldots$ The integral (4) can then be written as a sum over the individual panels. The 2-panel case is shown in Figure 1.

$$\mathrm{EDA} \;=\; \Upsilon_1\,(f_0-f_1) \;+\; \Upsilon_2\,(f_1-f_2) \;+\; \ldots \tag{5}$$

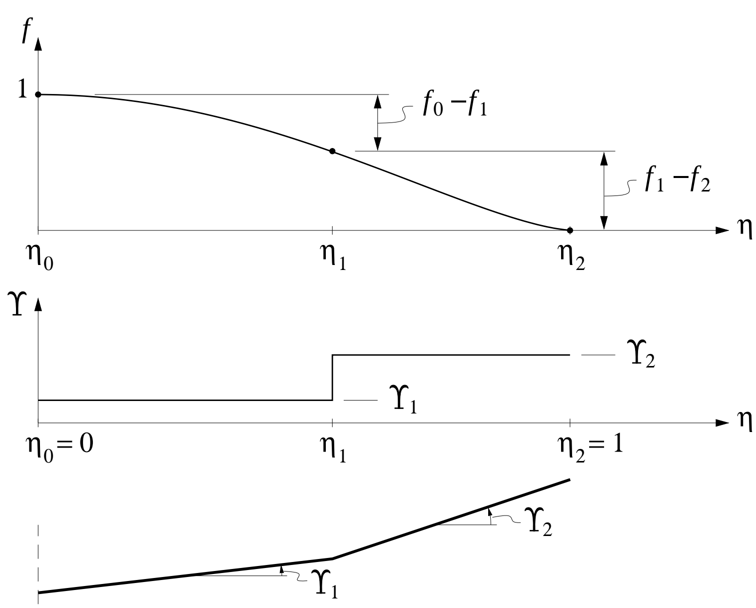

Figure 1: Quantities used for calculating the EDA of a 2-panel polyhedral wing.