CHAPTER 2 GUIDE

Abstract

The objective of this chapter is to offer the main theoretical background about thin-walled beams subjected to different internal forces: bending moments, shear forces and torsional moments. The student will also be provided by tools to apply the theoretical concepts to the solutions of different problems related to structural components of aircrafts subjected to different loads.

1. Introduction

In Chapter 1 we briefly presented several types of structural components found in aerospace construction and the various loads they are subjected to. The basic structure of an aircraft could be idealized as an assembly of stiffened shell structures subjected to axial and shear loads, and bending and torsional moments.
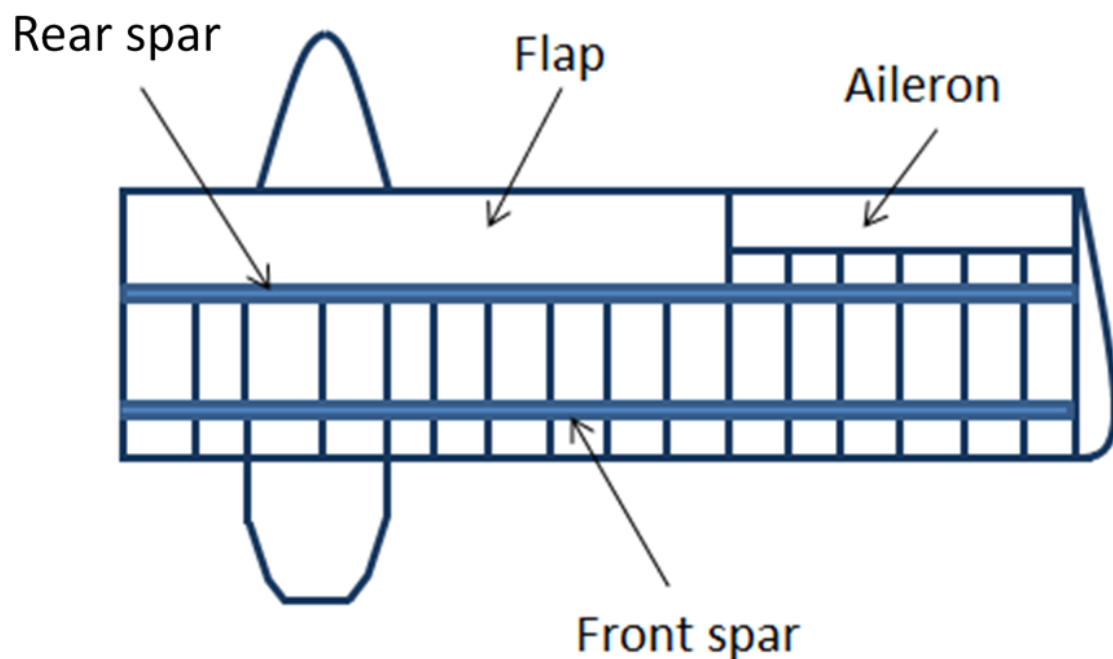

Thin-walled beams

Typical fuselage skin-stringer panels

Authors: Enrique Barbero Pozuelo, Carlos Santiuste Romero, José Fernández Sáez,

Structural members such as those shown in the figure above could be modeled as thin-walled beams (with an open or closed section), which are subjected basically to axial, bending, and shear loads.

On the other hand, other structural aircraft components such as a wing torsion box (both single-cell or multiple-cell) could be idealized as thin-walled beams subjected to torsional loads (see next figure)

In this chapter we investigate the stresses in thin-walled beams with both open and closed-section beams caused by bending, shear, and torsional loads.

2. Theoretical contents

The theory of thin-walled beams subjected to bending moments, shear forces and torques is divided in three documents.

2.1. Thin walled beams under bending moments and shear forces. This document includes the explanation of the next concepts:
- Kinematics of thin-walled beams
- Normal stresses produced by axial forces
- Normal stresses produced by bending moments
- Shear stress field on open section produce by shear forces
- Shear stress field on single-cell closed section produced by shear forces

2.2. Thin walled beams under torsional moments. This document includes the explanation of the next concepts:
- Shear stress field on open section produced by torsional moments
- Shear stress field on single-cell closed section produced by torsional moments
- Shear stress field on multiple cells section produced by torsional moments

2.3. Shear center. This document includes the explanation of the next concepts:
- Concept of shear center
- Classical method to calculate the position of the shear center
- Alternative method to calculate the position of the shear center
- Stress field on multiple cells sections
- Stress field on combined open and closed sections

All these documents are organized following the next structure:
- Specific objectives of the document
- Index
- Contents
- Summary
- References

Authors: Enrique Barbero Pozuelo, Carlos Santiuste Romero, José Fernández Sáez,

3. Exercises

To assimilate the concepts explained in this chapter the student have to study the documents, but this is not enough. A deep understanding of the main concepts is acquired only after the application of the theoretical explanation to the solution of different problems.

Chapter 2 includes eight problems that cover the main concepts of bending, shear and torsion on thin-walled beams:

- Exercises 2.1, 2.2 and 2.4 cover the concepts explained in document 2.1: thin-walled beams subjected to bending moments and shear forces applied at the shear center.

- Exercises 2.6 and 2.7 cover the concepts explained in document 2.2: thin-walled beams subjected to torsional loads.

- Exercises 2.3, 2.5, and 2.8 cover the concepts explained in document 2.3: thin-walled beams subjected to shear forces applied at a distance to shear center.

4. Auto-evaluation exercise

Finally, chapter 2 includes an auto-evaluation exercise. The students must use this exercise to check if they have a deep understanding of the main concepts of this chapter. This exercise includes different questions that cover all the theory explained in chapter 2.

5. Suggested readings

o   H.G. Megson. Aircraft Structures for engineering students. Elsevier. 2007

   Chapter 16: Bending of open and closed, thin-walled beams sections

   Chapter 17: Shear of beams

   Chapter 18: Torsion of beams

o   Benham, P.P. Y Crawford. "Mechanics of engineering materials". Logman Scientific & Technical, 1987

   Chapter 5: Torsion

Authors: Enrique Barbero Pozuelo, Carlos Santiuste Romero, José Fernández Sáez,

Chapter 6: Bending: Stress

o   Gere, J.M. "Resistencia de Materiales". Thomson. 2002

Cap.1 Tracción, compresión y cortante

Cap.4 Esfuerzos cortantes y momentos flexionantes

Cap.5 Tensiones en vigas (temas básicos)

Cap.6 Tensiones en vigas (temas avanzados)

o   Cervera Ruiz, M. y Blanco Diaz, E. "Resistencia de Materiales". Ed. UPC, 2001

Cap.7 Momento torsor

o   Garrido García, J.A. Y Foces Mediavilla, A. "Resistencia de Materiales". Universidad de Valladolid, 1994

Cap.6 Torsión uniforme en barras de sección de pared delgada

o   Ortiz Berrocal, L "Elasticidad". Ed. McGraw Hill, 1998

Cap.7 Torsión

o   Samartin Quiroga, A. "Elasticidad". Ed. Bellisco. 1990

Cap.7 Estudio de la torsión

Authors: Enrique Barbero Pozuelo, Carlos Santiuste Romero, José Fernández Sáez,