Introduction to Aerospace Engineering

Lecture slides
Aircraft & spacecraft loads
Static & Dynamic
Faculty of Aerospace Engineering
29-11-2011
Learning objectives

Student should be able to...

• Describe the most relevant loads for
  • An aircraft
  • A spacecraft

• Explain whether these loads are
  • Static or dynamic
  • Concentrated or distributed
Identify relevant loads

Aircraft structure

- The airframe is externally loaded
Identify relevant loads

Aircraft structure

- The airframe is externally loaded
Identify relevant loads

Aircraft structure

- The airframe is externally loaded
  - Maneuvers
  - Gust
  - Cabin pressure
  - Landing
  - etc.

by concentrated or distributed forces
Load paths

Simple structure

- What is a load path?
  - Path to link applied load to equilibrium forces
Load paths

Buttress structure
Load paths

Simple structure

• Bending of beam
Load paths

Simple structure

- Bending of beam

Load path
- Upper girder: tension
- Lower girder: compression
- Web plate: shear
Load paths

Simple structure

• Bending of beam

• Load path
  • Upper girder: tension
  • Lower girder: compression
  • Web plate: shear
Identify relevant loads

Airframe

- Bending
  - Wing bending (upward)
  - Fuselage bending (downward)
Load paths

Airframe

- Landing and taxiing
  - ‘concentrated forces’ acting on undercarriage
Load paths

Airframe

- Vertical tail load
  - Bending of vertical tail
Load paths

Airframe

- Vertical tail load
  - Bending of vertical tail
  - Bending & rotation of fuselage
Load paths

Airframe

- Vertical tail load
  - Bending of vertical tail
  - Bending & rotation of fuselage
  - Shear of fuselage side panels
Load paths

Airframe

- Wing load $\Rightarrow$ deformation
  - Upward bending of wing
  - Rotation of wing

- Deformation $\Rightarrow$ stresses
  - Compression and shear in upper wing skin panel
  - Tension and shear in lower wing skin panel
Load paths

Airframe

- Bending and torsion

- Measure against torsion?
Load introduction

Wing/fuselage connection

- Example
  - A400M
Load introduction

Wing/fuselage connection

- Example
  - A400M
Load introduction

Wing/fuselage connection

- Example
  - A400M

Wing/fuselage connection F-27
See question 14 related to the study collection
Design load cases

Aircraft fuselage structure

- Different locations ⇒ different loads & criteria!
Design load cases

Aircraft structure

- Dynamic loads (example of flutter)
  - Oscillation of aircraft component caused by the interaction of aerodynamic forces, structural elastic reactions, and inertia
Identify relevant loads

**Spacecraft structure**

- Gravity
  - Handling and transportation loads
- Vibration and acoustic test loads
- Launch loads (static & dynamic)
  - Quasi-static
  - Sine vibration
  - Acoustic noise and random vibration
  - Shock loads
- In-orbit loads
  - Shocks
  - Structurally transmitted loads
  - Internal pressure
  - Thermal stress
Identify relevant loads

Spacecraft structure

- Steady state load
  - Axial: launch vehicle engine trust
  - Lateral: wind gust & vehicle maneuvers
Identify relevant loads

**Spacecraft structure**

- **Load path**
  - Primary axis \( \perp \) direction of maximum acceleration
  
- Primary axis \( \parallel \) direction of maximum acceleration
Summary

Aircraft & spacecraft loads

- Identify relevant loads
  - Static or dynamic
  - Concentrated or distributed

- Load paths
  - Load introduction
  - Equilibrium