Project 5 – Wing Loads

Updated March 27, 2014

5.1 Context and objectives

The objective of this project is to study structural constraints within the wing of an airliner designed according to simple aerodynamic and geometrical requirements.

You are working for an aircraft manufacturer which is developing a wide-body aircraft that is to be powered by two engines. Without diving into a full-depth structural analysis, you are asked to quantify efforts in the structure of the four-engined aircraft wing.

Based on calculations as well as your best judgment,

- Sketch plan views of a wing box design that meets the manufacturer's requirements;
- Plot the load distribution along the wing box;
- Estimate the magnitude and position within the wing box of the maximum shear force and maximum roll bending moment that the aircraft is likely to encounter over its service life.

Your mark will be based on the appropriateness of your design, the clarity of your work, and the validity of your calculations. You may use any tool you wish (e.g. software, books), but you are required to quote all of your sources.

Groups handing in written reports must hand in one single printed or PDF (A4-size) document, no longer than 8 pages.

Groups making an oral presentation must aim for less than 15 minutes (all members participating), and then answer questions from the class. Please hand in your slides as a print-out or PDF file.

5.2 Main requirements

The geometrical constraints are as follows:

- The cabin should provide space for 9-abreast seating;
- The aircraft overall span shall not exceed 65 m;
- The aircraft must be able to land with a 5° roll angle without engines striking the runway;
- The fuel must be stored in the wing box structure (this may include the section crossing the fuselage).

Each wing must accommodate one Rolls-Royce Trent 800 turbofan (max. nacelle diameter: 3,2 m; weight: 6,5 t).

5.3 Aerodynamics-related constraints

The aerodynamics team within your company has already selected the following parameters:

- Quarter-chord sweep 38°; Dihedral 3°
- Taper ratio: 0,45
- Proposed box dimensions at wing root: 6 × 1,5 m;
- The lift distribution is observed to be elliptical to a good approximation.

Atmosphere and cruise conditions do not matter in this project, but for convenience of calculations you may use $\rho = 1\,\mathrm{kg\,m^{-3}}$ and $V = 200\,\mathrm{m\,s^{-1}}$ as placeholder values.

5.4 Structural constraints

In this project, we will consider that the wing is perfectly rigid and that the loads are uniformly distributed accross the wing box section.

Preliminary estimates for the aircraft component weights yield:

- Fuselage, tail and all systems, in flight at MTOW: 70 t
- Weight of one wing, empty, including all high-lift-coefficient devices: 20 t