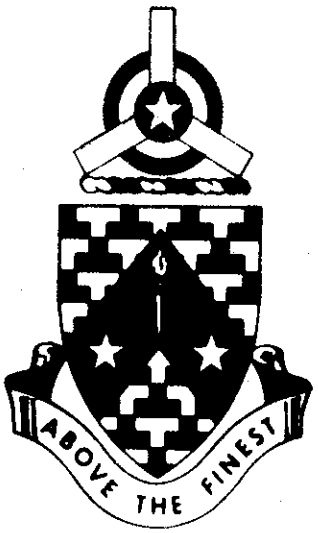
PROGRAMED TEXT

AIRCRAFT STRUCTURES

AM-5



NOVEMBER 1968

UNITED STATES ARMY

PRIMARY HELICOPTER SCHOOL

FORT WOLTERS, TEXAS

PROGRAMED TEXT

PROGRAM TEXT

FILE NO: AM-5

PROGRAM TITLE Aircraft Structures

POI SCOPE: Discussion of the forces acting on aircraft structures; basic definitions to help understand the construction of aircraft and materials used.

INSTRUCTOR REFERENCES:

TM 55-403, Chapters 2 and 6

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DATE: November 1968

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Aircraft Structures

PREFACE

An Army Aviator must have a basic knowledge of the aircraft he flies. An understanding of the types of aircraft construction, the materials used, and the stresses that act on your aircraft will enable you to make sound decisions as to the serviceability of an aircraft.

This program text is designed to acquaint you with the two basic types of construction and the most common materials used in Army Aircraft. It also covers the nomenclature and construction of main rotor blades and the five stresses that act on an aircraft.

Read each frame carefully, then select the correct answer or answers to each question. The correct response will be shown at the top of the next page.

PERFORMANCE OBJECTIVES

Given diagrams of various types of airframe and rotor blade construction, the student will:

1. Label the diagram as to type of construction and proper nomenclature of components.

2. Identify, without error, from drawings or written descriptions, the five stresses that act on an aircraft.

3. Identify the most common materials used in aircraft construction.

FRAME 1

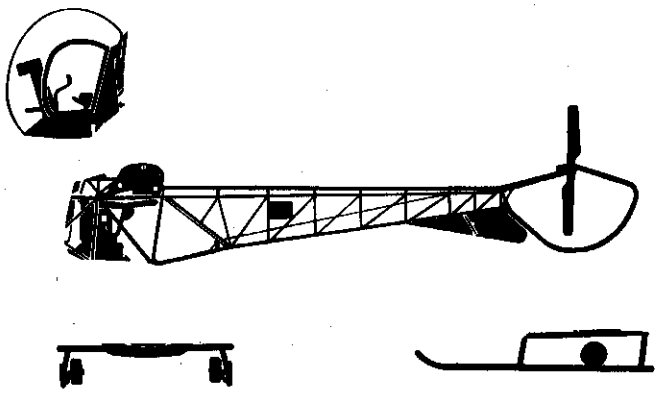
The parts of an aircraft that are designed to carry a load and that make up the structure of the aircraft are called structural members. The aircraft skin, stringers, ribs, and formers are examples of structural members.

Structural members can be grouped into assemblies or structural units. The major structural units of a typical single engine helicopter are:

the cabin

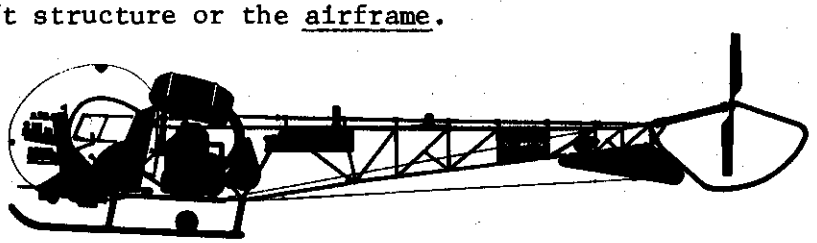
the tail group

the landing gear



When these structural units are assembled, the combined whole is called the aircraft structure or the airframe.

Airframe



1. Which of the following is a structural member?

   a. The cabin
   b. A radio antenna
   c. An engine mount

2. Which of the following is a structural unit?

   a. The skin
   b. The landing gear
   c. The engine
   d. The airframe

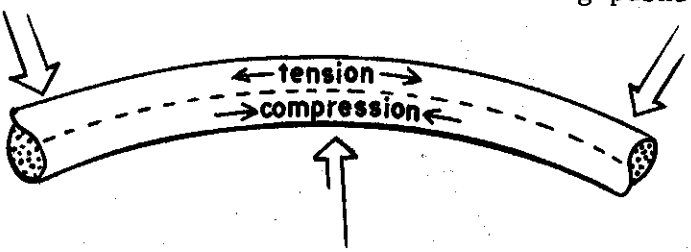
TURN TO PAGE 3 FOR FRAME #2.

ANSWERS: 1. b
2. d

FRAME 7

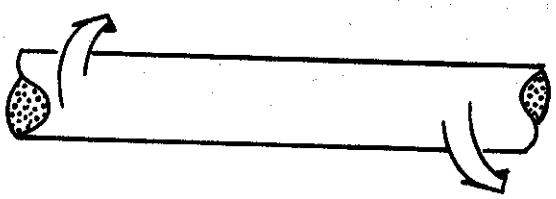
BENDING

Bending stress is a combination of tension and compression acting on the same member. When a steel rod is bent, one side of the rod is pulled apart while the other side is being pushed together.



TORSION

Torsion stress is the internal resistance of a structural member to a force tending to twist the member. As an example, an aircraft engine exerts a torsional force on the main rotor mast to turn the main rotor.



TURN TO PAGE 4

ANSWERS: 1. c. An engine mount
2. b. The landing gear

FRAME 2

Aluminum, magnesium, and steel are the three most common materials used in the construction of Army helicopters.

Aluminum alloys are used extensively because they are about one third as heavy as steel although nearly equal in strength.

Magnesium is an even lighter material although not as strong.

Despite its heavy weight, steel is used for many parts due to its high strength, its ability to resist high temperatures, its ability to resist corrision, and because it is more easily welded than most metals.

Write the name of the material that best fits the stated requirement in each blank space.

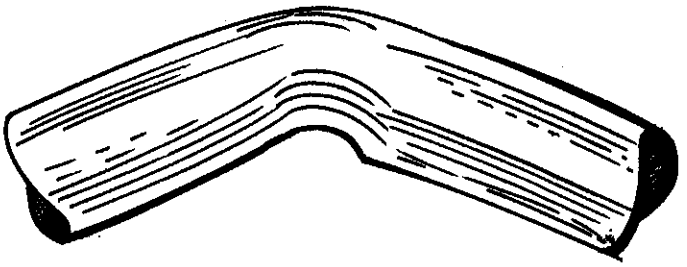
1. Very light weight required, low strength acceptable. magnesium
2. Member subject to very high temperature. steel
3. High strength and low weight required. aluminum alloy
4. High strength and corrosion resistance required. ~~aluminum alloy~~ steel

TURN TO PAGE 5 FOR FRAME #3

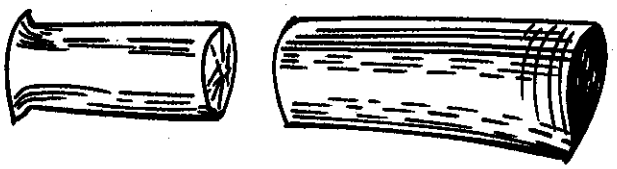
1. In the illustrations below, which member has failed as the result of a bending stress? a

2. Which member failed due to torsional stress? c

a.



b.



c.

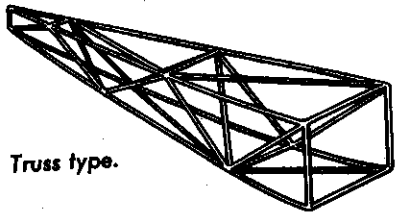
d.

ANSWERS: 1. Magnesium
2. Steel
3. Aluminum
4. Steel

FRAME 3

The two basic types of airframe construction are truss and monocoque.

Truss construction is used where relatively large openings must be in the skin (such as around doors) or when a skin covering is not necessary or desirable.

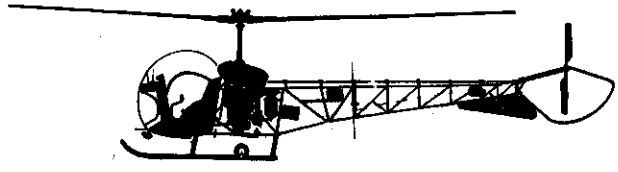


Truss type.

The major advantage of the truss is that its members can more readily withstand the stresses of tension and compression. In other words, the members carry only end loads which tend to pull apart or push together.

The tail boom of the OH-13 helicopter is an example of what type of construction?

1. Monocoque construction
2. Bridge beam construction
3. Truss construction
4. Box beam construction

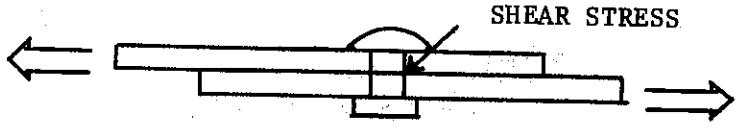


ANSWERS: 1. a
2. c

FRAME 8

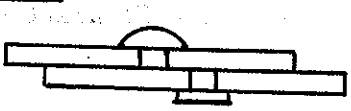
SHEAR

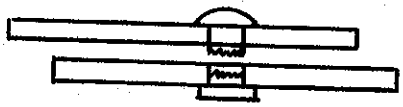
Shear stress is the internal resistance of a structural member to forces similar to those applied when using heavy scissors or shears. When two flat pieces of metal, bolted or riveted together, are pulled apart or pushed together by sliding one over the other the bolts or rivets are subjected to a shearing force.

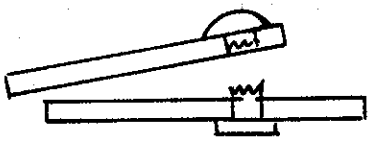


The bolts or rivets which fasten the skin of an aircraft to the other structural members are constantly subjected to shear force.

In the illustrations below, which rivets have failed as the result of shear?

a.


b.


c.


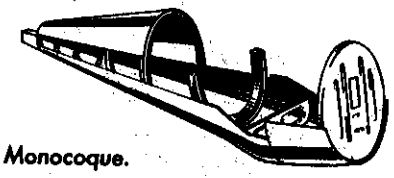
d.


ANSWER: 3. Truss construction

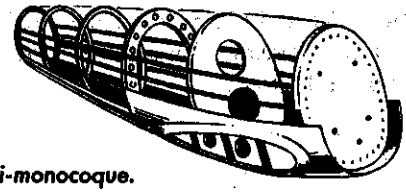
FRAME 4

MONOCOQUE CONSTRUCTION

The true monocoque or "single shell" is seldom used today, but a modification of this type, called the semi-monocoque, is used in the construction of most military aircraft.



Monocoque.

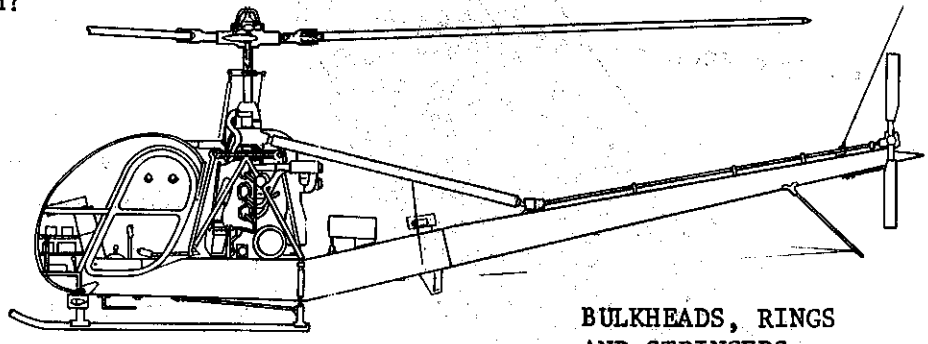


Semi-monocoque.

In semi-monocoque construction bulkheads and rings are used to reinforce the assembly and to give the skin form and shape. In addition, long metal strips called stringers, which run the length of the assembly, are fastened to the rings and bulkheads.

The major advantage of this type of construction is that it does not depend on a few members for strength and rigidity. Because of its stressed skin construction, it may withstand a considerable amount of battle damage and still hold together untill repairs can be made.

The tail boom of the OH-23 helicopter is an example of what type construction?



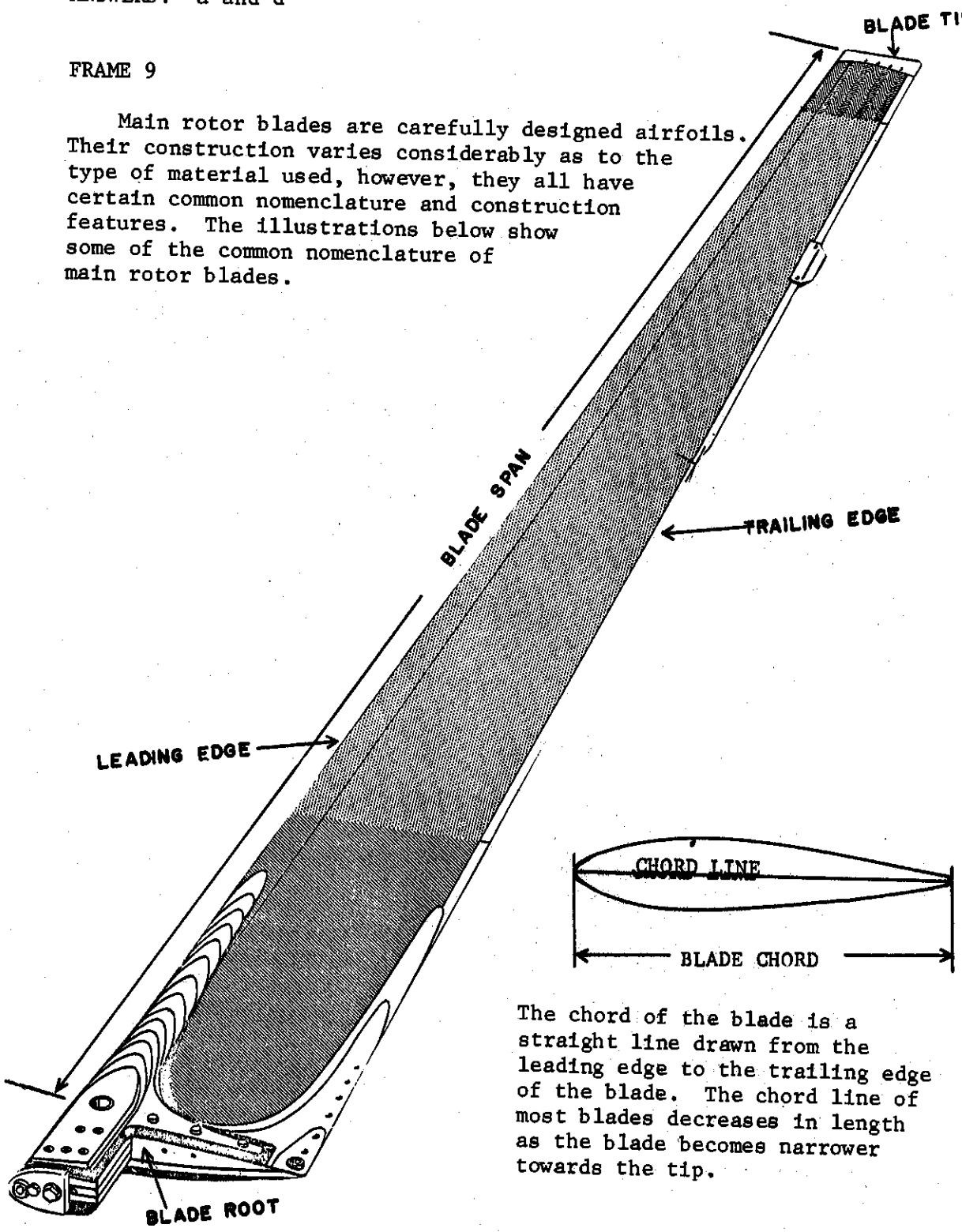
BULKHEADS, RINGS AND STRINGERS

1. Monocoque construction
2. Truss construction
3. Tube frame construction
4. Semi-monocoque construction

ANSWERS: a and d

FRAME 9

Main rotor blades are carefully designed airfoils. Their construction varies considerably as to the type of material used, however, they all have certain common nomenclature and construction features. The illustrations below show some of the common nomenclature of main rotor blades.



The chord of the blade is a straight line drawn from the leading edge to the trailing edge of the blade. The chord line of most blades decreases in length as the blade becomes narrower towards the tip.

ANSWER: 4. semi-monocoque

FRAME 5

Forces acting on an aircraft, while it is on the ground or in flight cause pulling, pushing, or twisting within the various members of the aircraft structure. These forces are passed on from member to member causing bending, twisting, pulling, compressing, and shearing stresses. These stresses are, in reality, an internal resistance to the externally applied force. These five stresses rarely act singly, but in combinations of two or more. Often all five types of stresses will act on the aircraft structure at the same time.

When applied forces cause stresses in a structural member, the resultant distortion of the member is called strain. Forces, stresses and strain beyond the design limits of a structural member will result in a permanent distortion or failure of the member.

1. More than one type of stress may act on a single member of an aircraft at any one time.

   (a) True

   b. False

2. Stresses applied to an aircraft member will inevitably result in failure of the member unless the cause of the stress is eliminated.

   a. True

   (b). False

3. Stress is defined as a force applied to a structural member.

   a. True

   (b). False

FRAME 9 (Continued)

1. The length of a main rotor blade is referred to as the

   a. root length.
   b. blade chord.
   c. blade span.
   d. tip distance.

2. The width of a main rotor blade is referred to as the

   a. root length.
   b. blade chord.
   c. blade span.
   d. tip distance.

3. The chord line of a main rotor blade usually decreases in length as the blade becomes wider towards the tip.

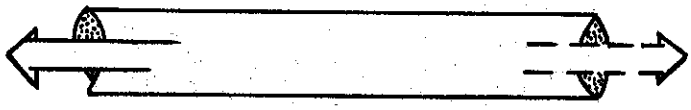
   a. True
   b. False

ANSWERS: 1. True
2. False
3. False

FRAME 6

TENSION

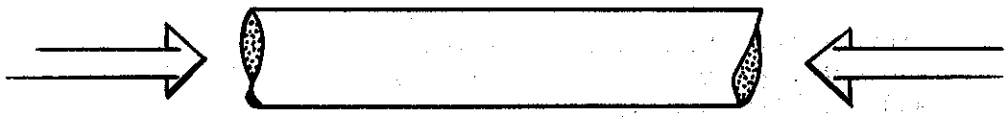
Tension stress is the resistance to stretching or pulling apart of a structural member.



In a helicopter, the control cables are subjected to tension stress when the pedals are moved.

COMPRESSION

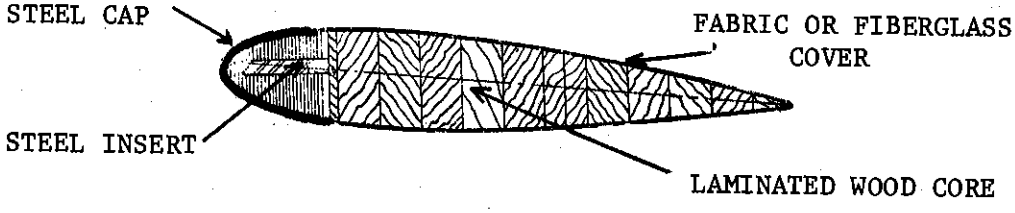
Compression stress is the internal resistance of a structural member to a crushing force. This force works directly opposite to tension.



ANSWERS: 1. c. blade span
2. b. blade chord
3. b. (False)

FRAME 10

Today most main rotor blades are of metal construction although some wood blades are still in use on Army helicopters. Wood blades are commonly made up of four or five different woods laminated together and may be either solid blades or have holes or pockets left in the blade for lightness.



Wooden blades are commonly covered with a steel cap over the leading edge to protect it. The remainder of the blade is covered with fabric, or fiberglass, to waterproof the blade and prevent warping and separation of the wooden core due to moisture. In some blades a steel insert is built into the wood core near the leading edge for **mass balance.**

1. The purpose of the steel cap on a wood blade is to:

   a. protect the blade from moisture.
   b. protect the leading edge from damage.
   c. add strength and rigidity to the blade.
   d. provide a smoother airfoil.

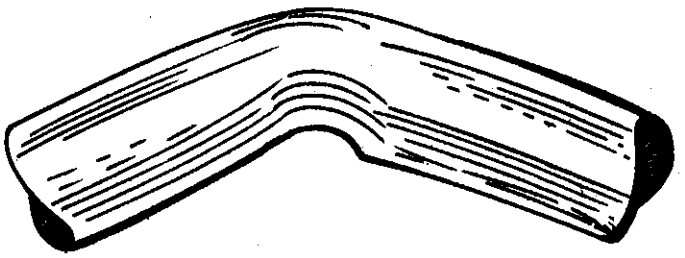
2. Wooden main rotor blades are:

   a. used on all Army helicopters.
   b. considered to be superior to metal blades.
   c. used only in case of emergency.
   d. made up of several different kinds of wood.

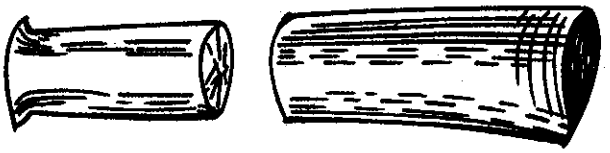
1. In the illustrations below, which member has failed as the result of a tension stress? b

2. Which failure is due to compression? d

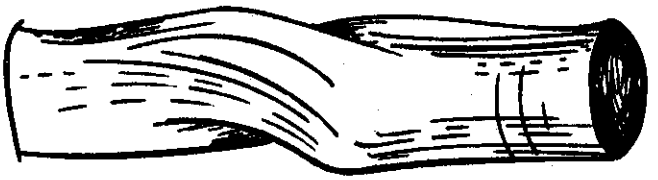
a.



b.



c.



d.

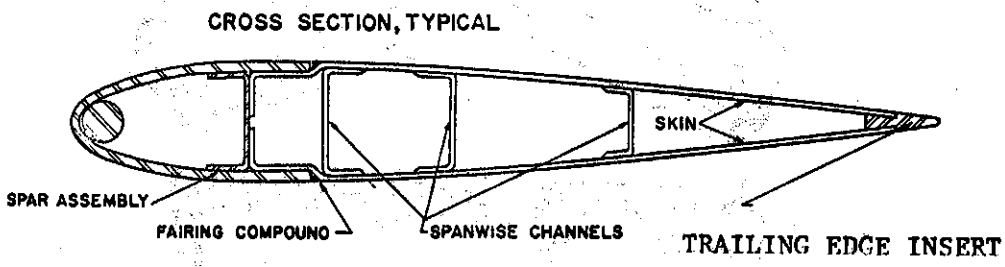
STOP. TURN TO PAGE 2 FOR FRAME #7.

ANSWERS: 1. b. protect the leading edge from damage.
2. d. made up of several different kinds of wood.

FRAME 11

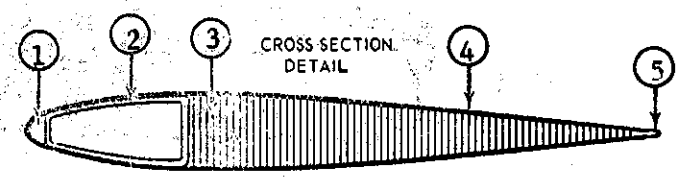
Metal rotor blades utilize a steel spar assembly which runs the length (span) of the blade. This spar is the heart of the blade construction as it provides strength and rigidity to the entire blade assembly. In flight this spar carries most of the load imposed on the main rotor blade.

In addition to the steel spar, the leading edge and the trailing edge are usually made of steel. An aluminum skin covers the remainder of the blade to provide a smooth surface to the airfoil.



The interior of the rotor blade may be of various types of construction. In some blades, spanwise channels are used to strengthen the blade and to give form and shape to the skin. In other blades, very light aluminum honeycomb material is used for the same purpose.

1. Nose Block
2. Spar
3. Honeycomb Core
4. Skin
5. Trailing Edge Strip



The major load bearing unit of a metal main rotor blade is:

a. the spar.
b. the steel leading edge.
c. the spanwise channel.
d. the stressed skin.

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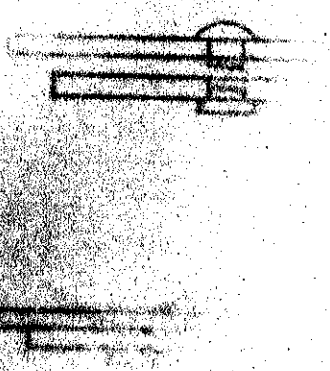
ANSWER: a. the spar



CONTINUE TO THE SELF EVALUATION EXERCISE

AIRCRAFT STRUCTURES
SELF EVALUATION EXERCISE

1. What type of aircraft construction is best described as "a stressed skin with internal bracing"?

   a. Monocoque
   b. Semi-monocoque
   c. Truss
   d. Single shell

2. What stress applied to an aircraft structure is a combination of two other stresses?

   a. Tension
   b. Compression
   c. Shear
   d. Bending

3. The most important advantage of semi-monocoque structure is:

   a. it is stronger and easier to repair than any other type.
   b. it is lighter than any other type of construction of the same length.
   c. any one member can be damaged and the aircraft may still be flyable.
   d. it provides a smooth unbroken surface for the air to pass over.

4. During flight the main rotor mast is subjected primarily to what stress?

   a. Compression
   b. Tension
   c. Bending
   d. Torsion

5. The airframe of a helicopter is made up of:

   a. structural members and structural units.
   b. a body or frame and a skin.
   c. structural and non-structural members.
   d. stringers and ribs.

6. Stress is best defined as:

   a. an external resistance to an internal force.
   b. an internal resistance to an external force.
   c. an external force applied to an airframe.
   d. a combination of forces acting together.

7. The major advantage of truss type construction is its:

a. ability to resist shear force.
b. low aerodynamic drag.
c. members carry mostly end loads.
d. low strength to weight ratio.

8. The distortion of a structural member which is being stressed by an applied force is called:

a. bending.
b. strain.
c. torque.
d. effort.

9. The type of construction used in most Army aircraft is:

a. semi-monocoque and box frame.
b. monocoque and semi-monocoque.
c. truss and monocoque.
d. truss and semi-monocoque.

10. One of the major reasons for the use of steel as an aircraft construction material is:

a. its ability to resist corrosion.
b. its smooth hard finish.
c. its low cost.
d. its ease of repair.

11. The distance between the blade tip and the blade root is called:

a. the chord of the blade.
b. the span of the blade.
c. the chord line.
d. the blade disk.

12. The main purpose of the fabric or fiberglass covering on a wooden main rotor blade is to:

a. protect the blade from damage by foreign objects.
b. protect the blade from moisture.
c. protect the blade from heat.
d. protect the blade from scratches and dents.

13. The landing gear of a helicopter is classified as:

a. a structural member.
b. a non-structural member.
c. a structural unit.
d. an aircraft structure.

14. The chord line of an airfoil is:

a. the width of the airfoil from the leading edge to the root.
b. the distance from the leading edge to the tip of the airfoil.
c. a straight line from the root to the tip of the airfoil.
d. a straight line from the leading edge to the trailing edge of the airfoil.

15. The most common materials used in Army helicopter construction are:

a. aluminum, copper, and steel.
b. aluminum, copper, magnesium.
c. steel, magnesium, and aluminum.
d. steel, aluminum, and wood.

AIRCRAFT STRUCTURES
ANSWERS TO SELF EVALUATION EXERCISE

1. b
2. d
3. c
4. d
5. a
6. b
7. c
8. b
9. d
10. a
11. b
12. b
13. c
14. d
15. c

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