INTRODUCTION TO AIRCRAFT STRUCTURES

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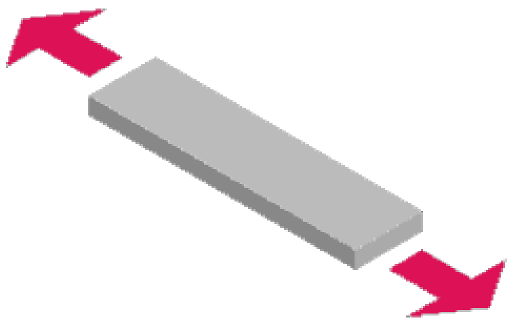
INTRODUCTION TO AIRCRAFT STRUCTURES : TYPES OF LOADING

Or ‘What type of structural elements can we consider in an airframe’

Types of Loading

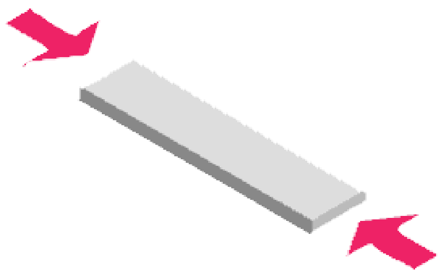


- **TENSION**

- A simple solid tie bar is a very efficient means of transmitting tensile loads. Cables are also very effective, and have the advantage that fracture of one strand does not cause complete failure of the whole cable.

- The main issues in structures loaded in tension are fracture and fatigue. Some high strength materials are very brittle, which makes them undesirable for tension members because of the risk of sudden catastrophic failure.

Types of Loading



- **COMPRESSION**

- Stiffness is critical in compression members because of the risk of buckling. This depends on the material stiffness (Young’s Modulus) and the structural stiffness related to shape (second moment of area).

- The ideal member is a thin walled tube because it maximises the second moment of area for a given amount of material. However, if the ratio of radius to wall thickness is too large there is a risk of local wall buckling.

- Fatigue is of much less concern because cracks do not usually propagate under compression.

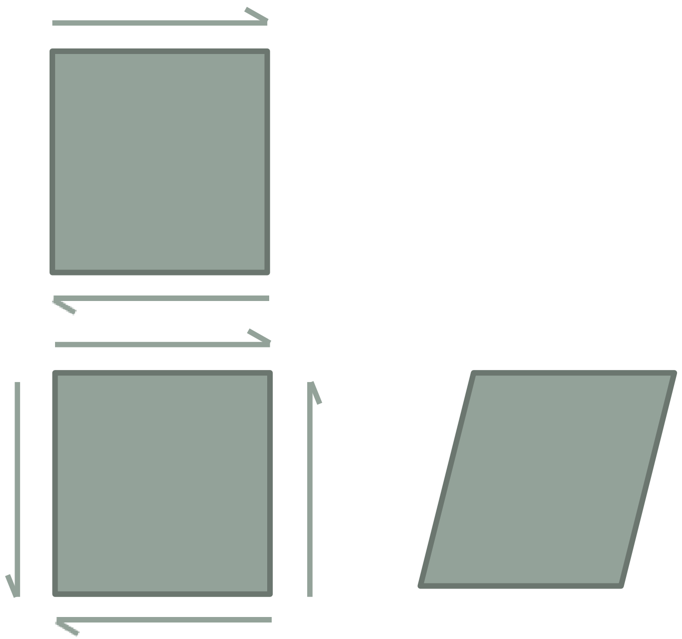
Types of Loading

- **SHEAR**

- Shear involves a change in angle or shape. Complementary shear forces are required to produce pure shear.

- Simple shear causes bending – not pure shear

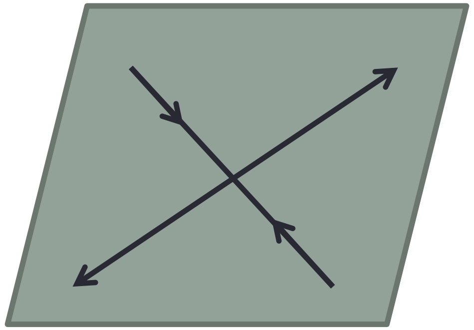
- Pure shear from complementary shear
- forces causes a change in angle



Types of Loading

- **SHEAR**

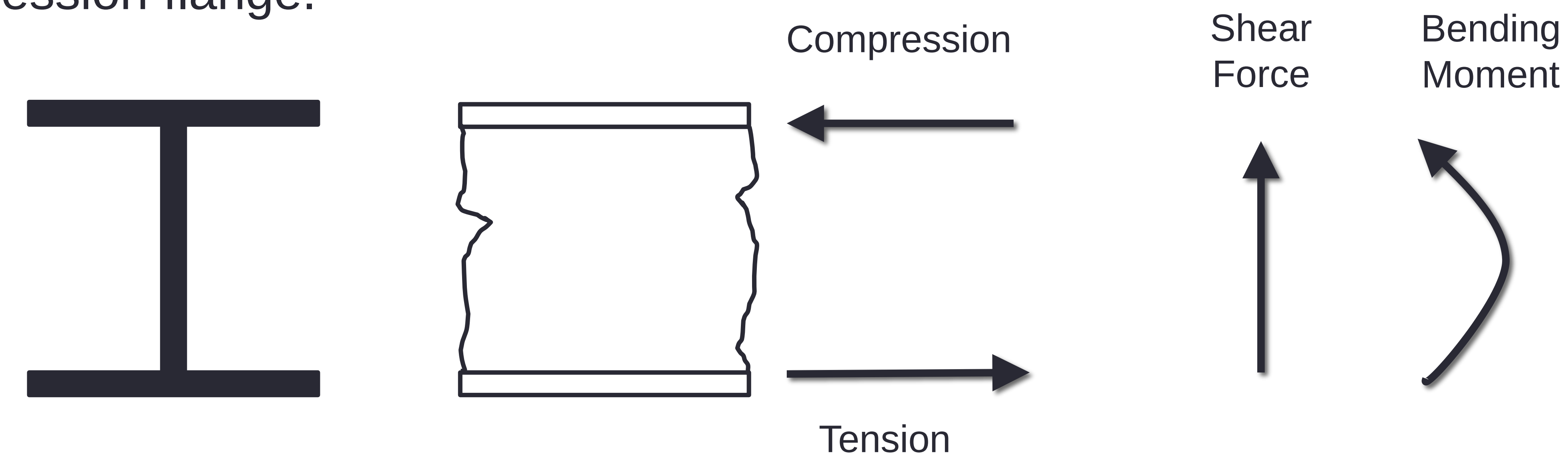
- Shear can be carried by tensile and compressive members at 45 degrees. Panels are also good at carrying shear by resisting shape change.



Types of Loading

- **BENDING**

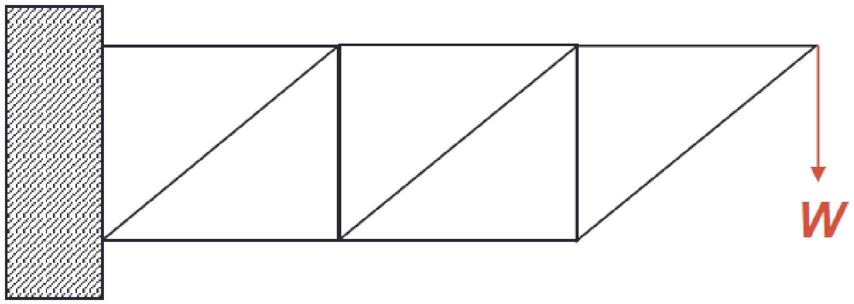
- In principal pure bending can be carried by tensile and compressive members separated in space. An I-beam approximates this, and is efficient for resisting bending. The web separates the flanges, and helps prevent buckling of the compression flange.

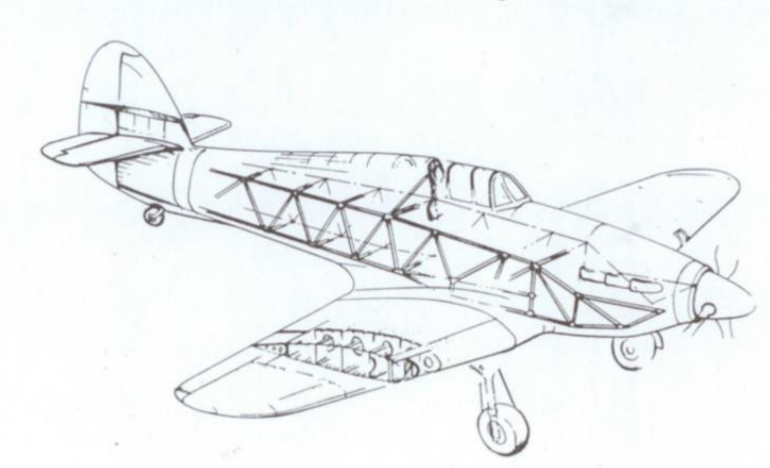


Types of Loading

- **BENDING WITH SHEAR**

- The web of an I-beam carries the shear that is not present in pure bending. A Warren truss is an efficient arrangement for carrying bending with shear, as in the Hurricane fuselage. Compression members need to be larger section than tension members to resist buckling. Ties can carry tension loads. But if the direction of loading reverses, all members need to be able to resist both tension and compression.

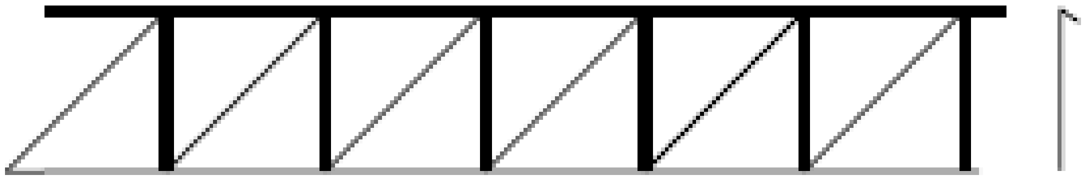




Types of Loading

- **BENDING WITH SHEAR**

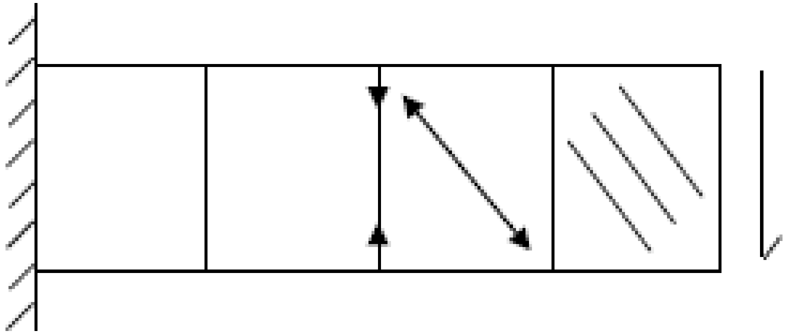
- A truss with vertical compression members can be very efficient since the compressive force for a given overall shear force is lower, and the members are shorter.



Types of Loading

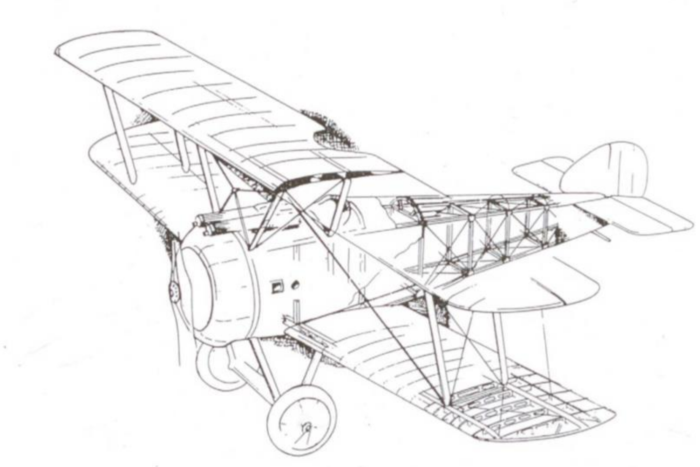
- **BENDING WITH SHEAR**

- Diagonal cross-bracing can be used if both directions of loading need to be considered – two ties which only have to carry tension may be lighter than a single compression member. Alternatively a panel can carry the shear in combination with the top and bottom chord members to carry the bending loads.



Types of Loading

- **TORSION**
- Torsion is a twisting moment acting about the axis of the structure. It is most effectively carried by shear forces around a closed structure. A box or tube with a continuous skin is very efficient. Alternatively the shear can be carried by cross-braced members as in the Sopwith Camel fuselage.



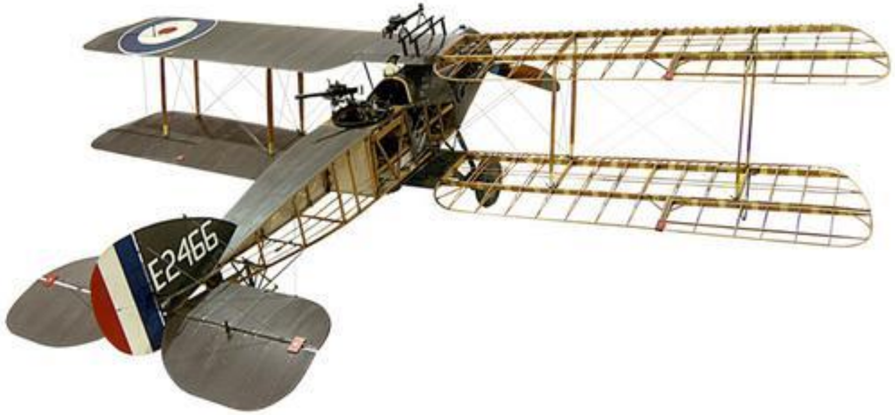
Types of Loading

INTRODUCTION TO AIRCRAFT STRUCTURES : TYPES OF AIRFRAME CONSTRUCTION

Or ‘Okay – so what does an airframe look like then ?’

TYPES OF AIRFRAME CONSTRUCTION

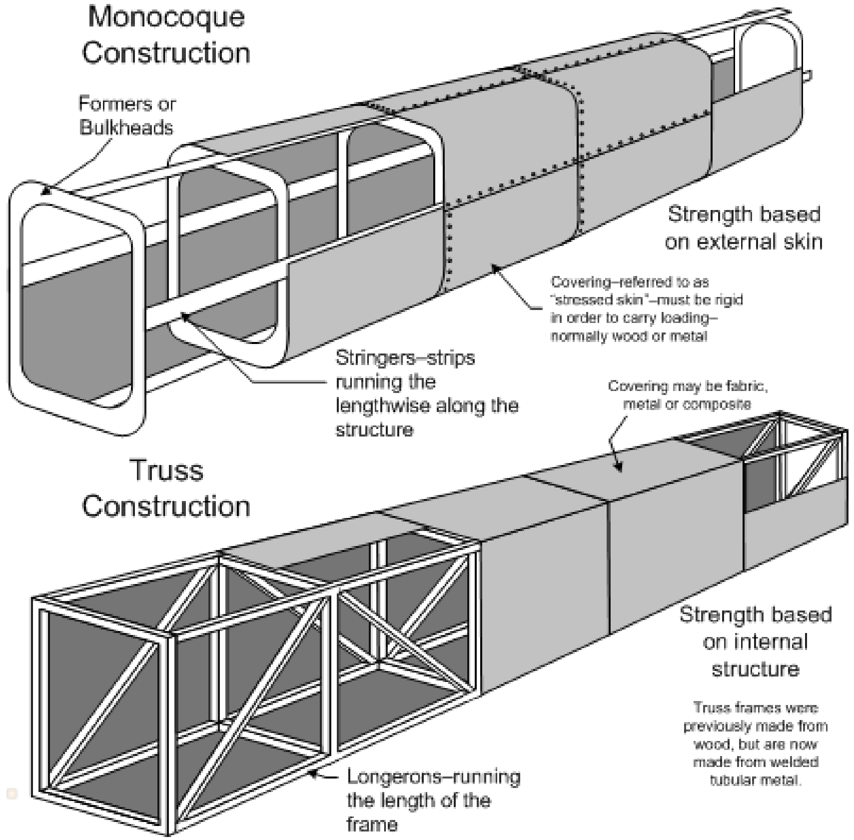
- **1. Frame with Non-Structural Covering**



- All loads carried by frame structure.
- Skin assumed not to carry any load except air pressure
- Could be used for very early aircraft where aerodynamic loads were low

TYPES OF AIRFRAME CONSTRUCTION

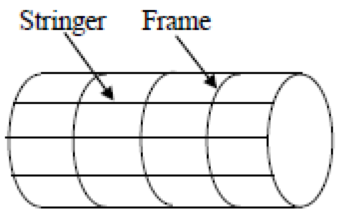
- **2. Monocoque**

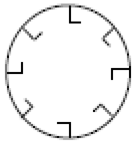


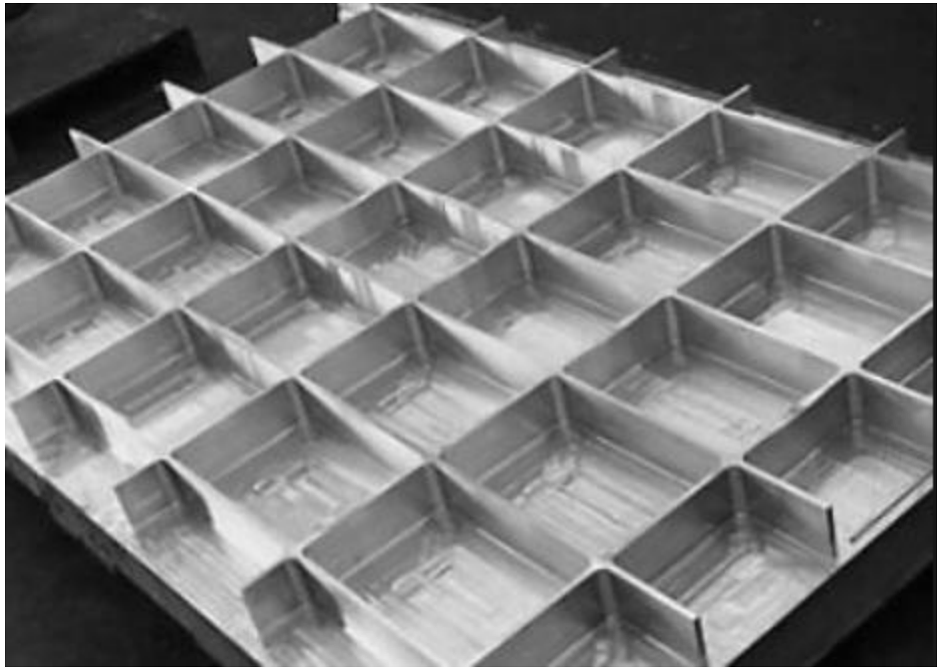
- Single skin with no supporting frame
- All loads have to be carried by skin
- True monocoque problematic for large size due to buckling
- Sandwich structures can be used without supporting members

TYPES OF AIRFRAME CONSTRUCTION

- **3. Stressed Skin**



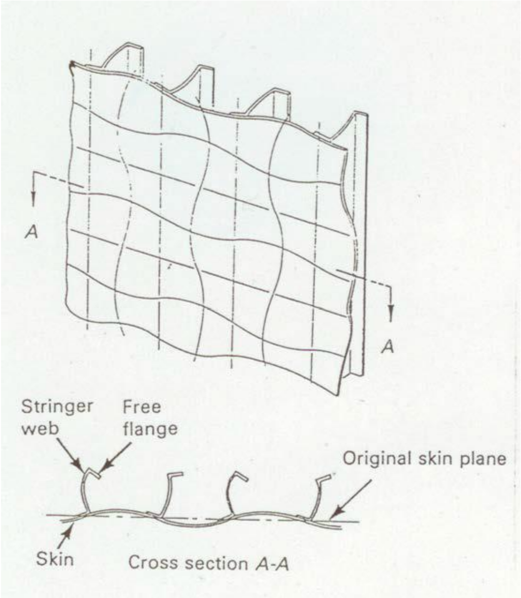


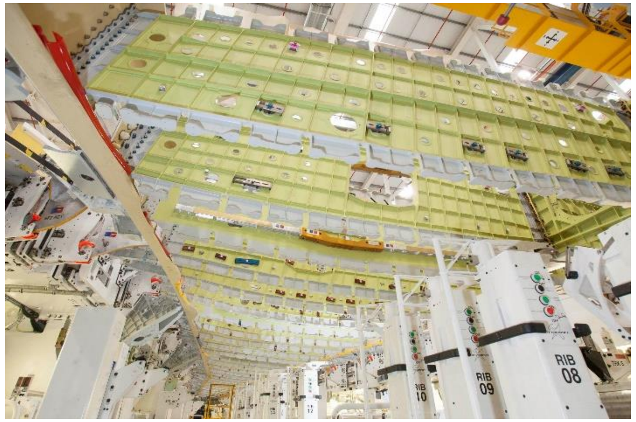


- Frame
- Stringer
- Load is divided between skin and stringers
- Stringers and frames (or ribs) divide skin into small panels to provide resistance to buckling.

TYPES OF AIRFRAME CONSTRUCTION

- **Shear Resistant Structures**

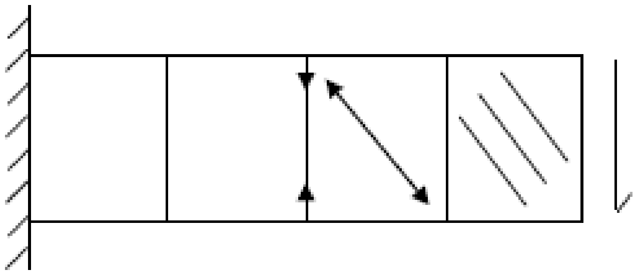


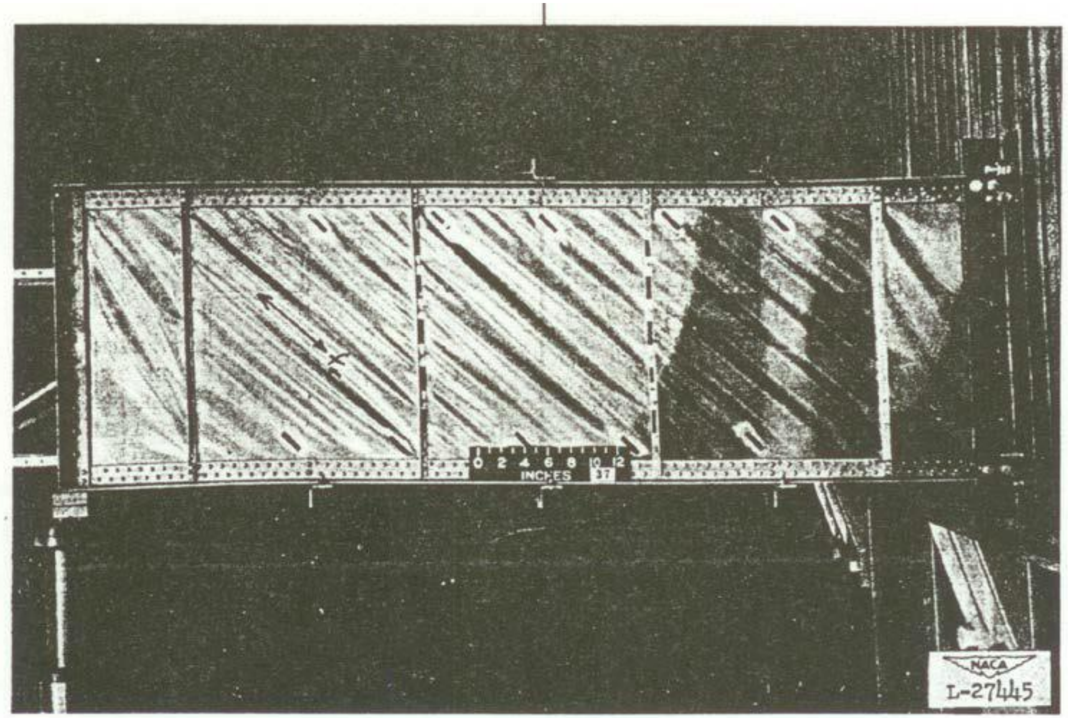


- Panels carry shear without buckling
- Stiffeners divide panels up to prevent buckling
- Can be a heavy design in some cases

TYPES OF AIRFRAME CONSTRUCTION

- **Tension Field Structures**





- Panels buckle – carry diagonal tension only – the ‘Diagonal Tension Field’
- Stiffeners carry compressive loads
- Generally more efficient for thin skin structures

INTRODUCTION TO AIRCRAFT STRUCTURES : FUNCTIONS OF STRUCTURAL MEMBERS IN STRESSED SKIN CONSTRUCTION

Or ‘What the major parts do in a typical modern airframe structure’

Functions of Structural Members in Stressed Skin Construction

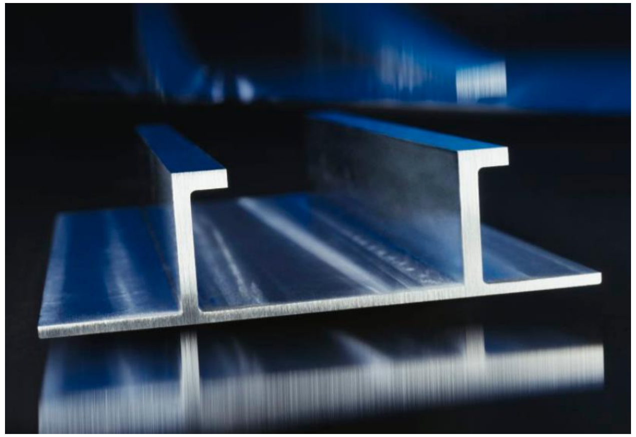
- **SKIN**

- To carry tensile loads
- To carry compressive loads - Effectiveness depends on degree of stiffening

- To carry shear loads
  - Shear associated with bending
  - Torsion

- To provide a smooth aerodynamic surface
- To provide sealed enclosure

Functions of Structural Members in Stressed Skin Construction



- **STRINGERS**
- To carry tensile and compressive loads
- To add stiffness to the skin to enable it to resist buckling and carry higher compressive stresses
- To provide bending stiffness to resist distortion of skin due to local loads
- To divide up the skin into small panels to reduce buckling due to shear and / or compression

Functions of Structural Members in Stressed Skin Construction

- **FRAMES and RIBS**

- Frames are normally associated with Fuselage Structure
- Ribs are normally associated with Wing or Box structure

- To support stringers against compressive buckling
- To divide skin into panels to reduce shear buckling
- To distribute discrete loads into rest of structure
- To maintain cross-sectional shape